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Series Editors

Gerhard Goos, Karlsruhe University, Germany
Juris Hartmanis, Cornell University, NY, USA
Jan van Leeuwen, Utrecht University, The Netherlands

Volume Editors

Klaus Miesenberger
University of Linz, i^3s^3 – integrated studying
Altenbergerstr. 69, 4040 Linz, Austria
E-mail: klaus.miesenberger@jku.at

Joachim Klaus
Technical University of Karlsruhe
SZS – Study Centre for Blind and Partially Sighted Students
Engesserstr. 4, 76128 Karlsruhe, Germany
E-mail: klaus@szs.uni-karlsruhe.de

Wolfgang Zagler
Vienna University of Technology, i^3s^3 – integrated studying
Favoritenstr. 11/366-1B, 1040 Wien, Austria
E-mail: zagler@fortec.tuwien.ac.at

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Preface

Success and efficiency are the latest standards and scales of our society. Virtual surroundings and communication rooms, electronic portals and platforms are pushing us into a new world of personal and professional interaction and cooperation. The network to subdue violence is fragile and crumbly, tradition is no longer a power of our community.

What of leisure time, dreams, and fantasy?

What of education in the family, at school and at university?

Travelling round the world to develop yourself – how man becomes man: pleading for a new determination of the idea of education – a mission of past centuries inadequate nowadays?

Regarding September 11th last year, the conflicts and confrontations round the globe, and events in our direct surroundings these questions seem to be a cry at least to reflect upon what is happening around us and where we – all of us – still play an active role.

An International Conference on Computers Helping People with Special Needs is like an island – is this a topic at all these days, is it worth discussing the area of ICT and the situation of people with disabilities, persons who are segregated from developing their personal and professional careers?

Indeed the biennial meeting has never included these actualities, but the basic idea behind ICCHP, starting in 1989, was to focus on these fringe groups and to offer a platform of exchange on all aspects of Human Computer Interaction and the usage of ICT for people with special needs. Assistive devices, accessibility and usability of ICT based topics, as well as special systems for people with disabilities are discussed.

Implications for the quality of life and for society in general should encourage a holistic approach. The orientation towards practice leads to an interdisciplinary exchange symbolized by the ICCHP-cube and invites all disciplines working in the field to take part and to discuss their ideas, approaches, and results. The general topics of

- Accessible Communication and Information
- Designing the Environment for All
- Medicine
- Assistive Technology
- ICT in Special and Inclusive Education

meet the concrete demands of people with special needs.

The vision and mission of those responsible for the conference and contributing to its success is, by stressing the special field of disability and ICT, to open the door to a humanistic, democratic, and social world, and to present models for the future. What applies to the periphery can be extended to apply to the whole, to open eyes, and to motivate the construction of networks for a common peaceful world.

The structure of ICCHP 2002 offers researchers and practitioners the opportunity to present their work and experiences and additionally invites specialists to set up, organize, and to chair Specific Thematic Sessions (STS).

Together with the tutorials and seminars of the pre-conference, the ICCHP 2002 will be a rich field of discussions and exchange. Participants should leave Linz with the intention of forming new active working groups, chat-rooms, and networks to deepen and broaden the themes discussed at the conference.

Let us all interact together in this way, transfer, and continue in order to make ICCHP a permanent platform of communication, apart from, but within the framework of our urgent world questions!

ICCHP 2002 was made possible by the expertise and the great enthusiasm of the General ICCHP 2002 Chair Harry Murphy, founder and former director of the Center on Disabilities (California State University, Northridge, USA) and of the Program Chairs – D. Burger (INSERM, France), A. Karshmer (Florida State University at Tampa, USA), A.M. Tjoa (Technical University of Vienna, Austria), R. Vollmar (University of Karlsruhe (TH), Germany).

The Publishing Chairs – J. Klaus, K. Miesenberger, W. Zagler – would especially like to thank the Program Committee for their participation and reviewing tasks.

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The daily and therefore biggest burden was to be undertaken by the Organizing Committee at the University of Linz.

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Their ideas, their improvisational talent, and above all, their friendliness and kind attitude while solving all sort of problems were all very much appreciated.

Roland Wagner Award

We thank the Austrian Computer Society for announcing and sponsoring the *Roland Wagner Award on Computers Helping People with Special Needs*.

Prof. Dr. Roland Wagner is a pioneer in the field of ICT for people with disabilities and the founder of ICCHP. The Roland Wagner Award in the range of 3000 Euro will be given at ICCHP 2002 to a distinguished professional who has rendered outstanding service in the area of technology for people with disabilities.

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We would like to express our gratitude towards all our partners, sponsors, and supporters.

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Structured Access to Documents, Digital Talking Books, and Beyond: The DAISY Consortium

George Kerscher, Senior Officer, Accessible Information

Recording For the Blind & Dyslexic (RFB&D)
Project Manager to the DAISY Consortium
<http://www.daisy.org>
1203 Pineview Dr, Missoula, MT 59802, USA
kerscher@montana.com

Abstract. Keynote presentation July 18, 2002

1 DAISY: Digital Accessible Information System

DAISY digital talking books are not just digital audio talking books, they are structured books that give access to people who have a visual or other print disability - access equal to or greater than the access sighted readers have to print books. The DAISY Consortium was established in 1996. Its main goal since its inception has been to develop the international standard for accessible information, and to implement that standard around the globe. The time to move from analog cassette tapes which provide linear access which is limiting and restrictive, to DAISY digital talking books which allow readers to navigate through the book by heading, page number, paragraph, and even by word if the DAISY book has been created with word level synchronization, has arrived.

Communication and exchange of information within the DAISY Consortium is fundamental. The center of information is our Web site, located at <http://www.daisy.org>. Our Web site serves to provide information about the Consortium and DAISY DTB to anyone interested in accessible reading materials, their production, playback tools; it is a comprehensive center for the best information relating to DTB standards and their implementation.

The Global navigation bar at the top of each page provides links to areas such as "About Us", "Publications", "Support", and "Tools". Each of these areas also contains a local navigation bar with links to specific topics or areas of interest. Guest users can access all of the areas from the global navigation bar; some areas accessible through local navigation have restricted access limited to DAISY members or friends.

"About Us" provides historic and current information about the DAISY Consortium. "Publications" provides links to specifications, standards, guidelines, training materials and other relevant publications. The FAQ, Knowledge Base, and HelpDesk are located within "Support" an important area restricted to our Members.

Providing training in the use of DAISY production tools and processes is a major objective of the Consortium. Member organizations may request to host a training course and the DAISY Consortium provides qualified, highly skilled trainers to conduct these courses. The Web site and discussion lists reinforce information provided in the courses.

Over the past couple of years the Consortium has been heavily engaged in developing the DAISY 3 standard through the National Information Standards Organization (NISO). Work has been done in conjunction with the Library of Congress, Library Services for the Blind and Physically Handicapped in the United States. Together we have moved DAISY 3 to an ANSI/NISO standard formally known as the ANSI/NISO Z39.86, and there are future plans to move it to an ISO standard. The current DAISY 2.02 Standard is XHTML and SMIL 1 based, while the new standard is XML and SMIL 2 based.

DAISY 2.02 marries XHTML content and digitized audio through the use of SMIL (Synchronized Multimedia Integration Language) files. It is the links in the XHTML that provide the navigation through the audio and to the various parts of the book. DAISY books can be produced as original recordings or can be created through an analog to digital conversion process. DAISY 3 builds on these principles and uses XML as the foundation for all text, navigation, and synchronization. A DAISY XML file can be used to generate braille (hard copy or electronic), large print, digitized human voice, or synthetic speech; One single file, many potential output options. The result is the same: accessible information.

The DAISY Consortium also works closely with other standards organizations such as the W3C, and the Open eBook Forum (OeBF) to insure that DAISY standards build on existing specifications. Strategically, the DAISY Consortium intends to move to converge standards wherever possible, and to move the DAISY standard into the mainstream of audio and electronic publishing.

The DAISY Consortium invites you to visit our Web Site and join the movement.

Acknowledgement.



Fig. 1. Logo of the Daisy Consortium

eEurope – eAccessibility – User Participation

Participation of People with Disabilities and Older People in the Information Society

Introduction to the Special Thematic Session

Christian Bühler

FTB

Grundschöttlerstr. 40, 58300 Wetter, Germany

c.buehler@ftb-volmarstein.de

www.ftb-net.de

The Council of Ministers of the European Union has brought forward the vision to develop the Information Society in Europe for all citizens in Europe to a leading status. The CEU supports the goal in the 5th Framework Programme, with research area IST – Information Society Technology. Of course is research a very important aspect and driving force in this development, but also other measures are needed. The development of the infrastructure, realisation of borderless interoperability, and support of implementation are also required. This has been realised by European Union and the individual member states. Therefore, they all have started action on national and European level. A common position has been adopted in the eEurope Initiative, which has led to the eEurope action plan 2002. In this action plan concrete targets and timelines have been set in order to support the development of the Information Society in Europe. One direction is the Information Society for all people, and here specific actions are combined in “eAccessibility”. eAccessibility is guided by a high level expert group of the member states (ESDIS) and coordinated by DG Employment with support of DG INFSO and other DGs. ESDIS has decided to create an eAccessibility expert working group of experts and/ or government representatives from all member states. The eAccessibility started working in January 2001 and is still ongoing. The group has to deal with four targets of the eEurope action plan and has made progress as follows:

Table 1. Targets of eEurope Action Plan

Target	Actor (s)/date	Progress made
Policies to avoid info-exclusion will be more effectively co-ordinated at European level through benchmarking of performance and exchange of best practice between Member States.	Member States, European Commission, 2001	e-Inclusion has become a key objective of the overall European Social Inclusion Strategy. Specifically, a Council Resolution on e-Inclusion set out detailed objectives for exploiting the opportunities of the Information Society for social inclusion and to avoid a digital divide. It builds on a comprehensive analysis of practices in the Member States, drawn up by the Commission services with the support of ESDIS ("e-Inclusion report").

Adoption of the Web Accessibility Initiative (WAI) guidelines for public websites.	European Commission, Member States 2001	Building on work of the eAccessibility group, this action has been addressed by the Commission's Communication on: "eEurope 2002: Accessibility of Public Web Sites and their content". Based on the criteria set out in the Communication, most Member States have already adopted (or are in the process of adopting) the use of the WAI guidelines for their public sites.
Publication of "Design for all" standards for accessibility of information technology products, in particular to improve the employability and social inclusion of people with special needs.	European Commission, Private Sector 2002	Further to a standardization mandate on Design for all and assistive technologies, an extensive report on the role of standardization in support of the eAccessibility principles has been produced by the standardization organisations. Recommendations concerning specific standardization activities have been discussed by all parties over the last year, and as a result, some eAccessibility standardization initiatives have been launched within the standardization environment (CEN, CENELEC, ETSI and other ICTSB members such as ECMA, W3C etc). Several of these activities carried out in CEN, CENELEC and ETSI have been granted financial support from the Commission via the eEurope standardization contracts (eSAP 1 and eSAP 2). In addition, the European standardization organisations have created a Design For All co-ordination group which met for the first time in November 2001, in Geneva. The next meeting of this group is schedule or March 2002. The eAccessibility group is represented in this coordination group.
Review relevant legislation and standards to ensure conformity with accessibility principles.	Member States, European Commission 2002	On the basis of responses of the Member States to a questionnaire, the eAccessibility Group has defined a framework for examining the conformity of legislation and standards with eAccessibility principles. Content gathering is in progress and will continue in 2002.
Ensure the establishment and networking of national centres of excellence in design-for-all and create recommendations for a European curriculum for designers and engineers.	European Commission, Member States 2002	Analysis has been undertaken by the eAccessibility group on the basis of a questionnaire issued to the Member States. Most Member States have identified one or more such Centres. Arrangements for their networking are ongoing. The recommendations concerning curricula will be further discussed and produced in 2002.

The adoption of the WAI guidelines has been one mayor achievement of eAccessability so far. However, it becomes clear through this example, that much of the actual implementation is up with the responsibility and interpretation of the member states. In the case of adoption of WAI guidelines for public websites, still a

lot of differences might be given, with respect of level of conformance, implementation through legislation or recommendations, implementation measures in the respective country, effort and money spent, etc. Still open is the question of benchmarking and comparing the results between the countries in Europe.

Another issue is the participation of people with disabilities themselves in the process. As the eAccessibility expert group is a group of member states experts/representatives some countries have people with disabilities in their delegations, who are either civil servants or experts in one of the targets. Organisations of users in their capacity as representatives users (not specific experts in one of the targets) can not be involved. However, the CEU has managed to get representation of EDF as observer in the eAccessibility expert group. On the level of concrete work in the framework of eAccessibility user involvement needs to be continuously supported. Only few of the mandates for standardisation funded by the CEU have representatives with disability in the special task force. On the other hand people with disabilities have been invited to the standardisation workshops and the Design-for-all and Assistive Technology Standardization Co-ordination Group (DATSCG). This group intends to coordinate activities between standardisation (ICTSB, CEN, CENELEC, ISO, ETSI) and the field of people with disabilities and older people. In the area of centres of excellence in Design-for-all the relation of such centres to the field and cooperation with organisations of users has been set out as one of the selection criteria. It seems that an attempt to improve user participation is ongoing, but it is not taking place without further effort.

Concerning the accession countries plans have been set up under the title eEurope+ to catch up with the eEurope initiative. Further, plans are ongoing to implement a succession activity called eEurope 2005 in order to continue what has been started in 2001.

This session will focus on eEurope and the ongoing efforts concerning eAccessibility including Web Accessibility (WAI), Design for All, standardisation and legislation. Contributions will also concentrate on how to put user participation in all these fields into practice. Speakers from the eAccessibility group of ESDIS are be invited and report about achievements and ongoing developments:

- | | |
|---------------------------------|---|
| – Henry Haglund (CEU DG INFSO): | The eEurope –eAccessibility Action Plan |
| – Rudolfo Cattani (EDF, I): | Implementation of user participation |
| – Erkki Kempainen (Stakes, Fi): | Legislation in relation to an integrative Information Society |
| – Jan Engelen (KUL, Be): | Standardisation activities in DfA and AT |
| – Judy Brewer(W3C, USA) | Adoption of WAI guidelines |
| – Christian Bühler (FTB, De): | Centres of Excellence in DfA |

Disclaimer: Please note that this information is based on public information of CEU represents the author's own point of view. It does not necessarily reflect the views of the European Commission.

From Research to Business Improving the Take Up of Results of Research Projects

Introduction to the Workshop

Christian Bühler

FTB

Grundschtötterstr. 40, 58300 Wetter, Germany

c.buehler@ftb-volmarstein.de

www.ftb-net.de

Research and Development (R&D) in IT for people with disabilities feels the pressure to bring the results of their projects successfully to the market. R&D in this field, after a pilot period, now must show its impact on practice, on the quality of life of target groups and therefore on related markets. The take up of results of research projects more and more becomes a key issue of any call for proposal for research and development activities. The European Commission for example clearly states in its IST programme that proposals have to show how they can reach this goal.

Basically the R&D programmes are prenormative and precompetitive. On the other hand CEU and European citizens expect that R&D will have a concrete impact in Europe. In the IST application domain of people with special needs, this impact should improve industrial competitiveness and support the life situation of people with special needs, namely people with disabilities and older people. In this respect the transition from research to market is a very important step. However, even if we see good R&D prototypes, it is not guaranteed that the will lead to products or services on the market or to market success. Certain steps need to be taken after the end of an R&D project to make this happen. The prototype needs to be transferred in a series production, sales, after sales and services need to be organised, a marketing strategy needs to be implemented, etc. It is often a considerable investment. To make all this happen a business plan must provide evidence for commercial success after the investment. In addition other organisational problems might jeopardise the process: conflicts of interest might arise between competitive partners, other partners might withdraw from the exploitation. Maybe the roles of the project partners change after the project expiry or new partners need to be involved or project partners revise their original business plans

This workshop will concentrate on this topic by inviting experts coming from different countries to give introductory statements which will lead to a discussion on possibilities how to improve the outcome of R&D in regard to these aspects.

Karl Henry Haglund, Head of Unit Applications relating to the disabled and the elderly, European Commission, Information Society Directorate-General will keynote in close relation with this workshop. He will point out the CEU expectations, link to experiences of past programmes and projects and the interest of the Commission to improve this aspect.

Joe Lane, from the Rehabilitation Engineering Research Center (RERC) on Tech Transfer, University at Buffalo (UB), USA, who works in the same field in the USA will keynote to the workshop. He will concentrate on the models of tech transfer and the related experiences as made by the RERC in the USA.

Also in Sweden the government has supported actions to improve the transition from R&D to market. Claes Tjäder from the Swedish Handicapped Institute will report on experiences which have been made within this national programme.

Among the project examples the European project Play2 will be presented by Giuseppe Nicotra. This project has managed the transition to the market.

The workshop participants will be invited to report on other success stories and the key issues for success, but also reason for failure. Users, experts from R&D, industry, insurance companies, public sector, interested and willing to contribute to this workshop are asked to get in contact with the chair or join the workshop.

As this workshop has been recommended by European Commission, DG Information Society Technology ST, it is supported by the European Commission and organised in close co-operation. It is an objective to pass results and recommendations back to the European Commission.

Universal Access to Information Society Technologies: Opportunities for People with Disabilities

Introduction to the Special Thematic Session

Constantine Stephanidis^{1,2} and Pier Luigi Emiliani³

¹ Institute of Computer Science, Foundation for Research and Technology - Hellas
Science and Technology Park of Crete, GR-71110, Heraklion, Crete, Greece
cs@ics.forth.gr

² Department of Computer Science, University of Crete

³ Institute of Applied Physics "Nello Carrara" (IFAC), National Research Council
Via Panciatichi, 64, 50127 Firenze, Italy
ple@iroe.fi.cnr.it

1 Introduction

The Information Society is bringing about radical changes in the way people work and interact with each other and with information, and offers new opportunities to improve the quality of human life. The target user population addressed is broadening, while the availability, type, functionality and content of new products and services is expanding, and access technologies are being diversified. At the same time, however, each new generation of technology has the potential of introducing new difficulties and barriers in the use of products and services - and eventually in everyday life, new risks for the health and safety of people, and new forms of social exclusion and discrimination.

Disabled and elderly people have been traditionally underserved by technological evolution. They currently make up about 20% of the market in the European Union, and this proportion will grow with the ageing of the population to an estimated 25% by the year 2030. Not only there is a moral and legal obligation to include this part of the population in the emerging Information Society, but there is also a growing awareness in the industry that disabled and elderly people can no longer be considered as insignificant in market terms. Instead, they represent a growing market to which new services can be provided. Therefore, amongst the ingredients of success of the emerging Information Society, accessibility and usability of Information Society Technologies acquire paramount importance.

2 Perspectives on Accessibility

Over the years, accessibility has been addressed through various collaborative efforts. The traditional approach to rendering applications and services accessible to people

with disabilities, is to employ assistive technologies for adapting such products to the abilities and requirements of individual users. Adaptations facilitate access to the interface via suitable mechanisms, such as filtering, or dedicated interaction techniques, such as scanning, and specialised input/output devices (e.g., tactile display, switches, eye-gaze system). Typically, the results of adaptations involve the reconfiguration of the physical layer of interaction and, when necessary, the transduction of the visual interface manifestation to an alternative modality (e.g., auditory or tactile).

The adaptation approach to accessibility, though may be the only viable solution in certain cases, suffers from some serious shortcomings, especially when considering the radically changing technological environment, and, in particular, the emerging Information Society technologies. Firstly, such an approach is not viable in sectors of the industry characterised by rapid technological change. By the time a particular access problem has been addressed, technology has advanced to a point where the same or a similar problem re-occurs. In some cases, adaptations may not be possible at all without loss of functionality. Finally, adaptations are programming-intensive, which raises several considerations for the resulting products. Many of them bear cost implications due to the fact that adaptations are difficult to implement and maintain. Recently, there have been a number of initiatives by mainstream actors (Microsoft, Sun, IBM, Apple, etc) and research consortia to develop technological frameworks that provide more adequate support for accessibility and easier integration of assistive technology applications. These efforts aim to overcome the problems identified above and provide accessibility tools as integral components of mainstream interaction platforms and environments.

In the light of the above experiences, and of the increasing importance of accessibility as a global requirement in the Information Society, there have been proposals and claims for proactive strategies, resulting in more systematic solutions to the problem of accessibility. In this context, the notion of Universal Access becomes critically important for ensuring social acceptability of the emerging Information Society [1, 2]. Universal access implies the accessibility and usability of Information Society Technologies (IST) by anyone, anywhere, anytime. Its aim is to enable equitable access and active participation of potentially all citizens in existing and emerging computer-mediated human activities. To this end, it is important that the needs of the broadest possible end-user population are taken into account in the early design phases of new products and services. Universal Design in the Information Society has been defined as the conscious and systematic effort to proactively apply principles, methods and tools, in order to develop IST products and services that are accessible and usable by all, thus avoiding the need for a posteriori adaptations or specialised design. The rationale behind Universal design is grounded on the claim that designing for the “typical” or “average” user, as the case has been with “conventional” design of Information Technology and Telecommunications (IT&T) applications and services, leads to products which do not cater for the needs of the broadest possible population, thus excluding categories of users. Proactive strategies entail a purposeful effort to build-in universal access features into a product, starting from the early stages of product design. Universal design in IST has not been conceived as an effort to advance a single solution for everybody, but, instead, as a user-centred approach to providing products that

can inherently address the widest possible range of human needs, abilities, skills, requirements and preferences. Though the field lacks substantial data and comparative assessments as to the costs of designing for the broadest possible population, it has been argued that (in the medium- to long-term) the cost of inaccessible systems is considerably high, and is likely to increase even more. In the recent past, R&D work has demonstrated the feasibility of Universal design in the field of HCI, by introducing the concept of User Interfaces For All, as well as a development methodology and tools which constitute the first systematic effort in this direction, and have been successfully validated in practice [3].

In addition to RTD efforts aiming to provide solutions to accessibility problems, there is work aiming to consolidate existing wisdom on accessibility, in the form of general guidelines (e.g., HFES/ ANSI Draft, Section 5) or platform- or user-specific recommendations. (e.g., for Graphical User Interfaces or the Web). Guidelines are typically documented on paper and reflect previous experience gained, as well as best practice available for designing accessible interactive software (also including content). The systematic collection, consolidation and interpretation of guidelines is currently pursued in the context of international collaborative initiatives (e.g., W3C-WAI Initiative¹, ISO TC 159 / SC 4 / WG 5).

While efforts toward technological developments are clearly necessary, they do not constitute a sufficient condition for leading to an Information Society for all citizens. There are additional requirements for accompanying measures to assess the efficacy and ensure the adoption, acceptance and diffusion of these technologies, leading to economic feasibility in the long run, versatility and economic efficiency. Socio-economic and policy issues are relevant to the extent to which they cover R&D planning, industrial policy and innovation, assessment of the products and services envisioned in the information age, security and privacy, cost factors, diffusion and adoption patterns, standards, legislation, and technology transfer.

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¹ <http://www.w3c.org/WAI/>

Accessibility and Usability of eCommerce Systems

Keith Gladstone, Cathy Rundle, and Tara Alexander

iSys R&D, Royal National Institute of the Blind,
105 Judd Street, London, WC1H 9NE, UK
{KGladstone, CRundle, TAlexander}@rnib.org.uk

Abstract. RNIB has had a presence on the web since October 1993, which it has used both to disseminate information and to develop and demonstrate good practice. As an integral part of this work, RNIB launched its Online Shop in March 2002, a practical example of eCommerce tailored to address the needs of both visually impaired customers and their sighted friends and carers. Currently, user access is being significantly enhanced by the addition of a natural language interface as part of the EU funded project 'IMAGINE'. This paper focuses on aspects of both developments that have advanced our understanding of best practice in the area of eCommerce.

1 Context

In developing best practice guidelines, it is essential that we appreciate not only the needs of the end user but also of the service providers and intermediaries who have the responsibility to implement and support the systems. For eCommerce, companies have not just a right but also a duty to ensure that developments that enhance access for disabled people do not significantly detract from the service offered to the rest of their customers. Companies also have to understand their own internal processes, at times challenging the culture of 'that is how we always do it' in order to tailor the service to the new dynamics of online access.

For an organisation like RNIB, implementing its own guidelines can be a testing experience. From its inception, every effort has been made to ensure that the RNIB website has met and exceeded the requirements of the WAI guidelines. The aim has been to demonstrate that it is possible to produce an interesting and informative site that can be used by everyone, albeit with access technology where that is relevant. This has certainly precluded the implementation of elements such as transient messages or complex frames since these are inherently inaccessible to people whom have little or no sight. The site has been designed to be visually appealing to help sighted and partially sighted users access the shop. However the development of a visually aesthetic site has not presented a problem for those accessing it through speech as accessibility via the screen and through speech has been considered throughout the development phase.

It is within this context that RNIB has developed and implemented its online shop. The fundamental rationale was to provide 24-hour access to the complete RNIB catalogue of devices that support visually impaired people in education, employment, daily living and leisure. The catalogue has traditionally been made available to

customers in print, braille and audio and a rudimentary version has also been provided on the website, though it has been difficult to maintain its accuracy. Customers can place orders via post or email, though the most popular contact is via the LoCall phone number to Customer Services. As well as giving quality advice about RNIB's products and services, Customer Service staff are trained to provide an empathetic ear, which is very important for people facing the reality of sight loss for themselves or a friend or relative. An account is created for each customer, against which they can charge the cost of orders. Whereas RNIB would prefer customers to pay immediately by credit card, most opt to use the account, which defers payment for several weeks. In practice, most customers purchasing from the Online Shop have paid by credit card.

RNIB operates a complex pricing policy partly to favour its VI customers and partly to reflect the vagaries of UK VAT legislation. An item designed for and sold to a VI person is zero-rated for VAT, as are all books and a small number of other specific products. A number of other items are subsidised by RNIB when bought by or on behalf of a VI person. Such subsidies are not available to people outside of the UK and many products carry an export premium where this is legally permitted. Where applicable, products are shown with dual pricing in the UK catalogues and there is an entirely separate catalogue for the export market.

2 RNIB Online Shop

The fundamental remit of the project was to reproduce the customer ordering process as a web-based application. Although the various elements for this development seemed to be in place, it soon became apparent that considerable work was needed to ensure the integrity of the catalogue data. Basic product information was not only stored on the main order processing system but was also held separately, and in more detail, to generate the print and braille catalogues. From the initial analysis, it was decided that a new product database would be established that would be used to generate the catalogue information automatically in all formats and to update the order processing system. The value of this work became apparent in subsequent discussions that resolved the many inconsistencies that existed within the product information.

2.1 User Needs

The focus of any service development project has to be its acceptance by its users. In practice, we cannot simply rely on potential users' opinions for a new service since their experience is too limited. Jakob Nielsen has quoted anecdotes where web elements that people praise on demonstration they heartily dislike in practical use (<http://www.useit.com/alertbox/991212.html>). This is far from unusual and one of the causes of unhelpful design. There is always the challenge when considering any user wish list to identify what is really wanted and what will work for the user. In this project, the user needs were derived from a number of sources:

Users. Much of the user-based work was derived from previous projects in which users had had the opportunity to experiment with simple access systems. This was backed up by the use of focus groups to ascertain some of those factors that were important to users but had not been evident in earlier studies.

Customer Services. Members of Customer Service staff were particularly helpful in identifying the pattern of enquiry with which they deal. Whereas some customers are specific about what they want to order, many start by asking for help with a particular problem that they or one of their relatives have. Questions that start with “Do you have anything that will...” are common. It also became evident that many customers do not use the ‘official’ product name or description, preferring a generic designation that is usually interpreted readily by the operator.

Online Sites. A great deal of information was derived from other eCommerce sites and the ways in which people used and responded to them. Of particular value was the work that RNIB has carried out in collaboration with a number of commercial organisations to make their sites usable by VI people.

2.2 Process Requirements

A major design goal was that the Online Shop should be seen from a process viewpoint as simply another customer channel alongside telephone, post and email. There seemed to be a possibility that it could make an improvement by directly linking to the sales order processing system. Unfortunately, due to the obsolete nature of the corporate system, such a link was found too unreliable. This will prevent the system providing instant stock information. The advent of a new Core Business System early in 2003 should make it possible to realise this goal.

As part of customer relationship management, RNIB always opens an account for anyone placing an order. Over time, this has been seen as a rich opportunity for acquiring customer information with registration questions including such details as visual status, ethnic origin and date of birth. Analysis of the registration process not only suggested that it would be far too long but also that the questions were too intrusive for someone simply buying a catalogue product.

The plethora of stories of web based fraud has made many people nervous about using eCommerce. The Online Shop has been designed to include full security to guard the payment details from the stage when the user enters the data through to when Customer Services takes the payment. This necessitated encryption of the data through the complete payment process so that only designated staff can access the customer information.

2.3 User Interface

A major design criterion was that the Online Shop should be fully accessible and usable by people with access technology and that it should be visually attractive. Although the WAI guidelines were used as the basis of the design, a great deal of care was also taken in reviewing the user interaction with the system. It was recognised at

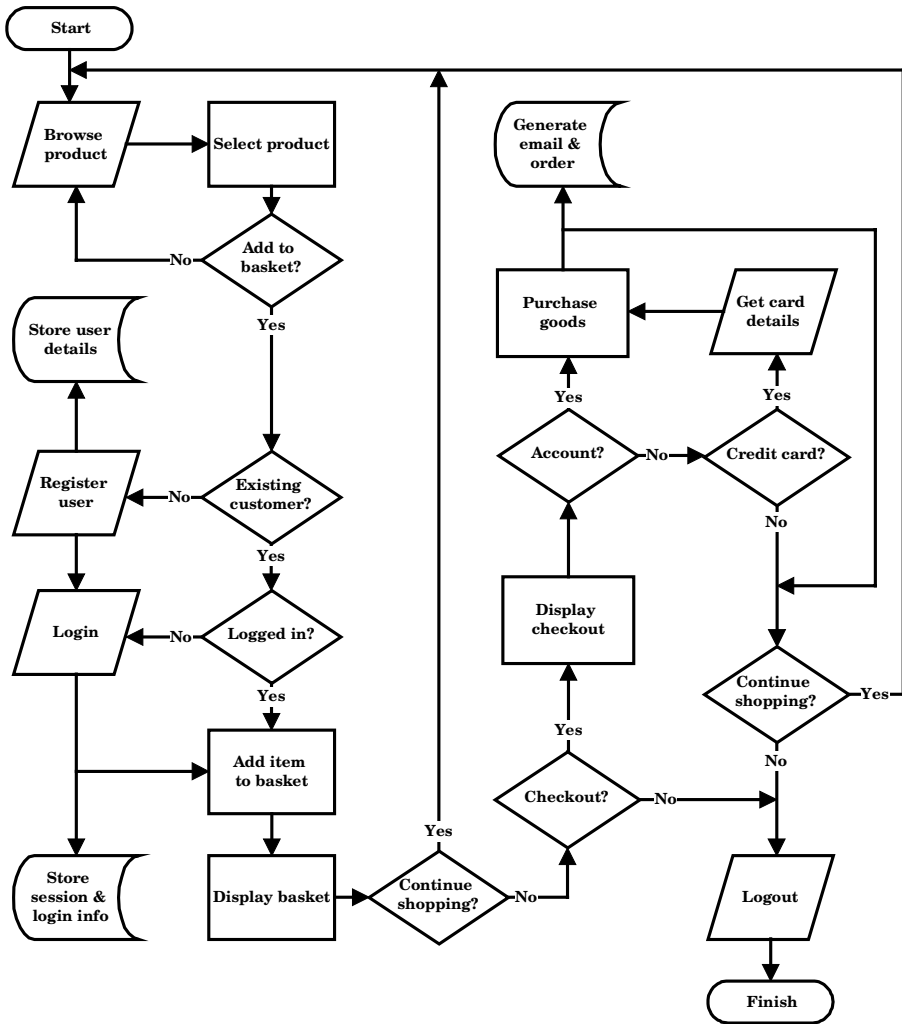


Fig. 1. System flow diagram for the RNIB Online Shop

an early stage that many potential users may have had little previous exposure to web based applications and could need considerable guidance along the way. This had significant impact on how the content is presented to the user, particularly the use of context sensitive help and meaningful 'alt' tags for graphic elements.

The product database has been designed such that the user is offered a maximum of ten choices at any level. Any greater number makes it difficult for the user to retain enough information to make an informed choice when using braille or audio output. The browse capability is supported by a full search facility on the product database. Some product names have been reviewed to ensure that they are unique and include words that users are likely to use. A log is being retained of all search queries. Those

that are unsuccessful but reasonable will be used to add to the product metadata in order to improve the search capability.

2.4 Evaluation

Throughout its development, the Online Shop was tried and tested by a range of people with various degrees of visual impairment. Two factors have been of prime importance: were the users able to use the various elements of the application and did they enjoy the experience. Many people with whom we work are very keen to see the success of this type of development and, if they have difficulties, will tend to blame themselves rather than the system. It has been important, therefore, to observe how a well a user is able to use the system by giving specific tasks and recording whether they were completed and how long they took. We also have asked people to talk us through their interactions with the system, which has helped the designers to understand where particular parts of the interface may be confusing. Where possible, evaluations were observed by the designers themselves so that they get a better feel about those areas that are successful and those that cause irritation or perplexity.

Even when people find that they can use a system, they may still find it frustrating. Part of the evaluation assessed how enjoyable users find the interaction both through observation and by discussion with participants. This is a vital element in the practical success of any implementation since if people perceive its use as disagreeable they will avoid it in the future. The extension of testing for accessibility into usability is seen as vital for the successful design and deployment of systems. For some of the users, the evaluation of the Online Shop was the first time that they had used computers with access technology. Although care had to be taken to account for the novelty factor, these users gave us an insight into an interaction largely uncluttered by expectation. One lady who had not used a computer before was able to fulfil tasks on the Online Shop after only ten minutes of tuition.

Although it was not unexpected, the registration process gave users most difficulty because of its sheer length and complexity. Consequently, agreement was gained from Marketing to request only that information needed to complete a purchase. The agreed registration process takes users an average of six minutes to complete, though some will still struggle for forty minutes or more.

3 Natural Language Access

The EU IST project IMAGINE, has given RNIB the opportunity to investigate the use of a natural language interface for the Online Shop. The prime intention of the project is to develop a set of tools that will allow a natural language front end to be provided for user interaction with the minimum of modification to the base application. The RNIB Online Shop is a good test bed since it is a well-bounded application fully under our control.

A natural language interface seeks to allow a customer to use normal phrases and responds with well constructed information and prompts. In applications where a user profile can be established, the system can build an adaptive knowledge of the user's idiosyncrasies. This allows the system to respond to a far greater range of phrases. For

the Online Shop, most customers will be infrequent visitors and, so, it will not be possible to build such a profile. This means that the system must prompt the user such that responses are naturally constrained rather than the system having to be learnt. There is no intention to build a traditional menu based system since they are only effective where there are a far more limited choice of options than is necessary for the Online Shop.

User Interaction. The dynamics of a system based on voice input and output are very different even from access via a speech based screen reader. Voice input does not allow the user to navigate around the information space easily, so it is harder to browse. Natural language gives the user the ability to construct complex queries, though these have to be translated into meaningful system commands. This translation forms the heart of the natural language design, which is based on the understanding of the user and the application system.

Forming the Corpus. The corpus (dictionary of utterances) forms the starting point for the lexical and semantic analysis of phrases. In order to gain an appreciation of unconstrained user interaction, Customer Services provided recordings of customers ordering products from the catalogue. Generally, only a limited amount of each call related to the order, customers often seeking advice or empathy, sometimes in the most distressing of circumstances. Some customers were well prepared with exact order codes but most had only a partial idea of what they wanted.

The second stage required a careful examination of the various nodes in the interaction schema and the possible prompts or responses that the system could provide. From this sample interactions were generated as below:

Customer: What are the contents of my basket?

System: You currently have one CW67*, watchcase/box priced at £2.22 and one CP03*, General use AA battery priced at 76p in your basket. Your basket total including postage is £2.98.

Customer: I'll have two of the watchcases instead.

System: That's two of the CW67* watchcase/boxes priced at £2.22?

Customer: Yes please.

System: Ok. That's updated. Your order total is now £5.20. Do you want to update again, continue shopping or checkout?

Customer: I'll checkout now please.

System: Ok. You have ordered the following: two CW67*, watchcase/box at £2.22 each. One CP03*, general use AA battery at 76p each. That's a total of £5.20 including postage. Do you wish to complete your order now? ...

The analysis of this information provides the parameters for the design of the speech recognition and lexical analysis elements of the system. The output of the analysis is a list of possible phrases corresponding to the customer utterance. The semantic analysis then matches the phrases with possible interactions with the base application. This either generates a response from the application or a request for clarification.

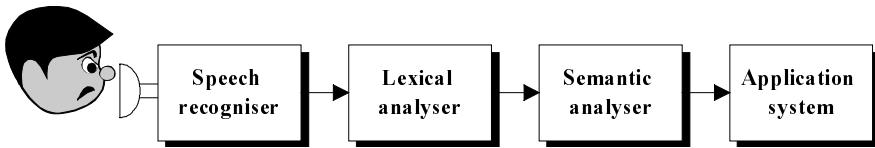


Fig. 2. Elements of natural language input

Design. The design phase of the natural language interface will be an iterative process that will involve a high degree of user testing. It remains to be seen whether the right point has been chosen in the continuum between a fixed menu driven interface and an unconstrained natural language interface. There is no reason to doubt that the system will be accessible but the challenge is to ensure that it is also sufficiently acceptable to users that they will find it of benefit.

4 Best Practice

When developing any system, designers need to be aware of the needs of end users, service providers and intermediaries such as support staff. Although the goal should be fully inclusive design, there is no point in slavishly following such a precept that the compromises produce a system that is acceptable to no one. Equally, a system that is designed for use by the public, such as the RNIB Online Shop, should not ignore the desire of sighted people for a visually stimulating interface so long as it remains both accessible and usable by people with little or no vision.

The plethora of guidelines that have been produced by WAI and several other organisations seek to ensure that web sites are designed to be accessible. However, such guidelines, by being comprehensive, are frequently too long and technical for the average web designer. One outcome of RNIB's work has been to formulate the following quick checks that can be done on any web site before further testing is carried out. If these are not possible, the web site will be inaccessible to some users and changes need to be made before further testing is carried out with users.

- *Use the site without touching the mouse.* If you have to use the mouse then that part of the site is not accessible to keyboard users.
- *Set your browser to ignore colours set by the website* then use the site with:
 - Windows colours set to High Contrast Black
 - Foreground and background colours set differently in your web browser
- *Set the display resolution* to 640x480 and the browser text size to largest and see what the site looks like. Can you access all the links? Do you have to use the scroll bar a lot? Do any parts of the page overlap each other?
- *Switch off graphics* in your browser and see if you can understand and navigate around the site with just the ALT text displayed.
- *Switch off JavaScript* in your browser and check that all essential parts of the site can be accessed and that no essential functions are disabled.
- *Get disabled users to try it out.* The RNIB website has a list of agencies in the UK for blind and partially sighted people

In the end, though, the success of any system is not just whether it is accessible but whether it is designed in such a way that people want to use it. Demonstrating system accessibility must be the precursor to full usability testing by representatives of the potential user group and within a meaningful context.

5 Conclusions

The digital revolution has placed unimaginable amounts of information within the reach of most people throughout the technologically developed world. The advent of eCommerce has brought many services into people's homes. We have a duty to ensure that the design of such services meets the needs of everyone wherever possible. With modern access techniques, people who are unable to see the screen need not be disadvantaged so long as applications are designed carefully. While many of the current guidelines are excellent, they concentrate on accessibility rather than usability. However, people have to use the systems that we design and that requires designers to think more carefully about the context in and the tasks for which they are used. Though end users remain the key stakeholders, system designs must address the needs of service providers and intermediaries, such as support engineers and trainers.

Technology has its place within our lives but the failure of many recent initiatives is a clear demonstration that many people have reached a threshold above which they are not prepared to go. It is all too easy to see technological devices as the way to give disabled people a degree of independence that they are otherwise denied. There is no doubt that such advances have improved the quality of life for many people. However, there is also growing evidence that increased independence can also mean greater social isolation. The implementation of the RNIB Online Shop has so far proved to be very popular and, no doubt, this will reduce the number of orders received through Customer Services. This should mean that those people who do still want the more personal service and advice provided by the operators will find it easier to make contact. The tragedy will be if customers feel that they are expected to use 'the system' because that is more effective for the organisation.

Acknowledgements and Further Information. The work on natural language access forms part of the IMAGINE project, funded by the European Commission under the IST programme of the 5th Framework.

RNIB has worked with the Web Accessibility Initiative and other bodies to generate and promote guidelines that are making more parts of the web usable by visually impaired people throughout the world. Further information can be found at <http://www.rnib.org.uk/digital/hints.htm> or at <http://www.useit.com/>.

Recommending Context-Sensitive and Process-Oriented Tourist Information to the Disabled – The PALIO Case

Michael Pieper

Fraunhofer Institute for Applied Information Technology (FhG-FIT)
Schloss Birlinghoven,
D-53754 Sankt Augustin
michael.pieper@fit.fraunhofer.de
<http://www.fit.fraunhofer.de>

Abstract. Aim and ambition of the PALIO project is to provide new information services, directly available for tourists and citizen by developing and implementing complex data systems with user friendly and personalized interfaces. PALIO is sensitive to the tourist needs and makes the organization of touristic stays easier. The system offers services like information on how to move in a visited town, gives hints about available accommodation, parking lots, tourist guides, restaurants, museums, cultural events etc. A certain part of this information is especially related to disabled tourists, e.g. about places which have easy accessibility in terms of entrances, large doors, slides, lifts, toilets, etc.

1 Introduction

PALIO (Public Access to Local Information for Tourists) is funded by the European Commission as an “Information Society Technologies” project under IST 20656 0. Aim and ambition of the PALIO project is to provide new information services, directly available for tourists and citizen by developing and implementing complex data systems with user friendly and personalized interfaces. The design of PALIO services is driven by the combination of some new concepts as: personalisation, localisation, accessibility anytime, from anywhere and with any communication technology in real-time interaction. These objectives will be gained through the development of some technological and service innovations in particular:

1. Integration of mobile and fixed telecommunication networks;
2. Methodologies and technologies for the design of scalable and personalized access to information and services;
3. Tools for service personalisation and for interaction through mobile and portable terminals.

PALIO is sensitive to the tourist needs and makes the organization of touristic stays easier. The system offers services like information on how to move in a visited town, gives hints about available accommodation, parking lots, tourist guides, restaurants, museums, cultural events etc. A certain part of this information is especially related to

disabled tourists, e.g. about places which have easy accessibility in terms of entrances, large doors, slides, lifts, toilets, etc.

Thus, in PALIO corresponding content adaptations to serve the special needs of disabled and elderly tourists will be based on context-sensitive and process-oriented knowledge. Central for the design of adaptations based on context-sensitive process-oriented knowledge is the *Basic PALIO Tourist Scenario Framework* and the behavioural means-end approach underlying the *PALIO basic user model*.

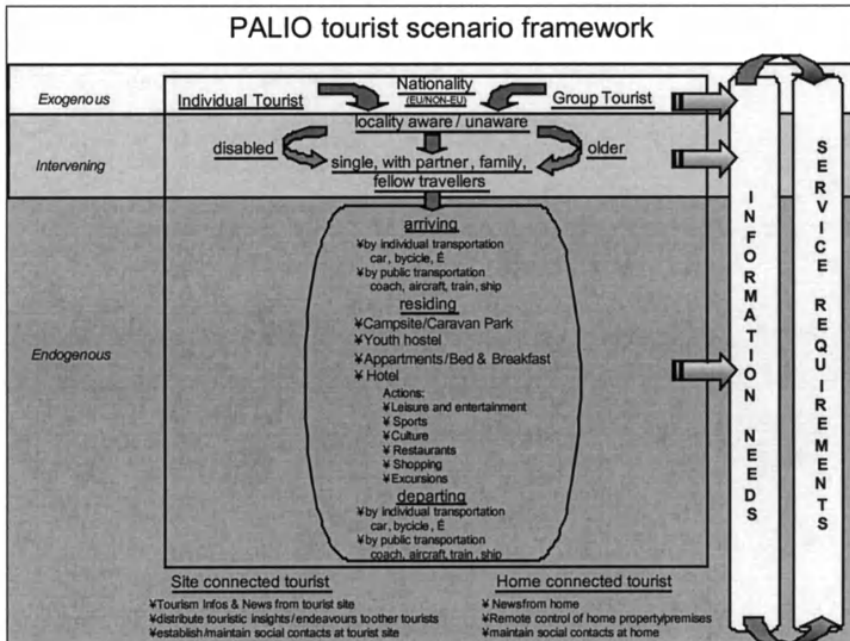


Fig. 1. Basic PALIO tourist scenario framework

2 The Basic PALIO Tourist Scenario Framework

The Basic PALIO Tourist Scenario Framework comprehensively describes distinct touristic situations. It thus forms the basis for deriving numerous information needs of tourists in distinguishable touristic situations and corresponding service requirements including situatively meaningful user interface adaptations and accessible hardware devices.

The framework differs between exogenous, intervening und endogenous dimensions of distinguishable scenario descriptions. Rules for content related adaptivity features for the PALIO adaptivity module may be inferred from the modifiable interplay between the *exogenous* variables, its *intervening* attributes and the *endogenous* impacts on certain scenarioclusters. E. g., it makes a difference

whether locality unaware individual tourist arriving with his family needs information on the best suited hotel accommodation or whether a single tourists, who is by the way locality aware because he visited the tourist site before needs the same information. Content adaptation has to take these differences accordingly into account.

3 The PALIO Basic User-Model

The *PALIO basic user model* conceptualises a tourists’ information processing behaviour in terms of so-called behavioural means-end analysis. Basically behavioural means-end analysis states that tourists in certain scenario based situation perceive a limited set of means or better optional action alternatives A_1 to A_n to reach out for certain touristic ends or better touristic purposes or objectives O_1 to O_n . According to certain preassumptions optional action alternatives are cognitively rank-ordered by their assumed utility value to reach certain objectives. This valuation V_{11} to V_{nn} has to be regarded as being *subjective* in the sense, that at least initially not all objectively available action alternatives or objectives are comprehensively taken into account by a tourist. In this context learning by incrementally accommodating to an initially insufficiently known touristic environment contributes to comprehend this view in an ever more distinctive and exhaustive manner. This shall be supported by corresponding content adaptations making PALIO reacting like a recommender system according to rules to be derived from the already mentioned interplay of the exogenous intervening and endogenous dimensions of the Basic PALIO Tourist Scenario Framework.

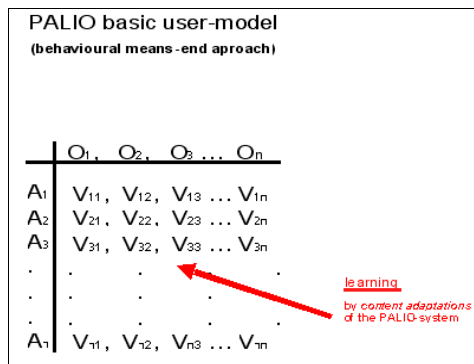


Fig. 2. PALIO basic user-model

The behavioural means end approach of the *PALIO basic user model* serves as a conceptual tool to derive rules for adapting the PALIO user interface to personalized information needs of tourists (see example in section 3.2).

3.1 Differential-Dynamic Adaptation

With regard to the mechanisms of the Basic Palio Tourist Scenario Framework some exogenous variables and different intervening variable attributes shape the so-called *differential dynamic valuation* about what measures have to be taken to reach the mentioned purposes or objectives. On the exogenous dimension distinctions between individual tourists, group tourists and the tourists' nationality are important under these circumstances. On the intervening dimension it may be important whether the arriving tourist is disabled or an elderly person, whether he or she is locality aware or locality unaware.

A locality aware individual tourist maybe able to take a public bus. Individual tourists so ever who are disabled or older generally prefer door to door transportation by taxi cab. A group tourist instead who is disabled or an elderly person will most probably be picked up by special transportation from his hotel.

These conventions and many more can be defined as so-called *differential dynamic adaptivity* rules by applying the behavioural means-end approach of the *PALIO basic user model* to the Basic PALIO Tourist Scenario Framework.

3.2 Sequential Hierarchical Adaptivity

In contrast *sequential hierarchical* adaptivity to be derived from the PALIO basic user model simply refers to the fact, that certain touristic objectives or purposes are hierarchically subordinated in a way that they can only be reached by a certain sequence of means or actions to be taken. E. g. the general objective of a tourist arriving by aircraft to reach his or her hotel as soon as possible can only be reached if first of all he or she passes passport control to get the luggage to be finally able to pass the customs clearing. These kinds of hierarchically sequentialized action-chains have also accordingly to be taken into account for designing adaptive dialogue features of the PALIO system.

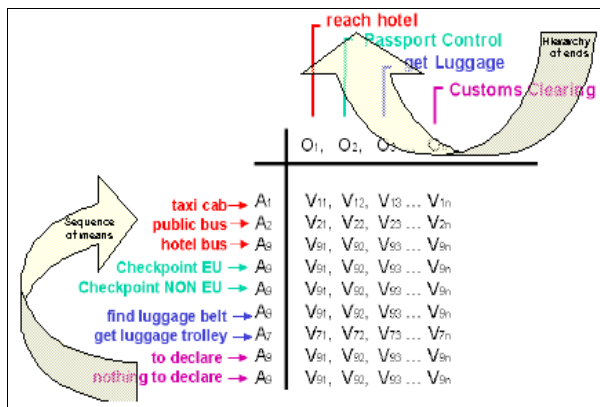


Fig. 3. Sequential hierarchical adaptivity

4 Scenario Descriptions for Content Adaptation

Because especially content – and only to a lesser extent device- – adaptation is a prerequisite of user-interface personalization it is – so to say – in the nature of user interface adaptation, that there will never be a systemized and exhaustive list of at all possible adaptation features in terms of individualized Human-Computer Interaction. *Individualization* conflicts with an apodictic overall *standardized framework* of possible adaptation features. That is why details of content adaptation can only be circumscribed by scenario examples taking into account the actual use of adaptive systems in different contexts and processes of use, especially if the disabled and elderly are affected. However, at least if it comes to the software/technological realization of personalized content adaptations the software applied for personalization can be systematized in terms of the techno-logical architecture underlying the unlimited variety of personalized information needs and corresponding services.

The following examples illustrate some context-sensitive (e.g. establishing a sightseeing interest sphere) and process-oriented (e.g. looking for accommodation) real life scenarios related to motor-impairment¹ which have already prototypically been implemented on top of the LDAP Dynamic Personalization Server (DPS©) - a trademark of PALIO's subcontractor HUMANIT – which serves as the development platform for the so called “PALIO ADAPTER” module. With regard to these examples user-based personalization of the DPS©-based “PALIO ADAPTER” is based on four techno-logically distinguishable layers of content adaptation...

- triggered by individually set Defaults
- by Frequency Stereotyping
- through Stereotype Definition by Collaborative Filtering
- through Stereotype Enrichment by Collaborative Filtering

4.1 Content Adaptation Triggered by Individually Set Defaults

When logging into the PALIO system for the first time each user is asked to specify a personal user profile by being asked for certain demographic user characteristics like age, gender etc.). Accordingly PALIO user Hans Smith, who is a wheelchair driver adds this characteristic remark about his individual disability to his user profile.

This causes the DPS in a first step to search the overall taxonomy of attributes for all attributes which are of relevance for a handicapped tourist and have this special

¹ Inferential analysis, which was performed by the PALIO predecessor project AVANTI (“Adaptive and Adaptable Interactions to Multimedia Telecommunications Applications”, AC042, partially funded by the European Commission [DG XIII]) factoring disability features (three levels: visual, motor, others) with regard to tourist behaviour revealed a constant pattern of differences between motor and visual disabled:

- Motor disabled people travel more often.
- Motor disabled people travel more frequently with their friends.
- Motor disabled people are more inclined to use travel agencies and associations they belong to as a source of information.
- Motor disabled people require much more information than other disabled people.

information available for Hans Smith whenever he is asking for contents which contain additional information for the handicapped. In the PALIO DPS taxonomy this additional information is amongst others available for the content subdomains accommodation and restaurants (see fig. 4)

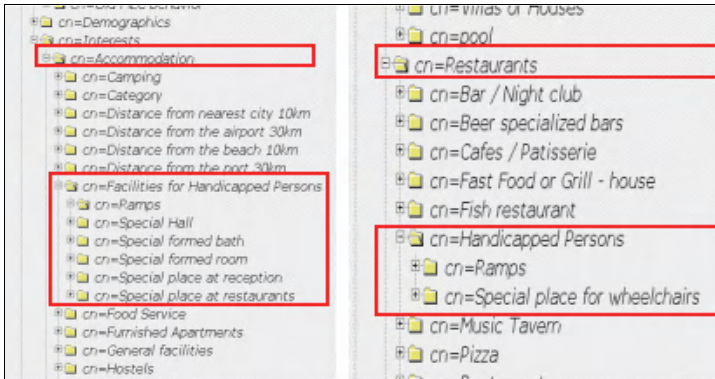


Fig. 4. DPS taxonomy section for default triggered Content adaptation

4.2 Content Adaptation by Frequency Stereotyping

So called Frequency Stereotyping causes the DPS to have additional special information available for a tourist user, whenever he or she has to a certain extent (for which a certain threshold value can be specified by the DPS administrator) asked for this information in previous dialogues with the PALIO system.

If, for instance, in the above example wheelchair driver Hans Smith would not have explicitly specified his disability whilst setting up his user profile in the login-dialogue, PALIO would well have been able to implicitly infer this attribute from statistical frequencies resulting from having repeatedly asked for corresponding special needs information.

4.3 Content Adaptation and Stereotype Definition by Collaborative Filtering

Content Adaptation by collaborative filtering causes the DPS to look for tourists with similar interests on frequency based correlation statistics with which they request certain touristic information.

In terms of scenario descriptions it might be reasonable to assume, that according to his physical disability tourist Hans Smith might be less interested in visiting beaches or caves during his vacation. Instead he might be more interested in sightseeing, and that ever more if he can assume that the sites he wants to visit are in general accessible for wheelchair drivers.

The following figure indicates that PALIO users Sabrina and Hans have the most common interests in sightseeing ancient Greek and Roman monuments, whereas Ellen

and Mike are obviously more interested in sunbathing and swimming at a beach (see fig. 5).

	Greek Sites	Beach	Caves	Pizza	Roman Sites
Sabrina	0,9	0,3	0,1	0,3	0,9
Ellen	0,2	0,9	0,9		0,2
Mike	0,1	0,7	0,3	0,2	
Hans	0,8	0,2		0,4	0,9

Fig. 5. Stereotype Definition by Collaborative Filtering

Accordingly PALIO will implicitly infer that whenever out of their common interest sphere Hans or Sabrina request *either* Greek *or* Roman Site monument information they are interested in the non requested part of their common interest sphere as well. Thus, anytime Hans or Sabrina are requesting certain content attributes out of their common interest sphere in sightseeing *either* Greek *or* Roman Monuments, this will cause PALIO to offer the non requested complementary information of their spreading interest sphere in addition.

4.4 Content Adaptation and Stereotype Enrichment by Collaborative Filtering

This will also take place, if statistical frequency measures for certain attributes of a content subdomain are missing, either because – due to a lack of awareness about this content attribute - the frequency of explicit requests for these attributes is zero or

	Greek Sites	Beach	Caves	Pizza	Roman Sites
Sabrina	0,9	0,3	0,1	0,3	?
Ellen	0,2	0,9	0,9		0,2
Mike	0,1	0,7	0,3	0,2	
Hans	0,8	0,2		0,4	0,9

Fig. 6. Stereotype Enrichment by Collaborative Filtering

below the specified threshold value. Under a ceteris paribus condition PALIO may then assume Sabrina’s interests in Roman Sites as being similar to Hans’ interest in Roman Sites.

As a result, by matching her incomplete sightseeing interest profile with the otherwise most similar interest profile of Hans, Sabrina’s individual interest profile will be enriched by a second frequency peak for Roman Sites (see fig. 6).

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Web Site Accessibility Auditing Tool for Visually Deficient Persons OCAWA

Denis Chêne¹ and Michel Hoël²

¹France Telecom R&D /DIH/UCE 38-40 rue du Général Leclerc 92794 Issy les Moulineaux
Cedex 9, France

denis.chene@francetelecom.com

²Urbilog, 42 rue Fénelon 59000 Lille, France
m.hoel@urbilog.fr

Abstract. Accessibility to the Web for the blind and visually impaired is an issue that has become more significant since the introduction of direct manipulation interfaces. The problem can be approached with respect to two complementary points of view : it is possible to act at the beginning of the process, during the creation phase of web pages or it is equally possible to act at the end of the process, on the web pages that already exist. Our contribution to the subject of accessibility is based on the latter point of view. In this document, we will describe an accessibility evaluation tool with a corrective function, based on the following principles : the implementation of a syntactic analysis of html pages, the execution of a first series of accessibility rules based on the document generated by XML, the execution of a second series of more complex rules with the ability to be enriched by the rule server, the production of a report adapted for the user and the continual management of the implementation phase.

1 Graphics and Accessibility

In the past, the web was accessible to the blind and visually impaired due to the fact that the majority of pages consisted of text. Command line interfaces, of ms-DOS type, were and still are generally accessible as they are based on a purely textual interaction. On the other hand, these interfaces are not at all suitable for the general public as they require extensive training to use, an issue that concerns all command language systems.

An event which has affected both the web, or interfaces in general, has been the introduction of graphics for interfaces (Graphic User Interface), which for the sighted, has been a significant step forward in usability.

When the interfaces WIMP (Windows Icons Menus Pointer), are used in an intelligent way, there are very practical and intuitive for those with the ability to see. For a person endowed with sight, what is more natural than selecting an object in order to use it. On the contrary, for the blind or visually impaired, what is more inaccessible than an interface where it is necessary to pinpoint an object in order to use it.

Consequently, the only part of graphic interfaces generally accessible, is the part concerning expert users : these are the short cuts available through the keyboard. However, not only are these hot keys sometimes non-existent but when they do exist, the list of available hot keys is not always easily accessible. This is the case, for example, with the interface of mobile phones, where the hot keys are listed in the instruction manual.

Interfaces and the web in general, are becoming more and more graphically orientated. A telling example of this movement is illustrated by the html editors.

Before now, the code was written from a simple text editor, whereas at the present time, WYSIWYG tools are readily available. This has a clearly positive aspect as everyone is able to create and share information at a global level without having a very detailed knowledge of the language. However, at the same time, this tool does not comply with the structure of an html page, which can prove to be disastrous. For instance, it is possible to find on the web a "Title" format used to highlight a word within a paragraph of text. This practice does not help the visually deficient to have a clear vision of the structure of a document. As html language is already very tolerant, the editors must take when formatting it.

2 Accessibility, Before or After?

Stephanidis states that "Universal access to computer-based applications and services implies more than direct access or access through add-on (assistive) technologies, because it emphasizes the principle that accessibility should be a design concern, as opposed to an afterthought." [6]. We are headed in this same direction and stress that the best way to prevent such a practice from being carried out, is to control it during the creation of the web document or, more globally, of the interface. It is an area that we are exploring, with an more or less long term impact.

Another way of acting, in shorter terms this time, is to place oneself at the conception stage. Admittedly, this type of reactive approach is no longer considered suitable since a evaluation of an interface, in hindsight, is not always welcomed by the developer. In addition, this type of approach is inadequate if we take into account technology which has developed at a rapid rate in recent years, such as mobile phones or other personal digital equipment. The changes are so fast that a corrective evaluation would be groundless, seeing that a new product would be launched before the completion of the evaluation.

However, we are operating in the specific field of the web which is already well-established : the contents already created are considerable and developments are fairly restrained. It is clear that a corrective evaluation tool has a place in such a context.

Tools of this type already exist (Bobby, W3C html validation service, CSS validator, A-Prompt [11, 12, 13, 14]), however they only partially fulfil their role as corrective evaluators. The number of rules that they take into account are limited, the recommendation of corrections issued are not specific to different members of the public targeted as potential users (manager and developer), and targeted interfaces (Braille, vocal or screen reading). Therefore, this type of tool is limited to the web domain and mobile interfaces, which have other constraints, pose similar problems. These are, of course, new interfaces and interfaces of the future, however WAP compatibility, for example, should not be neglected [3]. Thus, we are proposing a new

tool, able to integrate new rules with ease and capable of handling a large number. The specifications concerning this tool are defined hereafter.

3 OCAWA

The objective of the Ocawa application is to analyse HTML type files in order to create, based on a certain number of established rules (WCAG/WAI rules, INOVA rules, FTR&D rules [1, 4, 7, 8, 9, 10]), an audit report regarding elements which cause problems or that may cause problems for an individual with a visual handicap. The elements to distinguish are the following : a syntactic analysis of the html web page, a first application of the basic rules at the XML format level, a second application of more complex rules with the help of an inference engine, a module which allows the management of these rules, a module which allows the reporting of the analysis carried out and the management of the operations executed.

3.1 Collecting HTML Flow

It is difficult to content oneself with the recovery of a HTML stream by simply subjecting an Url to a web server. In effect, the most complex parts of a web site, for example its service section, impose full HTTP access, in order to generate the HTML stream expected.

For example, if the net surfer wants to order a service on the site, he can be asked to identify himself and, following verification, he can be given a session number (often by using cookies) that must be recalled each time a request is made. Of course, it is the brother that is responsible for this function.

Another example is the subscription by the user and the subsequent request to complete a detailed form. In this form, the keying in of data in a certain number of fields is required. After the submission of the form, the server reacts differently depending on whether the supplied information is correct or not. However, the level of accessibility to the responses given by the server is often neglected;

A final example is the need to take into account the restrictions imposed by Proxy services which are often used in companies.

All these examples demonstrate that if we wish to measure the accessibility of a site, it is imperative that we respect the exchange between customer mail and server from the outset. This is the role of the function "HTTP brother".

3.2 HTML Syntactic Analysis Using TIDY

The WBC has made software available which permits the analysis (even the "repair") of an HTML file. This analysis, among other things, takes into account certain WCAG/WAI rules.

The Tidy programme operates by providing its guidelines via a configuration file. This file defines the "configuration rules".

Using an HTML type file and analysis configuration files, the TIDY module is responsible for providing a summary of the faults or errors encountered. In the

occurrence of an error, the audit of the HTML flow is interrupted. Errors will occur when the pages analysed are not readable by the browsers.

We will thus consider that the analysis will continue only with or without "Tidy warnings".

The second phase for this module will be the generation of initial statements in terms of an inference engine based on a certain number of warnings.

3.3 HTML Syntactic Analysis

As Tidy does not recover all the original file contents in the case of any problems, by "repairing" the faults encountered, an overall analysis with our own rules must be allowed using the original HTML streams. However, in order to allow for the application of the XSLT transformation rules, the entry streams must be in "well-formed" XML format.

Therefore, the HTML streams must then be transformed into, at least, XML of HTML streams. To accomplish this, we will use an HTML parser whose only role will be XML transformation by applying to it certain "grammar rules".

These rules will be of two types:

Detection of the indicators which never close and modifying the syntax to close them.

Detection of the unclosed indicators and closing them at the correct moment.

To guarantee a reliable transformation, we need a complete HTML syntactic grammar which will assist us in the construction of the HTML information stream tree, and to then go back through the tree and transform these streams into "well-formed" XML standards.

3.4 XSLT Engine

The Saxon or Sablotron permits the execution of an XSLT source within an XML file.

The XSLT rules file permits fact generation for the inference engine for all the remarks found by the XSL rules. These XSL rules will be primarily the application of the WGCA 1.0 standard (WAI recommendations : the Directives for the accessibility to Web contents).

3.5 Management of Analysis Rules

This management is based on the rules of the inference engine.

The module using the inferencing engine permits the execution of associated rules to the initial facts generated by the XSLT engine. The resulting file will be in XML format and catalogue all the facts encountered in terms of audit.

3.6 Module Reporting

The XML fact file will allow the generation of a site audit report in function of the mission entry parameters : initial HTML page, depth of analysis type page searches

(WGCA priority level). According to the confirmed facts, the report can provide advice and measure the accessibility situation of a site in the «Web Access» sense. Different formats can be issued : HTML, PDF, RTF.

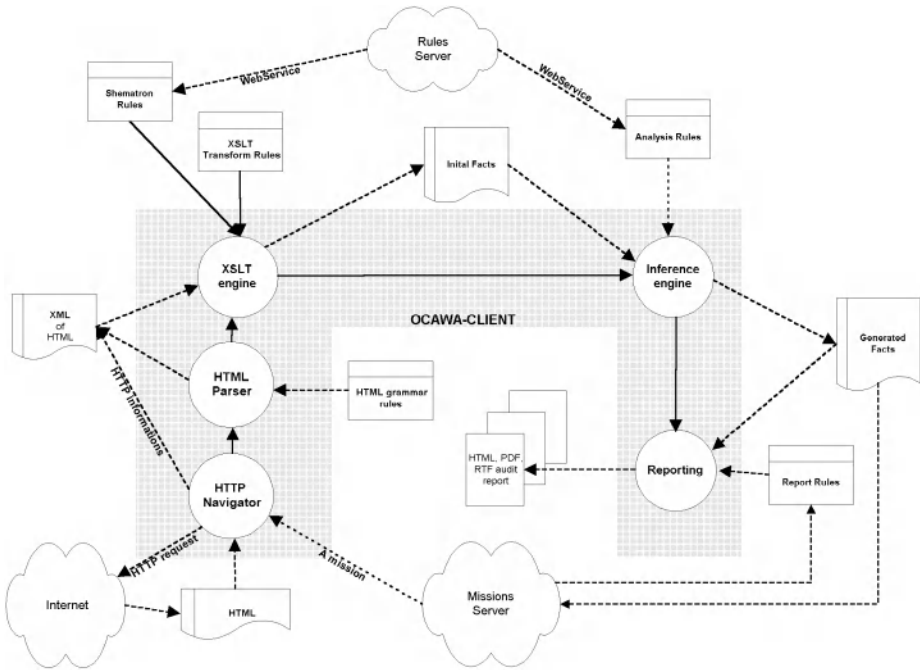


Fig. 1. Functional chart of OCAWA

4 Conclusion

Just as the developer is the person most apt to grasp the subtleties of a functional chart, an ergonomist is the person most capable of supplying ergonomic expertise, and a blind or visually impaired ergonomist is the most suitable person to provide expert knowledge on accessibility. Therefore, this tool is also intended for use by blind or visually impaired experts, such as the Association Braillet [5]. This tool will clearly allow them to perform accessibility tests more effectively by automating numerous procedures (for example, counting the number of hyperlinks per page). During the conception of this programme, everything was anticipated for it to be accessible to blind or visually impaired users. Regarding this issue, there remains certain adjustments to be made. The crucial matter is of it being a tool “for all”. Its modular appearance certainly allows it to transform and/or adapt certain aspects and to add functions; eventually it could even be a web tool capable of co-operating with other expert tools.

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13. CSS validator: <http://www.jigsaw.w3.org/css-validator>
14. W3C HTML validation service: <http://validator.w3.org/>

User-Centered Interface Design for Disabled and Elderly People: First Experiences with Designing a Patient Communication System (PACOSY)

Andreas Holzinger

Institute for Medical Informatics (IMI), Graz University Hospital, Engelgasse 13,
A-8010 Graz, Austria
andreas.holzinger@uni-graz.at

Abstract. At the clinical department of Oncology at the Medical University Hospital in Graz, a pilot system for an interactive patient communications system (PACOSY) was examined. The patients are able to retrieve and enter information interactively via a touch screen panel PC connected to the Hospital Intranet. The Interface is designed for patients with little or no computer experience (i.e. people with a low computer literacy or patients with visual impairment and/or restricted motoric ability). This paper reports on the selection of a suitable hardware and on first experiences during the User Centered Design (UCD) and in particular gives insights into problems discovered during experiments with elderly people.

"Programming is such a difficult and absorbing task that it dominates all other considerations, including the concerns of the user" (Alan Cooper, 1999, [1]).

1 Introduction

The pilot system of an interactive patient communications system (PACOSY) was developed at the Institute for Medical Informatics (IMI). The User Centered Design was developed with patients of the clinical department of Oncology at the Medical University Hospital in Graz.

1.1 Terms of Reference

The system is primarily designed for elderly and/or disabled patients. A stable system, designed to return to a defined initial state on exiting, was a compulsory prerequisite. No special precautions were taken to avoid deliberate vandalism.

An interactive questionnaire is completed by the oncology patients immediately on arrival in the Oncology Department and particularly asks about their psychological state of mind. From the viewpoint of the departmental psychologist in charge the objective is a screening: on the basis of the responses the psychologist is able to build

an opinion as to the necessity of immediate support etc. Up to the present an ordinary paper and pencil questionnaire was used. Investigations on comparisons between conventional usage of paper questionnaires and computerized versions (e.g. from Peterson & Johannsson (1996), [2]) showed that computerized versions could be advantageous. An automatic alert is being considered, either over the network and/or in the form of a screen output and/or on the mobile phone of the psychologist in charge, and will be implemented in a further implementation level. The patient is not supposed to fill in the questionnaire anonymously (for identification) but during the filling in confidentiality is necessary to inspire trust, for example, no one else should be able to see the screen. Special concern was given to the navigation through the questionnaire (cf. Nielsen (1990), [3]) and the simplicity of the user interface.

1.2 Technological Requirements

The solution was preferably near standard, scalable, and cheap within the Hospital Intranet. The same software supports touch screen and mouse alternatively. Extensive use of the hospitals standard equipment (PCs, Microsoft-Windows, MS server) was used as far as possible. In the future this solution should be adaptable to other clinics with a minimum of technical expenditure, that is, the expenditure has to be primarily targeted at flexible content, involving minimum or preferably no supplementary programming. The most important objective was maintainability of the content by clinic personnel (secretary etc.) with a minimum maintenance requirement.

Basically, the system was constructed to act as a client server system. The client connects, using a standard browser (in the hospital mainly MS Internet Explorer) via a TCP/IP connection to the server within the Intranet. The client requests the Webpage from the server. The communication between client and server is defined by HTTP (Hyper Text Transfer Protocol). The server sends the response in the form of HTML (Hyper Text Markup Language). The browser interprets the HTML correspondingly and displays the page graphically.

2 Touch Screen Technology

The first step was choosing the right hardware technology. Several experiments were carried out to find the most suitable equipment. The central component of the system is a touch screen. Each touch screen system includes three components that can be configured in various ways:

1. Sensor touch screen which serves as the user interface;
2. Controller, which processes the signals from the sensor screen and passes the event data to the computer; and
3. Driver software, which makes the touch screen compatible with the local operating system.

There are several different types of technology employed by the touch screens on the market today; resistive, capacitive, surface acoustic wave and infrared light. The technical constraints that limit the development and deployment of these touch screens are very specific to each type. In general, these constraints deal with factors such as the clarity of display, the specifics of the interaction with the touch screens,

and the maintenance of the touch screen equipment. Because of such constraints, touch screens' deployment is limited in/to certain environments and in specific manners (Holzinger (2002), [4]).

1. Resistive: A mechanical pressure on a resistive touch screen closes an electrical contact between two conductive layers. Since the pressure only sets up a connection between the two layers, the resistive touch screen can be activated by any solid object: a gloved finger, a pencil etc. This technology is used mostly in, for example, Personal Digital Assistants (PDAs) e.g. the Psion and Palm. Advantages include no alignment (justifying) is necessary, exact positioning, mainly used in the Medical field, i.e. use with gloves is possible;
2. Capacitive: A pane of glass coated with ultra-thin metal lies over the actual screen of a capacitive touch screen. From the corners of the display, a low voltage of alternating current, which creates a weak electrical field, is applied to the electrode grid of the conducting layer. When the user touches the screen they represent a form of condenser electrode and "ground" the area (field). From the (low) electricity, which is diverted around the users finger, the touch controller determines the respective coordinates of the contact point. Correspondingly, capacitive touch screens only respond to the touch with a conductive object (special metal pen, finger etc.). Advantages include higher resolution, higher light efficiency, not influenced by surrounding light; Disadvantages include that calibration is necessary and it is sensitive to errors from exterior influences.
3. Acoustic: Surface acoustic wave (SAW) technology. This technology is based on sound waves. The edges of the screen are equipped with ultra sound transmitters with reflectors at each opposite edge and a piezoelectric receiver in one corner. Ultra sound waves are continuously being sent across this reflector system. As long as this field is undisturbed the waves arrive without obstruction at the receiver. However, if the field is disturbed, through a finger, pen or similar, then the position of this object is determined from the missing wave course within this field.
4. Light: Infrared touch screens with infrared technology work, on principle, as light barriers. The infrared senders and infrared receivers in the screen frame build up a light grid, which is invisible to our eyes. If this grid is disturbed by a finger or other object, the sensor electronics detect the appropriate x and y coordinates of the contact point by means of the missing rays. Advantages include no light reduction of the screen, no wearout failure; Disadvantages include interference sensitivity (reacts on approach), resolution is low, position errors with convex screens.

3 User Centered Design

Involving the users in our design process from the outset was a primary concern, to understand how our users work and to provide a system, which is easy and pleasant to operate, with no learning effort.

We first discussed the system with the people involved i.e. the clinical psychologist who expressed her demands of what the system should do. In a requirement analysis a verbal description of the system emerged. First, screen designs and dialogues were sketched on paper. The second step was a paper prototype mock-up, which was further adjusted working with the psychologist. The use of the paper mock-up provided a first usability feedback with minimum effort and maximum feedback.

Further, a first working prototype was tested before the implementation of the final design, which was used for the user-studies.

Our core philosophy during the design was a minimalist design following the *less is more* principle: irrelevant information distracts.

4 Methods Used

Thinking aloud: According to Nielsen (1993) the method of thinking aloud allows us to understand how the users approach the interface and what considerations the users keep in mind when using the interface [5]. During the test procedure the users are asked to verbalize and describe their thoughts, feelings and opinions while interacting with the system. Although the main benefit of the thinking aloud protocol is a better understanding of the user's mental models and interaction with the touch-screen system, there are other benefits as well. For example, the terminology the user uses to express ideas or functions should be incorporated into the system design [6].

Questionnaires: These are generally an inexpensive way to gather data and allow a quantitative analysis of the results. A well-designed questionnaire, that is used effectively, can gather information on both the overall performance of the system as well as information on specific components of the system. Including demographic questions about the participants, they can also be used to correlate performance and satisfaction with the test system among different groups of users. According to our special target population we paid special attention to the order of the questions and kept it as short as possible [7], [8].

Qualitative interviews: Although interviews may be capable of discrimination from questionnaires in terms of their degree of formality they should not be considered less important. Instead, they should be used in a manner that makes the best use of their respective strengths. Rubin (1981) suggests that interviews are used at the beginning and end of an evaluation, initially to gather general information to form the basis for a questionnaire and afterwards to clarify its results and fill in gaps. However there are no absolute rules for the use of questionnaires and interviews, as with most human factors research, it depends very much on the circumstances and the type of system being evaluated. In many respects, within the context of a usability evaluation, the choice between structured interviews and directly administered questionnaires is likely to be determined by cost and convenience. The evaluator has to make a decision based on knowledge of the domain and of the advantages and limitations of the two techniques as discussed in the following sections [9].

5 Experimental Setting

12 patients of the Oncology Department took part in the first experiments on an anonymous and voluntary basis. 70% were female. Their ages ranged from 60 to 82 years. All of them had absolutely no computing experience. The attending clinical psychologist selected these people, arranged the appointments and provided them with information about the broad aim of the experiments. It was their first time

operating any touch-screen system. The first tests were conducted in German and consisted of four parts:

1. Briefing Interview: Introducing the test person to the aim of the experiment. Explaining the experimental setting and the sequence to follow. Obtaining permission to use video and audio recording and take pictures during the experiment.
2. Pre-Test Questionnaire: Collecting background information (as mentioned before e.g. age, experience with computers, etc.) by using a written questionnaire.
3. Running Test: The test person was asked to follow the sequences on the touch-screen and to think aloud about what s(he) is doing at every moment. The aim of the thinking aloud procedure was explained again but no further instructions as to how to use the touch screen were given. Video and audio recording was running and written notes were made.
4. Post-Test Questionnaire: Collecting information by using a specially designed questionnaire (see below).
5. Debriefing Interview: Finally we let the person summarize their impressions and feelings during the test.
6. Closing: Thanks were given to the test person and some information about the ongoing process and how important the input of the test person was.
7. According to Christensen (2001) this design can be used to provide some interesting information, although one should remain constantly aware of the possible confounding extraneous variables that can jeopardize the internal validity, [7].

6 Findings

Generally: According to Greenstein & Arnaud (1988) the most obvious advantage of touch screens is that the input device is also the output device [10]. Due to the use of direct eye-hand co-ordination, the operation of our system was easy for all of the examined patients. According to Srinivasan & Basdogan (1997) being able to touch, feel and manipulate objects on a computer screen, in addition to seeing and hearing them, provides a sense of immersion.

Touch Screen Technology: Because of the rise in demand for touch screens, more and more touch screen providers are emerging. Almost all of these companies sell integrated touch screen systems as well as components that can be added to non-touch screen monitors to convert them into touch screens. Based on the results of our examinations we decided to rely on a Panel solution and excluded whole Kiosk-Systems due to the fact that they are too heavy and unwieldy. The resistive technology was not suitable due to the disadvantages: unfocused, low brightness, and the monitor is less durable. This technology, determined by the number of layers applied, has less brightness and less focus. For example, if a normal LCD monitor has a brightness of 200 cd/m², then the LCD monitor with surface wave technology lies at 185 cd/m² and our five-wire resistance monitor had less than 150 cd/m² which was too less. Since the brightness must constantly be turned on fully the durability of the monitor is less. A model with capacitive touch screen had more than 200 cd/m², which is sufficient. The surface acoustic wave technology proved to be the most usable technology in our case due to its single glass panel and highest clarity. Its drawback is

that it is affected by contaminants on the screen, which absorb the waves and cause dead zones. Also it is not very flexible, in order for an acoustic wave to be sent, the screen must always be touched with a finger; something hard like a pen did not work, although this was not critical in our case.

Viewing Angle: The Viewing Angle proved to be highly important and differences caused adaptations, which are very disturbing during the experiment [11].

Content: The use of a thermometer scale (fig. 1) instead of a typical ranking scale to measure the emotional strain proved to be effective. The patients reported that they want a feedback in two ways: Having the input acknowledged by presenting a "tock" sound and setting the thermometer to the selected value by marking it in the same way as a thermometer mercury column (see fig. 1):

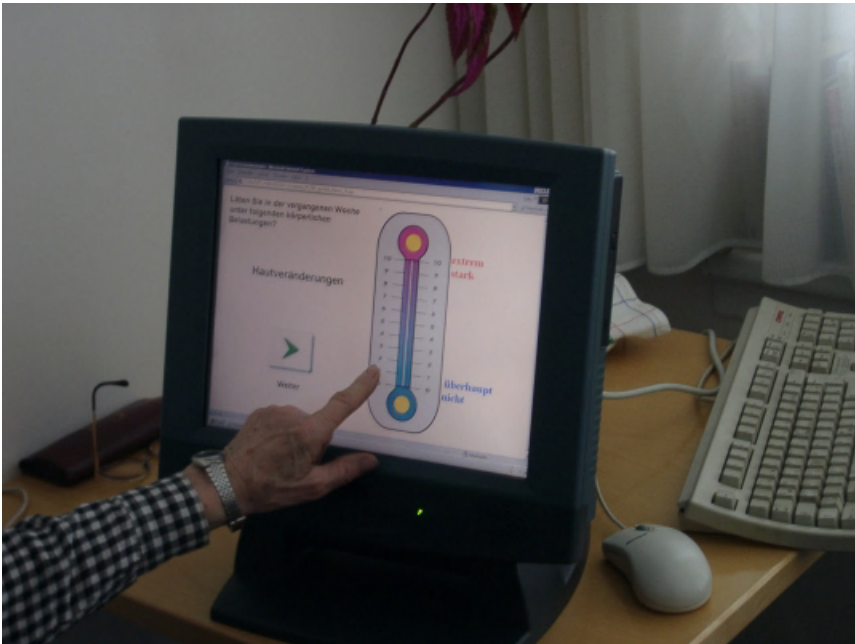


Fig. 1. The thermometer mercury column indicated the patient's emotional strain

Content Problems: Text intended only to give information to the user was unclear in the first cycle and was further simplified. The legibility of text was a crucial factor from the beginning. Some patients often had problems to decide which value they should assign to a specific question.

Design Problems: After clicking the thermometer the patients often think, that everything is done on this page. They see the reaction of the thermometer and are satisfied because the system has responded to their action and wait what happens next, instead of pressing the Next-Button. Sometimes the patient complains about a false value in the thermometer, commonly one point too much or too few. Patients are not sure what to do when they would answer the question with "absolutely not", or none or anything else. After proceeding to the next page the patient thought that it is

the same again. Pages with decision questions (button A – button B) are confusing, especially if both are not corresponding to the patient's situation.

7 Future Outlook

At a further implementation level a generally usable Software/Hardware solution for patients on a variety of different terminals is supposed to be implemented (a possible application both in the Graz University Hospital and in all Styrian County Hospitals). Patients can for example gather information about the department, their illness, therapy and so forth, with the possibility of providing feedback: Questionnaires, contentment, concerns etc. or for example simply the ordering of menus. Qualitative studies concerning what kind of information patients would prefer are necessary to gain further insight [12], [13]. Perhaps even surfing on the Internet will become possible for elderly and/or handicapped patients. Such simple, cheap and easy-to-use solutions can be according to Stepanidis & Savidis (2001) a step further to the information society for all where all people can have access to information [14].

8 Conclusion

Generally: Most of the patients reported that they "liked this kind of computer" and all patients who have never used a computer before found that touch screen interface simple to use.

Touch screen: Many different hardware solutions were examined including whole Kiosk systems, but the favorable hardware solution was a Panel-PC. Due to a brightness of less than 150 cd/m^2 the resistive touch screen was not sufficient. Although the surface wave technology was a solution, they were easily affected by contaminants on the screen. Finally a capacitive touch screen with more than 200 cd/m^2 was sufficient. Special care must be given to the viewing angle, which caused some trouble.

Content: To make it easier for the patient to quantify the answers it is intended to provide a concise on screen help system on demand.

Design: The User Centered Design proved to be a suitable method to design the system which must be simple and easy to use, according to the proverb: *less is more*. The patients reported the design of the buttons as being satisfactory in shape, color and size. Additionally they wished to have an audio feedback to confirm the given input. It's a problem for some patients that they have to click <Next> after pushing the thermometer value. One solution would be a timeout if the button is not pressed and a replacement of the button.

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The Disappearing Computer: Emerging Opportunities and Challenges for Disabled and Elderly People

Constantine Stephanidis^{1,2}

¹ Institute of Computer Science
Foundation for Research and Technology - Hellas
Science and Technology Park of Crete
GR-71110, Heraklion, Crete, Greece
cs@ics.forth.gr

² Department of Computer Science
University of Crete

Abstract. The emerging technological paradigm of the Disappearing Computer, which is anticipated to radically change the nature, scope, and interactivity of Information Society Technologies, will bring about new opportunities and challenges for the development of an Information Society acceptable by all citizens, including disabled and elderly people. This paper will discuss some of the most important issues in this respect under a Universal Access perspective.

1 Introduction

Computing technology evolves rapidly, and each generation of technology offers new opportunities to improve the quality of human life. The target user population addressed is broadening, the availability, type, functionality and content of new products and services is expanding, and access technologies are being diversified. At the same time, however, each generation of technology has the potential of introducing new difficulties and barriers in the use of products and services - and eventually in everyday life, new risks for the health and safety of people, and new forms of social exclusion and discrimination. Both opportunities and challenges are particularly relevant for disabled and elderly people. Human-Computer Interaction (HCI) is one of the key factors towards ensuring social acceptability of computer-based products and services, as users experience new technologies through contact with their user interfaces. In this respect, HCI plays a critical role and is continuously called upon to face new challenges.

In the years ahead, as a result of the increasing demand for ubiquitous and continuous access to information and services, Information Society Technologies are anticipated to evolve towards a new paradigm referred to as the Disappearing Computer, i.e., an environment characterised by invisible (embedded) computational power in everyday appliances and other surrounding physical objects, and populated by intelligent mobile and wearable devices [1].

As a result, the Disappearing Computer is expected to have clear and profound consequences on the type, content and functionality of the emerging products and services, as well as on the way people will interact with them, bringing about new research issues, as the dimensions of diversity currently identified in users, technologies and contexts of use will change radically, resulting in multiple new requirements for the development of Information Society Technologies. This technological evolution will inevitably need to be addressed in the broader context of developing an Information Society acceptable by all citizens. In this context, the notion of Universal Access is critically important. Universal Access implies the accessibility and usability of Information Society Technologies by anyone, anywhere, anytime [2, 3, 4], and aims to enable equitable access and active participation of potentially all citizens, including the disabled and the elderly, in existing and emerging computer-mediated human activities, by developing universally accessible and usable products and services, capable of accommodating individual user requirements in different contexts of use, independently of location, user's primary task, target machine, or run-time environment. This paper aims to discuss the anticipated opportunities and challenges that the Disappearing Computer will bring about for disabled and elderly people, and to identify some of the critical issues that will have to be addressed.

2 Emerging Opportunities

A detailed discussion of the emerging characteristics of the Disappearing Computer environment is provided in [5]. Here, the issues more relevant for the interaction and usage of the new environment by disabled and elderly people will be discussed.

Interactive Devices. The Disappearing Computer environment will be composed of multiple distributed processing and interactive units, will be capable of monitoring the user and will exhibit different degrees of intelligence. It will be populated by a multitude of hand-held and wearable "micro-devices", and computational power will be distributed in the environment (e.g., embedded screens and speakers, ambient pixel or non-pixel displays, smart clothing) [6,7]. Devices will range from "personal", carrying individual and possibly private information, to "public" in the surrounding environment. Devices will also vary in the type and specialisation of the functionality they offer, ranging from "personal gadgets" (e.g., wrist-watches, bracelets, personal mobile displays and notification systems, health monitors embedded in clothing), to "general-purpose appliances" (e.g., wall-mounted displays). As technology 'disappears' to humans both physically and mentally, devices will be no longer perceived as computers, but rather as augmented elements of the physical environment [8]. Personal devices are likely in many cases to be equipped with built-in facilities for multimodal interaction and alternative input/output (e.g., voice recognition and synthesis, SMS, pen-based pointing devices, vibration alerting, touch screens, input prediction, etc), or with accessories that facilitate alternative ways of use (e.g., hands-free kits), thus addressing a wider range of user and context requirements than the desktop computer [9]. At the same time, the way in which computing tasks are accomplished will un-

dergo radical changes. In the environment of the ‘invisible technology’, interaction will shift from an explicit paradigm, in which the users’ attention is on computing, towards an implicit paradigm, in which interfaces themselves drive human attention when required [10]. Moreover, the invisibility and complexity of distributed and dynamically defined systems will not allow humans to operate devices step-by-step towards the completion of a task. Rather, humans will manage tasks leaving the execution to intelligent computing units in the technological environment. Due to the combination of these intrinsic characteristics of the new technological environment, it is likely that the emerging forms of interaction, if appropriately designed, will have the potential of accommodating the requirements of disabled and elderly users, as well as of minimizing the effects of motor, sensory, cognitive and memory limitations [9, 11, 12].

Applications. A variety of new products and services will be made possible by the emerging technological environment, including “home networking and automation” (e.g., [13, 14]), mobile health management (e.g., [15, 16, 17]), interpersonal communication (e.g., [11, 14]) and personalised information services (e.g., [18]). Many of these applications and services are anticipated to address a wide variety of domains which are critical for disabled and elderly people. These applications will be characterised by increasing ubiquity, nomadicity and personalisation, and are likely to pervade all daily human activities. They will have the potential to enhance security in the physical environment, save human time, augment human memory and support people in daily routines and simple activities, as well as in complex tasks.

For example, in the healthcare domain, the technologies of the Disappearing Computer environment will have the potential to greatly contribute to improve services for everybody. Sensors measuring heart rate, blood pressure, etc, will provide the possibility of accurate and real-time control of the users’ state of health, and mobile communication devices will automatically dispatch emergency calls if necessary [16]. Portable positioning system (e.g., GPS) can also help in identifying the location of a patient, and various mobile communication devices can be used to obtain access to a patient healthcare record from anywhere and at anytime. The deployment of Telemedicine systems will also contribute to provide continued care and patient education, assist patients in taking medications, and improve healthcare delivery [16, 17].

In the home environment, the technologies of the Disappearing Computer environment will allow supporting or automating a wide variety of activities and tasks. For example, physical access can be facilitated through the automatic door opening on recognition of authorised people, making the use of keys unnecessary. “Smart” appliances can learn users’ habits, keep track of ongoing and planned activities (e.g., preparing meals, etc) and help their execution though reminding or suggesting steps [19]. At the same time, these technologies, through monitoring and alerting, can protect house inhabitants from accidents. In the open environment, new technologies and devices can provide support in orientation and navigation, notify the position of services, plan daily activities (e.g., shopping, visits), and deliver contextually relevant information through a verity of channels and modalities. Electronic transactions can replace the physical manipulation of money and the use of ATMs.

Furthermore, new devices can enhance interpersonal communication at any time, automate help requests, and allow monitoring in situations of illness or other problems. The combination of personal communication, security and access to integrative services is likely to offer important opportunities for social integration and independent living to disabled and elderly people [11].

3 Emerging Challenges

The Disappearing Computer environment, as briefly overviewed in the previous section, appears to offer a wide range of benefits for the disabled and the elderly. However, the anticipated enhanced, distributed and dynamic presence of technology anywhere and at any-time raises several issues, that need to be taken into account towards ensuring that the emerging potential is fully realised. These issues affect all phases and aspects of the development life-cycle of interactive applications and services. The most relevant of these issues, as far as disabled and elderly users are concerned, are briefly discussed below.

Interaction. Due to the intrinsic characteristics of the new technological environment, it is likely that interaction will pose different physical, perceptual and cognitive demands on humans compared to currently available technology. It is therefore important for ensuring access to these technologies by anybody, and in particular by disabled and elderly people, to investigate how human functions will be engaged in the emerging forms of interaction, and how this will affect physical interaction and an individual's perceptual and cognitive space (e.g., emotion, vigilance, information processing, memory). The main challenge in this respect is to identify and avoid forms of interaction which may lead to negative consequences such as confusion, cognitive overload, frustration, etc. This is particularly important given the pervasive impact of the new environment on all types of everyday activities and on the way of living. A first implication is that interactive systems in the Disappearing Computer environment must be capable of dealing in real time with the distribution of input and output in the environment [20, 21], in such a way as to provide humans with continuous, flexible and coherent communication [22], both with the environment and with others, by utilising proportionally all the available senses and communication channels, while optimising human and system resources. This implies an understanding of the factors which influence the distribution and allocation of input and output resources in different situations for different individuals, taking into account possible human limitations. The provision of effective and efficient human control on the dynamic and distributed system will also become critical. In particular, it will be necessary to establish an appropriate balance between automated learning on the part of the intelligent environment, human behaviour patterns, and human intervention aimed at directing and modifying the behaviour of the environment. This aspect of the emerging technologies needs to be carefully taken into account particularly when elderly and cognitively disabled people are involved, as services that monitor the health status or the location of users may also interfere with their capacity of taking decisions [11].

Content and Functionality. A prerequisite for the successful development of the disappearing computer environment is that future computing needs in everyday life are appropriately anticipated [23]. An in-depth understanding of the factors which will determine the usefulness of interactive artefacts in context is required. These requirements are likely to be more subjective, complex, and interrelated than in previous generations of technology. For example, disabled and elderly people will need personalised navigation services, including location-, content- and disability-dependent accessibility information.

Health and Safety. In a situation in which technology may act on the physical environment and deal with critical situations without the direct intervention of humans, it is likely that new hazards will emerge for people's health and safety. Possible malfunctions or even wrong interpretations of monitored data can lead to unforeseeable consequences, especially in application domains such as healthcare, home technologies and environment navigation, and for segments of the population which will use technology to overcome human limitations and will therefore be more dependent on it than others. This implies the necessity of monitoring every relevant element in context, and raises the issue of identifying the elements that should be monitored by each device, and the conditions and parameters according to which monitoring should take place. For example, in the healthcare domain, the challenge is to optimally extract the most critical information from the patient using a set of sensors and tasks and present it to a remote location in an appropriate form [16]. Furthermore, appropriate backup strategies must be elaborated. An important issue in this respect is the notion of redundancy (of information, communication channels, monitoring mechanisms, etc), which, through cross-checking mechanisms, can contribute towards increasing the correct functioning of the technological environment and minimising risks.

Ethical, Social & Cultural Issues. As technology becomes embedded in everyday objects and in the environment, functional and interaction aspects of technological artefacts may become subordinated to other personal factors of choice [21]. The most important ethical issue in this respect concerns privacy and anonymity, and the effective protection of personal data that are collected through the continuous monitoring of people. In this respect, new challenges arise concerning how a person will be able to know when and what type of information is recorded, by whom and for which use, in a technological environment where personal information is continuously collected by numerous 'invisible' receptors. Furthermore, the impact of technology on human social behaviour is bound to increase in an environment where technology is omnipresent. The individual and collective views of behaviour appropriateness become therefore important for establishing the social basis of technology behaviour and the constraints it should obey. Finally, cultural issues, including aesthetic considerations, are likely to play a relevant role in the choice of artefacts that exhibit multiple functions, of which computing may be a secondary one, as in the case of clothing, jewellery, and furniture.

4 Conclusions: Towards Universal Access in the Disappearing Computer Environment

The evolution of Information Society Technologies towards the Disappearing Computer environment is anticipated to be a complex and multifaceted process, in which a variety of diverse factors will play a critical role. Clearly, the accessibility and usability of a wide variety of omnipresent, critical, context-dependent and dynamically evolving technologies by users with different characteristics and requirements can not be addressed through ad-hoc assistive solutions introduced when the main new environment will already be in place. Moreover, the context of use is extended to include the physical and social environment and the number and potential impact of relevant factors increase dramatically with respect to conventional computing devices. Therefore, appropriate, personalised, systematically applicable and cost-effective interaction solutions need to be elaborated.

In this situation, proactive approaches towards coping with the multiple dimensions of diversity becomes a prerequisite, and the notion of Universal Access [3, 4] has the potential to contribute substantially towards ensuring that the needs and requirements of all users, including disabled and the elderly people, are appropriately taken into account in the development of the new technologies.

Universal Access, by definition, aims towards the accessibility and usability of Information Society technologies by anyone, anywhere and at anytime. Recent efforts, however, have mainly addressed issues concerning interaction with interaction platforms that work mostly independently from each other (e.g. desktop computers, PDAs, mobile phones). In the age of the disappearing computer, Universal Access will face new challenges posed by the pursue of proactive accessibility and usability in the context of embedded interactivity “hidden” in a variety of interconnected, multifunctional artefacts [5]. In particular, new approaches, and related instruments, are needed for capturing human requirements in the new reality. Design of interactive artefacts is also likely to become a more complex and articulated process, requiring new principles, methods, techniques and tools. This is due to the multifunctional nature of artefacts, to the necessity of embedding interactive behaviours in everyday objects, and to take into account the dynamic combination of the interaction capabilities of interconnected objects and devices [24]. New evaluation and testing methods will also be required. Finally, appropriate architectural frameworks and development tools will need to be elaborated. Under this perspective, it is argued that the concept of automatic adaptation, as elaborated and supported in recent and current approaches to Universal Access [25], as well as the related development methodology and tools, will offer a framework for providing accessible, usable and acceptable interactivity in the age of the disappearing computer.

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New Technologies and Services for Disabled and Elderly People in the Emerging Information Society

Pier Luigi Emiliani

Institute of Applied Physics "Nello Carrara" (IFAC)
Italian National Research Council
Via Panciatichi, 64
50127 Firenze, Italy
p.l.emiliani@ifac.cnr.it

Abstract. Developments in information technology and telecommunications are supposed to have an important impact on the possibilities of socio-economic integration of the population at large, but are particularly critical for people with disabilities and elderly people. Their impact depends on how technology is made available and accessible to all potential users. This paper discusses some of the challenges that need to be addressed in the context of the emerging Information Society. It does not aim at exhaustively reviewing current developments in technology and foreseeing in detail their likely outcomes, but rather at looking at the emerging situation, trying to figure out the main features of the new information and telecommunication environments that people will have to interact with, and what is needed to make such an environment accessible.

1 Introduction

Developments in information technology and telecommunications are considered the most important factor currently affecting the way people lead their lives. Fundamental changes brought about by technological innovation concern not only the organisation of the education and work environments, but also the way people organize their social activities, keep in contact with other people, interact with the environment and entertain themselves. This has an important impact on the possibilities and modalities of socio-economic integration of the population at large, but is particularly critical for people who have difficulties in communicating and accessing information. Technological developments are not good or bad in principle, but their impact depends on the way technology is used. In the case of current technological evolution, its impact depends on how technology is made available and accessible to all potential users.

This paper discusses some of the challenges that need to be addressed in the context of the information society. It does not aim at exhaustively reviewing current developments in technology and foreseeing in detail the likely outcomes of these developments, but rather at looking at the emerging situation from the perspective of the citizens, trying to figure out, at the extent to which this is possible, the main features of

the new information and telecommunication environments that people will have to interact with, and what is needed to make such an environment accessible.

2 Historical Background

When the interest in telecommunications and information technology for people with disabilities started, the situation was relatively simple: the main service for interpersonal communication was the telephone, and information was distributed using radio and television. Computers were mainly stand-alone units used in closed communities (e.g., scientists and businessmen).

In principle, the telephone was a problem only for profoundly deaf people. For all other people, solutions were within reach of simple technological adaptations. Blind people needed only keyboards with an easy identification of the layout. Visually disabled people needed only enlarged keyboards, which could accommodate also most of the motor disabled people. Viva-voice equipment was able to accommodate people who had problems in using the receiver. Simple images on the keyboard, e.g., the pictures of the mother and other relatives, could support cognitively disabled people in connecting. The technology used for implementing the telephone lent itself to the possibility of capturing the signal (electromagnetic induction) and making it available for amplification for deaf people. Even the problems of profoundly deaf people were facilitated by the telephone system itself, when it was discovered that the telephone line could be used to transmit data (characters) with suitable interfaces (modems).

Radio was an important support for the diffusion of information. In principle, radio can be a problem for deaf people. But amplification is inherent in a radio system; therefore problems occur only for profoundly deaf people.

Television was the first example of a service that used the combination of the visual and acoustic modality, not redundantly, but for conveying different types of information. It is evident that television can create problems to blind, visually disabled and deaf people. On the other hand, the fact that additional information can be transmitted allows support for people with disabilities to be added to the standard service. Therefore, programmes can be subtitled for deaf people and scenes without dialogue can be verbally described for blind people. In addition, text services can be set up solving problems related to access to information by profoundly deaf people. Television is a simple example of a general situation. An increase in the complexity of a system or service increases also the number and extent of problems that it can create to people who have reduced abilities. At the same time, technical complexity often implies additional features to recover from this unfortunate situation.

The situation started to change due to the development of computers and technology able to increase the bandwidth of communication channels. Immediately, personal computers were seen as a new and very important possibility of supporting people with disabilities in communication and access to information. Unfortunately, they were not directly accessible by some user groups, such as blind people and people with motor impairments of upper limbs. However, the possibility of encoding information was perceived as of paramount importance for blind people. Adaptations were

investigated, and through the synergy of new transduction technologies (mainly synthetic speech) and specialised software (screen readers), coded information was made available to blind people [1]. Blind people could also read information retrieved from remote databases, and write and communicate using electronic mail systems. Adaptations for motor disabled people (special keyboards, mouse emulators) were also made available.

From the short description of the traditional ways of communicating and accessing information some characteristics are relevant for the subsequent analysis:

- Services with predefined characteristics were available;
- These services use single or simple combinations of media (e.g., television);
- There was a clear distinction between interpersonal communication and access to information;
- Systems were mainly transmissive in nature, and non interactive.

When interest about accessibility by people with disabilities became wider, the situation asked for adaptations of existing systems, which were becoming slowly available. Subtitling for deaf people and description of scenes started to be made available a few decades after the introduction of television transmissions. Changes were faster with computers. Screen readers for blind people were made available a few years after the appearance of personal computers. But computer technology was moving fast. Text screen readers became obsolete when Windows substituted DOS. They were substituted by Windows screen readers, but again with a delay of some years.

As a preliminary conclusion, it can be said that when the relevance of telecommunications and information technology for the socio-economic integration of people with disabilities was recognised, the technological scene was dominated by a set of established services. The only available possibility at the time was to try to adapt them to be accessible by people with disabilities and elderly people.

3 The Emerging Situation

In the background of the commonly available and employed technology, a revolution was being prepared, with the emergence of the Information Society. The first component in this revolution is the development of computers, and more generally of digital technology. In the digital world, audio, pictures, video, text, etc., are no more present as individual physical signals with unique characteristics (e.g. bandwidth) but as numbers. Numbers can be freely transmitted and stored on computers. Multimedia systems are a reality. All the different components (audio, images, video, text) have equal possibility of representation and can be freely intermixed. The second component is the emergence of broadband telecommunication networks.

This new technological situation is often referred to as to the fusion between information technology and telecommunications. This fusion must not be seen from the trivial technological perspective that telecommunication networks are built using

computer technology and that computers are networked. What is really interesting is that computer intelligence is progressively being transformed into a distributed function. A computer is not any more conceived as a stand-alone system working on its own data, but as an intelligent agent able to cooperate with other intelligent agents (hardware and software) on distributed data. Communication is not considered any more as an additional functionality of computers, but as an integral part of their hardware and, particularly, software systems. Moreover, interconnected computers are starting to be embedded everywhere: in cars, hi-fi systems, kitchen equipment, clocks, shavers, etc.

Networked intelligence is supposed to be a new and very general characteristic of our living environment. One of the main practical limitations for the take up of this new technology, that is wiring, is going to be solved in the near future. Walking through a European city, one can see roads dug wiring the whole city. New generations of mobile systems are being deployed that will allow interconnection even when a broadband network is not available. Concerning houses, new wireless de facto standards (e.g., BluetoothTM) are emerging that will make possible an interconnection of house equipment without physical wiring.

Some features are immediately evident in this new networked environment:

- There are no clearly predefined services, but services are reconfigured in real time;
- * There is no clear distinction between interpersonal communication and access to information;
- Services are highly interactive;
- Most services are inherently multimedia;
- Interaction is often multimodal, i.e., different sensorial and motor abilities are concurrently used;
- Cooperation is a new important aspect, i.e., communication and access to information are concurrently used to cooperatively solve common problems;
- Cooperation may be among the users themselves or among representatives of the users (agents and avatars), which can be assigned variable degrees of trust;
- Contexts of use are more varied than with current services;
- Access to information and communications extend to communities of users, who have at their disposal common (sometimes virtual) spaces where they can interact.

A detailed analysis of the possible impact of these emerging environments on people with disabilities and elderly people is very complex, and has been already carried out, at least partially, in several projects funded by the European Commission RACE, ACTS and TIDE Programmes [2]. As it is normally true with technological development, the impact can be positive or negative as a function of how technology is used. Multimediality, for example, can be an enormous improvement for people with disabilities, if redundancy is used. If this is not used, multimediality will create new serious problems for people with disabilities. Interactivity can also create problems to people who do not have the capability of reacting within the expected time constraints, or do not have the sensorial or motor abilities necessary for the required interaction.

The “disappearance” of computers, i.e., embedding computers in everyday life equipment, is bringing interaction back to metaphors that people are familiar with, and can be an important step forward. For example, many people would not be very happy to interact with their kitchen using a computer screen and a mouse, but may be happy to interact with an environment where intelligence is hidden and they can use a natural interaction pattern, such as, for example, using voice.

The main potential problem is the complexity of the resulting environment. Apart from cognitively disabled people, most elderly people and people who do not have a specific training in the use of technology could face some problems. The acceptability of the entire environment will probably rely on a careful trade-off between the intelligence in the system and user’s capabilities and required training.

4 Strategies for the Future

The emerging intelligent environment, incorporating functions of communication, access to information and environmental control, needs an in depth study of the way information is collected, stored and distributed, and of the way people interact with information systems. So far, irrespective of the used platform, the availability of a screen, a keyboard, and a pointer has been taken for granted. Information is presented in windows and interaction is organised through direct manipulation. Now the situation is expected to change. For example, it is impossible for people to interact with the Internet or other information sources using a screen and a pointer while they are driving. It is unlikely that people will accept to interact with their oven to cook dinner using a computer screen. It is commonly thought that this new environment will be accepted only if computers will disappear in the background, and interaction will be organised according to already known metaphors (e.g., using voice commands).

The traditional approach to rendering applications and services accessible to people with disabilities is to adapt such products to the abilities and requirements of individual users. Adaptations facilitate access to the interface via suitable mechanisms, such as, for example, filtering [1], dedicated interaction techniques (e.g. scanning, [3]), and specialised input/output devices (e.g., tactile display, switches, eye-gaze system).

The reactive approach to accessibility [4] suffers from some serious shortcomings [2]. Firstly, reactive approaches, based on a posteriori adaptations are not viable in sectors of the industry characterised by rapid technological change. By the time a particular access problem has been addressed, technology has advanced to a point where the same or a similar problem re-occurs. The typical example is the case of blind people’s access to computers. Each generation of technology (e.g., DOS environment, Windowing systems and multimedia) caused a new wave of accessibility problems to blind users. In the information society there is an additional difficulty for any reactive adaptation approach. The emerging environment is too complex, not well defined and rapidly changing for being made accessible with adaptations.

Due to the above shortcomings of the reactive approach to accessibility, there have been proposals and claims for proactive strategies, resulting in generic solutions to the problem of accessibility (i.e., universal access) [5; 2; 6]. Proactive strategies entail a

purposeful effort to build access features into a product as early as possible (e.g., from its conception and early phases of design). Such an approach should aim to minimise the need for a posteriori adaptations and deliver products that can be tailored for use by the widest possible end-user population. Proactive approaches to accessibility are typically grounded on the notions of universal access and design for all. The term design for all (or universal design, the terms are used interchangeably) is not new. It is well known in several engineering disciplines, such as for example, civil engineering and architecture, with many applications in interior design, building and road construction, etc. However, while existing knowledge may be considered sufficient to address the accessibility of physical spaces, this is not the case with information society technologies, where universal design is still posing a major challenge.

As a summary of the above discussion, it is clear that the main challenge lies in the need of coping with diversity, both from the perspective of user groups and contexts of use. The notion of context of use is very interesting, because it is clear that many problems traditionally considered as important for people with disabilities start to become important also for the population at large. When people are driving and want to access the Internet, they are situationally blind (they cannot look at a screen) and motor impaired (they cannot use a pointer or a keyboard).

Finally, it should be emphasised that the fundamental problem of design for all in the information society, as opposed to the same concept used, e.g., in architecture, is technological in nature. When guidelines for constructing buildings accessible to all are available, the problems become essentially economical and political. In the case of information society technologies, it is clear that a single (optimal) configuration of systems and services and their interfaces suitable for the requirements of all potential users is a utopia. The goal is to produce an environment that has enough intelligence embedded to be easily adaptable, automatically or with a minimum of intervention, to the requirements of individual users [7].

5 Research Strategies

As already discussed in the previous section, accessibility in the information society must be tackled with a more generic and systematic approach than adaptation. It has also been clarified that this is a complex problem, which cannot be solved employing only guidelines and recommendations, but needs technological innovation. The related research problems have been widely debated in a set of meetings of the International Scientific Forum “Towards an Information Society for All” [8; 9].

The first set of recommendations is related to the need of promoting the development of environments of use, i.e., integrated systems sharable by communities of users that allow for rich communications. This implies the identifications of:

- Properties of environments of use, identifying their respective properties and characteristics, as well as the prevailing norms that characterise their operation;
- Novel architectures for interactive systems for managing collective experiences to support interoperability, adaptation, cooperation, intelligence, etc;

- Architectures for multiple metaphor environments, to adapt to different user requirements and contexts of use;
- Multi-agent systems and components to support cooperation and collaboration;
- Individualisation and user interface adaptation; to ensure accessibility by all users to community-wide information and communication resources.

A second group of recommendations is related to the need of supporting communities of users, with the emphasis on social interaction in virtual spaces. This is supposed to enhance the prevailing interaction paradigms (e.g., Graphical User Interfaces [GUIs] and the World Wide Web) to support the broad range of group-centric and communication-intensive computer-mediated human activities. This includes:

- Individual / collective intelligence and community knowledge management. Knowledge, therefore, no longer constitutes an individual's asset, but a community-wide resource, which can be shared and articulated by members of that community.
- Methodologies for collecting/analysing requirements and understanding virtual communities;
- Accessing community-wide information resources, to facilitate human interactions with large information spaces (and concurrently with other humans) and to provide technological solutions, which will make community-wide information resources accessible, scalable to new generations of technology, persistent and secure;
- Social interaction amongst members of on-line communities.
- A third set of general recommendations is connected with the integration of users in the design process and the evaluation of results and it is based on the concept of extending user-centred design to support new virtualities. Detailed recommendations include the identification of:
 - Foundations for designing computer-mediated human activities, to extend existing techniques and tools of user-centred design with concepts from the social sciences, so as to provide a broader foundation for HCI design;
 - Metrics for important interaction quality attributes, to cover additional quality attributes such as accessibility, adaptation, intelligence;
 - Computational tools for usability engineering;
 - Requirements engineering methods to facilitate the elicitation of requirements in novel contexts of use and different user groups;
 - Protocols for effective user participation in design activities.

A fourth set of recommendations deals with support actions as: articulating demand for design for all, supporting the industry, as well as promoting awareness, knowledge dissemination and technology transfer. These activities are of paramount importance. However, their discussion is considered outside the scope of this paper.

6 Conclusions

The emergence of the information society is creating a new technological environment where intelligence is ambient and all citizens will have to carry out new types of activities. This environment may be too complex and diversified to allow the use of the concept of “average user” in the design of its main characteristics; the needs of individual users are catered for through proactive design considerations. This means that requirements of all potential users have to be taken into account, and an appropriate degree of intelligence has to be built and embedded in the environment to make it adaptable and adaptive to the individual user’s abilities, requirements, skills and preferences. This will open important opportunities for people with disabilities and elderly people, whose requirements need to be integrated in the design specifications.

However, this is not only a matter of good will, but of scientific and technological development, because all necessary knowledge and technology is not yet available.

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A Strategy to Achieve the Accessibility of Public Web Sites

Sylvie Duchateau¹, Denis Boulay¹, Claudine Tchang-Ayo¹, and
Dominique Burger²

¹ BrailleNet, Université Pierre et Marie Curie

² INSERM U483 / INOVA, Université Pierre et Marie Curie

9, quai Saint Bernard, 75 252 Paris cedex 05, France

Sylvie.Duchateau@snnv.jussieu.fr

Abstract. At the European and national level, pressure has been made to invite public administrations to make their Web sites accessible to all citizens. This paper reports on the work of the BrailleNet Association together with Web designers of the French government to improve the accessibility of public Web sites. It explains the political context, actions that have been undertaken and the results of these actions. Finally, the perspectives for the future will be discussed.

1 Introduction

In many countries, a better access to Web services and Web administration is becoming an important issue. At the European level, the Council of the European Union mentioned in their resolution from March 25, 2002 [1], that: “National administrations should seek constantly to improve the accessibility of their Web pages and explore new and better ways to deliver Web content and services as new technologies and new versions of the Guidelines¹ are developed.” [2] In France, for instance, several governmental measures have been taken to encourage designers of public services to make their Web sites accessible to all citizens. For that reason, the demand for evaluations of public Web sites is growing steadily. The BrailleNet association, created in 1997, has set up actions in narrow co-operation with the French Government to promote the dissemination and application of the Web Content Accessibility Guidelines in France.

This paper presents the strategy undertaken to achieve this co-operation.

2 Evaluation of 30 Public Web Sites

In October 2000, the CIRE², stated in their decision that all French public Web sites (around 2600) should be made accessible till June 2001. Following this

¹ The text means the Web Content Accessibility Guidelines WCAG 1.0.

² CIRE: Comité Interministériel pour la réforme de l’Etat, is an interministerial body responsible for state reform

decision, the BrailleNet association was asked to review 30 public Web sites to find out if they were accessible, ranging from ministries to local Web sites, academic institutions, justice court, etc. For each of these sites, 30 significant pages have been selected.

The evaluation method, developed by BrailleNet, first relies on the WCAG 1.0, and also on an analysis of the site's usability with assistive technologies. The reviewing process is carried out by people with different competencies: programming techniques, assistive technologies, and human factors. Automatic online tools such as Bobby [3], W3C's HTML validator [4] and French version of A-Prompt [5] have been used.

For each Web site, a detailed document has been provided, reporting the main accessibility problems encountered, and suggestions for solutions. A final report has been published by the Ministère de la Fonction Publique on the Web [6].

The evaluation has evidenced that none of the evaluated Web sites was completely conformant to the WCAG 1.0. Therefore, there is a clear need for information and training on the WCAG 1.0 implementation techniques [7].

3 A Guide to Help Web Designers Make Accessible Web Sites

A guide for designers of public Web sites has been published on a governmental Web site [8].

This guide intends to help webmasters find their way through the design of accessible Web sites. It is based on the accessibility problems encountered during the evaluation. It requires knowledge of HTML, of the authoring tools and of Web site design.

After giving an introduction on Web Accessibility and what accessibility means for people with disabilities, the guide explains how to handle different problems such as images, forms, frames etc. Each topic is treated separately in a pedagogic card. This card recalls the guidelines from WCAG related to the topic, links to the checkpoints and techniques, and explains how to implement them. It also gives examples of good and bad practices. At last, the guide presents some automatic evaluation tools.

4 Training

Brailenet has set up a training programme for Web designers divided into three steps:

1. Two-day workshop, in which trainees learn how to review Web sites (different tools, browser settings) in order to repair those sites with their usual authoring tools. They also have to design accessible pages by themselves.
2. Practice at home. Trainees receive pages to evaluate and repair on their own. These exercises are corrected by experts.
3. A final one-day session is organised to give feedback on the exercises, answer questions and summarise problems.

5 Conclusion

The Government's request for a review of key public Web sites results from a will to improve the access of all citizens to all the public and administrative Web sites.

This review shows that in 2001 no French public Web site conformed completely to the Web Content Accessibility Guidelines. To conclude, we suggest a few action lines to improve the situation:

- by setting up e-learning modules for Web site designers;
E-learning is an efficient way to reach a big amount of people located in different places.
- constituting groups of accessibility reviewers inside public administration;
Well trained reviewers belonging to the designing teams of public Web sites will contribute to raise awareness about the design of accessible sites.
- developing software assistants for accessibility review;
Those tools would facilitate the work of reviewers as they would reduce the time spent for evaluation in performing automatic checks.
- extending collaboration over Europe;
European projects such as WAI-DA³ [9], and the constitution of centers of excellence, as planned in the 6th framework programme from the European Commission, would strengthen the European collaboration.

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Accessibility and Affordance for Voice Interactive Systems with the VoiceXML Technology

Régis Privat, Nadine Vigouroux, Philippe Truillet, and Bernard Oriola

IRIT, UMR CNRS 5505
118, Route de Narbonne
F-31062 Toulouse Cedex - France
{privat, vigourou, truillet, oriola}@irit.fr

Abstract. This article deals with the problematic of the oral modality as a mean of interaction, improving the usability of the interactive systems. We will introduce a typology of the systems where the use of speech technologies could benefit the Human-Computer Interaction. Then, we will briefly show some results from a case study based on an evaluation of speech recognition for dictation systems in French, relating to age. We will then lay out the future developments of this research.

On the one hand, speech is the most natural, efficient and flexible modality for the human-human communication. On the other hand, ergonomic researches have shown potential difficulties in the use of interactive systems based on direct interfaces, due to the lack of affordance, to inadequate modalities, to users' handicaps, etc.

Having remarked these facts, our objective is to determine in which situation — *application, user, environment* — the use of speech technologies could allow, improve or increase access to information for all.

The maturity of speech technologies¹ represents a great opportunity for people working with other or/and with a piece of information through Interactive Voice Systems. Progresses ([1] and [2] for instance) made this last decade in speech recognition and understanding, in spoken dialogue strategies, enable us to predict that we will be able one day to speak with a computer. Lay [1] wrote: “speech is the technology that will bring the Internet to everyone, bridging the Digital Divide by allowing Web access via a humble telephone, instead of requiring a computer”.

However, recent studies [3] show that the performance of recognition systems (ASR) and the comprehension of users' sentences are still far from matching human performances, in a lot of situations of communication. As reported by various studies of human-human speech, the main problem of spontaneous speech is that there are variations (faltering, false starts, ungrammatical phrases, emotional speech such as laughter, slurs, etc.), which introduce difficulties for both ASR and understanding systems. At the mere level of voice recognition, we can mention factors that are not

¹ There are many speech recognition products for Dictation (IBM, Dragon Systems, Lernout & Hauspie, Philips, etc.). There are also companies such as Nuance, SpeechWorks, AT&T Bells Labs, Philips, IBM, etc. developing SR over the telephone or Internet.

sufficiently controlled: “ecologic”² language, strongly disturbed environment, non-standard population (children, old people, foreign accents, people with speech pathologies), etc. Even if the technology of recognition (independence from the speaker, good lexical coverage of the application) has reached acceptable performance levels, is it efficient enough to replace the WIMP interfaces and their constraints (commands’ training, use of the keyboard/ mouse/ screen) and supply the comfort and the naturalness of vocal interaction (VI)?

Among the many challenges to overcome in developing human-like performance, we believe that spontaneous speech, for different age sections, is one of the most interesting and meaningful. This means that interactive systems based on vocal facilities would offer great opportunities to a lot of people handicapped by the new technologies (the novice computer users, the very young and the elderly, the disabled...) who need access to information services.

Our purpose is to discuss the VI as a means to improve access to information services and new technologies for everyone, especially for the disabled and the elderly. We are first introducing a typology of the interaction techniques of the interactive systems where the use of VI could be advantageous in terms of communication for the disabled. This categorization re-actualizes and supplements the one of Cohen [4]. We distinguish between two contexts in which VI is used:

- A monomodal context, where only oral input is usable. The constraints involving this exclusive modality may come from the system, the environment or the user:
 - Constraint coming from the system: the system doesn’t allow another modality or it is the only one usable, as for telephonic applications, including continuous speech ASR systems which are independent from the user with.
 - Environment constraint on the user’ activity: the user has busy hands and eyes. The VI is used to input data, to control the environment or to give orders. The ASR systems usually have a restricted vocabulary, and they are speaker-dependant.
 - Constraints on user capability: that is to say the user is handicapped, and can’t use another modality. The ASR systems can be used either for environment control, to give orders... as seen before, or to enhance performances as in a keyboard input activity (dictation...), with or without the use of a predictive system. We can also mention here the use of ASR systems by deaf people for communicating by telephone.
- A multimodal context, where the choice of the method to be used is left to the user. The VI can be used:
 - Alone: the VI may be preferred to all the other overly technologic media (by old people for instance). This is called assignation in the CARE model [5].
 - In a multimodal context: Oviatt [6] showed that the system performances and acceptability could be enhanced by the simultaneous use of speech with other modalities.

² Ecologic language means that the task domain is limited by the lexicon cover but opened for all sentences’ realization (all forms of sentences are available, for instance).

In a previous study ([7]) on speech, we noticed some effects of the voice degradation due to age in a reading task as well as in a “near interaction” task. The main effect was a decrease of the speech rate correlated to the speakers’ age. We also noticed an increase of the misrecognitions, due to articulation problems. This problem appeared mainly on small words, as shown in the following example:

Table 1. Two examples of misrecognition, with their phonetic transcriptions

Pronounced	Recognized
Qui /ki/	Il /il/
La /la/	Le /lɛ/

Our purpose is to follow up this study in a real task of VI. In our future works, we will discuss our choice of the VoiceXML language (<http://www.voicexml.org>), supported by the World Wide Web Consortium (W3C, <http://www.w3.org>), as a prototyping tool to quickly design VI. Then, we will set this prototyping language against the requirements for an interactive spoken system designed as a solution to improve information access for all by the voice.

Our studies will especially deal with new approaches in Interactive Voice Server such as the ecologic language approach (as seen before), but also with the problems of misrecognitions, the system affordance, etc., by the definition of different strategies in order to try to overcome the problems in the interaction.

We hope that this study and its perspectives will contribute to the universal access paradigm by speech for the new generation of interactive systems.

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Computer and Inclusive Education

Introduction to the Special Thematic Session

Ewald Feyerer

Pädagogische Akademie des Bundes in Oberösterreich
Kaplanhofstraße 40, A-4020 Linz, Austria
FeyererE@pa-linz.ac.at

Abstract. Inclusive teachers should be able to reach the special educational needs of all pupils. Computers and Information Technology can facilitate this challenging task. That is why Assistive Technology should be part of inclusive teacher training in any case. This thematic session will show and discuss how computers and information technologies can support and improve inclusive education. Concrete examples of e-learning projects will be presented and discussed as well as the consequences for the teacher training. What can computers information technologies contribute to a modern and flexible study program, what are the indispensable skills teacher trainees will need in order to use computers and new information technologies for an effective inclusive education? Fifteen people will present interesting aspects as basis for the discussion.

1 Introduction

Inclusive education is part of the regular school system in many European countries. Computers and software are in use with pupils who have special educational needs. The focus is geared towards the possibilities for inclusion presented by ICT and substantial resources are being assembled and implemented. These resources include hardware, software, Internet resources and not the least pedagogical resources and support material that contributes towards the fulfilling of the inclusive intention.

However, it seems that teacher training institutes did not take any notice of this developments. There was no coherent curriculum for inclusive teacher training in Europe. This situation gets more critical when modern Information and Communication Technology (ICT) and the possibilities of Assistive Technologies (AT) are taken into account. The term Assistive Technology (AT) basically describes all kind of tools, devices or systems enabling a person to (easier and safer) perform a task. [1]

People with disabilities can be seen as one of those user groups benefiting a lot from the movement towards the Information Society. Due to the technology push people working in close co-operation with them often were not able to catch up with the fast developments and changes in the style of working and also learning. Almost

any teacher training system faces the problem that developments in these fields are that fast that

1. teachers can not cope with these challenges at an individual, self organised level as well as that
2. teachers training organisations are not able to adapt curricula accordingly and to offer training possibilities.

Very often an integrative situation risks to fail because basic ICT and AT support is missing; possibilities for integration in school and at the labour market are not known, can not be taken into account or are ignored. This outlines the critical lack in teachers training concerning ICT and AT.

Today the pedagogical field as well as the field of AT start to answer this need from their own point of view. It seems to be obvious that both groups should work in close co-operation.

In this special thematic session concrete projects of using ICT and AT in order to support learning and teaching of children with special educational needs will be presented. Furthermore the question how ICT and AT aspects should and could be incorporated into teacher training programs will be discussed.

2 General Aspects

The presentation of Gry Hammer Neander, entitled “ICT and Inclusion in Norway” should give a short overview over the possibilities of ICT and AT in inclusive Education. Although the use of ICT related to SEN students has an extensive tradition in Norway students were often taught in separated rooms. Today, focus is geared towards inclusion according to the intentions of the Norwegian Education Act and the Norwegian Core Curriculum.

Amanda Watkins will present “National Information and Communication Technology Policies and their impact upon the use of ICT in Special Needs Education. Although the use of ICT is currently very high on the political agendas of nearly all European countries as well as the European Union itself an analysis in 17 European Agency member countries showed that there is very little information available about SNE specific use of ICT. Five different levels of ICT in SNE practice are covered in her report: ICT infrastructure, support systems for educational practice, training, cooperation/research and evaluation. The need for a shift in focus of ICT in SNE policies and programs seems to be obvious. This required shift in emphasis of ICT policy should help centre attention upon using ICT to learn in different contexts rather than upon just learning to use ICT in different ways. Genuine inclusion of ICT in the curriculum for pupils with special educational needs will only occur when the full potential of ICT as a tool for learning is understood.

3 Special Help for Pupils with Special Educational Needs

Educational software is widely used in the field of special educational needs education. But what makes a software, a web portal etc really helpful for learners with special educational needs. How could the high diversity of an inclusive learning group be considered? The presentation and discussion of the following projects should help us to answer the question about the relevant criteria of qualitative ICT and AT use in the field of inclusion.

First Barbara Prazak will present the software “Step by Step 3” which is especially suited for the area of cognitive development of SEN and physically handicapped children. Furthermore she will also present common criteria for the judgment of educational software from a pedagogical point of view. Michael Pieper shows how standard applications as “Words of Windows” can be introduced to pupils with learning problems by special tutorial programs. The overall aim of the “Vickie Project” is to facilitate the inclusion of visually impaired pupils and students. The “Visually Impaired Children Kit for Inclusive Education” will be presented by Dominique Archambault and Dominique Burger and provides a technological environment to help these children into the digital age.

The following four presentations are developed as training programs for specific areas. Yehya Mohamad and colleagues have evaluated an autonomic tele-psychological training system of memory strategies called TAPA, Training with Animated Pedagogical Agents. “Addizionario: Words in your pockets” by Giovanna Turrini and colleagues is an example of ways in which technology can be used in classrooms with younger pupils. It reflects a new approach to the study of language and is an interactive and flexible tool, centred on the child, who gradually constructs his lexical knowledge. Jaakko Kurhila and Hanna Varjola will present their experiences “Using Adaptive Hypermedia to Evaluate Basic Arithmetic Skills in Special Education”. How SEN pupils can gather competence in multimedia will be shown by Cordular Edler. Her catch-phrase is “Take it easy”.

4 Bridging the Information Gap between IST¹ and SEN

In all areas of education the new media are beginning to open new ways of learning. But certain groups of learners are at risk of not being fully involved in this new ways, either because their social disadvantages or their disability – or both. In order to build a socially inclusive Information Society based on participation for all, new pedagogical approaches and appropriate technologies must be developed and applied to suit the learning requirements of all children and young people, including those who have special educational needs. Jorgen Greve and Harald Weber will introduce a practical approach on European level to provide support for the two communities such that learners with SEN will have access to the benefits of leading edge technologies and that the IST program ensures the development of inclusive technology-enabled learning systems and materials for the future.

¹ Information Society Technologies

Accessibility is one of the keywords in order to bridge the gap between computer technology and people with special educational needs. Universities all around the world are putting parts of their courses and frequently entire courses and degree programs online for remote access. Two major components have to be considered to avoid difficulties: the infrastructure and the content. Norman Coombs will present a few studies on the accessibility of distance learning focused only on the course infrastructure. The results are discouraging.

5 Teachers Development

Four projects will be presented by Ewald Feyerer, Klaus Miesenberger, David Wohlhard and Walter Rainwald. Then the question how ICT and AT should be implemented in teacher training courses will be discussed.

The SOKRATES ERASMUS project INTEGER offers five basic modules, 22 optional modules and some teaching and learning materials. Furthermore a glossary with the most important terms related to inclusion and a corporate workspace for international cooperation were developed. The module B4 includes the ideas of Assistive Technology in order to “Enabling personal autonomy and independent living”. [2]

EUMIE is a masters program also within the guidelines of SOKRATES in order to develop a study program for an “*European Master in Inclusive Education*”. Again the modular structure enables the incorporation of modules on ICT and AT to guarantee that a “Master in Inclusive Education” has the basic skills to manage the complex situation of employing and teaching ICT and AT in class. The possibility to specialize in these fields by choosing an optional intensive course in AT will be available.

The SOCRATES/MINERVA project ODL:Inclusive develops a teacher training course on Inclusive Education. The course will be offered as a coherent series of Open and Distance-Learning modules running on the platform “eLearningSuite” (HyperWave). A self-study edition on DVD complements the online-offering with richer multimedia material. [3]

Walter Rainwald will present the “EUN Virtual School Special Needs Education” which offers a forum for teachers to learn from each other’s experience. An open community of teachers from all over Europe, working with SEN pupils, discuss didactical aspects, how ICT can enhance the abilities of pupils and in which ways European cooperation can be developed.

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National Information and Communication Technology Policies – Their Impact upon the Use of ICT in Special Needs Education (SNE)

Amanda Watkins and Harald Weber

European Agency for Development in Special Needs Education,
Teglgaardsparken 100, DK-5500 Middelfart, Denmark
{amanda, harald}@european-agency.org
<http://www.european-agency.org>

Abstract. The use of information and communication technology (ICT) is currently very high on the political agendas of nearly all European countries as well as the European Union itself. However, until now, information on the use of ICT in the field of special needs education (SNE) has been limited to National level sources – very little information has been available at the European level. In order to address this, the European Agency for Development in Special Needs Education has undertaken a major European wide investigation into the use of ICT in SNE in 17 Agency member countries. This has lead to dedicated web-based resource banks of information which aim to present easily accessible information on policies, key issues, examples of interesting and innovate practice, key information sources plus future challenges in the field. This paper focuses upon the findings relating to ICT in SNE policies in the participating countries.

1 Introduction

About 10% of the population of Europe has some form of recognised disability [3] and it is estimated that there are 84 million pupils – approximately 22% or 1 in 5 of the total school aged population – who require special educational provision either in a mainstream classroom, as part of a special class or within a separate institution [6]. Depending on the way a child is identified and assessed in the countries of Europe, pupils with special educational needs (SENs) make up between 2% and 18% of the school age population [1].

Despite differences in political standpoints and practical provision, all European Union countries are in agreement that meeting the educational needs of every individual pupil and student can be viewed as an important element of guaranteeing the quality of life of all European citizens. In all countries, information and communication technology (ICT) is increasingly seen as a major tool in meeting this challenge.

The European Union eEurope Action Plan [4] underlines the fact that education is the foundation of the Information Society, since it has an impact on the life of every citizen. The OECD study Learning to Change: ICT in Schools [8] clearly shows how

ICT is potentially set to transform pupils' school experiences in all countries. The study outlines how large financial and time investments are being made by countries to fully equip schools in terms of hardware, software and Internet connectivity. Information from Eurydice [6] highlights how almost all EU, EEA and pre-accession countries have National or official policy documents which promote the use of ICT in educational sectors. In addition, most countries are currently implementing National or Regional level projects and initiatives to introduce and support the introduction of ICT into educational organisations.

However, the present indications are that an information society for all is far from a reality for all European school pupils. The OECD study emphasises that installing the hardware and using ICT to do traditional things in different ways will not in itself lead to pupils and teachers taking full advantage of the knowledge/information society. The study also argues that schools have to learn to change to new ways of learning if the potential of ICT is to be realised for each individual pupil.

The Eurydice survey ICT@Europe.edu: Information and Communication Technology in European Education Systems [7] argues that ICT in itself will not result in massive changes in the education systems of European countries unless its potential as a tool for learning is more fully explored. This survey points out that many countries are still at the stage of introducing technology into sectors of their education system and the real influence that technology could have on educational practice has yet to be seen.

The Eurydice [7] survey discusses the possible effects of this disparity of access – the survey considers an impending “digital divide” unless countries take action to ensure certain groups are not disadvantaged in their access to and competence in using ICT in educational contexts.

Whilst there are very important National level sources, European wide information on ICT usage with pupils who have a range of special educational needs is very limited. None of the European studies referred to above specifically considers the use of ICT with pupils with special educational needs. Information on ICT within SNE concerning policies and practice, or the impact of key issues emanating from the application of ICT within an educational context is not easily available at a European level from either educational or ICT research observers.

It is within this arena of increased ICT application in education across Europe, but the limited availability of information regarding ICT use within SNE that a targeted project was developed by the European Agency for Development in Special Needs Education.

2 Background to the ICT in SNE Project

Information technology is one of the main tools both for communication and dissemination used by the European Agency for Development in Special Needs Education. This fact was partly instrumental in the use of ICT in SNE being identified as the focus of Europe wide research during 1999 – 2001, the aim been to establish a resource bank of information relating to ICT in SNE. The specific objectives of the

project were to provide an overview of existing country-based information in relation to ICT in SNE, highlight the key issues regarding ICT in SNE in the countries and identify examples of interesting ICT in SNE practice that could act as useful reference material for teachers and support professionals in other countries.

Information databases were developed in co-operation with ICT in SNE support experts who acted as the key contributors as well as a main target audience for the project outputs [10].

The first phase of the project was to develop web based overview information relating to the ICT in SNE situation in: Austria, Belgium Flemish and French communities, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden and the UK. The overview information collected for each of the participating countries highlighted the strengths and weaknesses of the policy and infrastructure of equipment (hardware and software as well as Internet access), specialist support, access to information and ICT training available to teachers in special education settings. An analysis of the overview information relating to ICT in SNE policies has led to the production of this paper. A full analysis of all the data is available in the ICT in SNE project report [2].

3 ICT in SNE Policies and Practice across Europe

The Eurydice survey [7] clearly describes the national ICT in education policies and resulting patterns of provision and practice in place in each of the participating countries. The specific area of questioning within this project focussed specifically upon ICT in SNE policies and practice. A summary of the main issues raised within these areas is given below.

Contributors to the European Agency project were asked to outline the ICT in SNE policy arrangements within their countries, policy referring to a specific national level statement on principles, intentions, means, objectives and timetables relating to ICT in SNE. The possible different areas of concern for national level ICT policies appear to cover five elements: ICT infrastructure; support systems for educational practice; training; co-operation/research and evaluation, with different stress and emphasis being placed on different aspects of the policy according to Nationally set priorities..

It appears most countries have general – not SNE specific – ICT policies that include statements and objectives on these areas. Short and long term aims of national policies on ICT in the education system dictate the infrastructure of hardware and software made available to teachers and pupils. Policies also have a direct impact upon a teacher's access to training, support and information relating to ICT.

Most countries indicated that there was no specific ICT in SNE policy and that the general ICT in education policy for their country included special educational provision. Some countries indicated that the general ICT policy included statements of equity of educational opportunity with respect to and through the use of ICT. For some countries, national educational policy states that pupils with SENs have same rights as all other pupils – this includes access to appropriate ICT.

A number of countries (Iceland, Ireland, Portugal, Spain, UK) identified that there was a national level ICT strategy or programme – or defined as specific project (Greece) or funding arrangement (Netherlands) – specifically focused upon ICT in SNE. Only Portugal identified a specific policy, where ICT is incorporated as a particular element of national disability and SEN legislation. In some countries (Austria, France, Iceland, UK) as an element of educational policy, ICT is embodied within the school curriculum that applies to all pupils, including those with SENs.

All countries indicated that different bodies are responsible for policy implementation – national and regional level, school level (specialist ICT and/or SEN teacher coordinators) and support service and centre level (inspectorate, specialist teachers etc) – with overall responsibility being at ministerial, sometimes regional government level and then action (as termed by Denmark and Netherlands) or implementation responsibility being taken by a range of partners – even including private companies (i.e. network providers in Belgium [French community] and commercial providers in the UK).

Within countries with highly decentralised government (particularly those with autonomous regions who have their own legal frameworks and decision making powers), there is a pattern of policies and implementation programmes being set at this level of government with national policy being used as a guideline for implementation. Within Germany's 16 Lander and (most of) Spain's 17 autonomous communities, ICT and special education policies and implementation programmes are set at this level of government.

In countries with highly centralised Government – particularly within the smaller countries - implementation of ICT in SNE maybe conducted as initiatives at the level of the school, or even individual teacher. An example of this can be seen in Luxembourg where implementation of ICT in SNE is conducted as initiatives at the level of the school, or even individual teacher.

Some form of evaluation of general ICT policies is being conducted in countries (Austria, Belgium [Flanders], Denmark Finland, Greece, Ireland, Netherlands, Norway, Portugal Spain at a regional level, Sweden, UK). Specific information on SNE will be available from Ireland and on the impact of ICT on teaching and learning from UK.

4 Policy Dictating Provision and Practice

As a result of national or regional level policy, different types of provision – and subsequent practices – are currently available within special educational settings across countries each presenting different strengths and weaknesses.

The availability of appropriate support structures for implementing ICT in SNE settings is stressed as being as important for many teachers as having the appropriate hardware and software to use. This is a point highlighted by all countries in one-way or another. The different types of support structures available within countries focussed upon combinations of one or more of: national dedicated agencies for ICT in education (Iceland, Ireland, Norway, UK); support services that work directly with teachers and pupils within in SNE (Denmark, Sweden, UK); specialist resource cen-

tres where teachers obtain advice, materials and information (Denmark, Finland, France, Germany [some Lander], Greece, Iceland, Ireland, Luxembourg, Norway, Portugal, Spain, Sweden, UK); specialist regional working groups (Austria, Portugal); specialist websites and on-line networks (all countries); in school support (all countries).

Most countries offered a number of inter-related ICT services for teachers working in SNE. In school support was highlighted as being of particular importance, but also an area of potential difficulty as whilst most countries suggested that individual schools may have named staff with special expertise acting as ICT co-ordinators, these staff were not necessarily those with the necessary SNE expertise.

Specialist ICT in SNE training is another crucial area of provision dictated by National policy. ICT appears to be an integral part of initial basic teacher training in most countries – this fact is highlighted by the survey [7] as well as findings from this project. However, training in the use of ICT to meet SENs was identified as being available in initial teacher training in a limited number of the countries involved in the project.

In relation to in-service training, most countries offer general ICT courses for teachers. In-service teacher training focussed upon applying ICT to meet SENs was identified as being available less than half the countries participating in the project. However, ICT is an integral part of specialist training courses for SEN teachers in most countries.

Countries were asked to identify what they identified as being the main strengths and weaknesses in the systems of ICT in SNE within their countries. In relation to weaknesses, key factors (diffused responsibility for policy implementation; attitudinal barriers in relation to understanding the benefits and possibilities of ICT – at a policy and implementation level; lack of information on needs and requirements of schools and pupils upon which to base policy initiatives; limited finances supporting different aspects of provision or funding that is not needs targeted) clearly emerged as concerns within and across countries.

However, the perceived strengths appeared to exist as within country systems and were obviously influenced by national and regional ICT policy strategies (for example, local level implementation that is able to identify needs and target resources accordingly as evidenced in Denmark, Norway, Spain and the possibility for additional ICT funding based on need, upon application to authorities that is available in France and Ireland. It can be observed that in some instances, these perceived strengths are often the factors that specifically address the potential weaknesses identified earlier. Whilst there are elements within national ICT in SNE systems that require attention, this fact presents ICT in SNE professionals with some useful information on how to overcome obstacles within the system in the long term.

In considering the possible supporting and hindering factors within systems of ICT in SNE that dictate support for individual teachers, the inter-relation and influence of strengths and weaknesses of policies upon teacher-focussed issues cannot be ignored.

5 The Impact of Policy upon Practice

The contributions suggest that the role of policy makers relating to ICT must be to: promote basic and specific training for teachers in the use of ICT; ensure adequate hardware and software infrastructure is available for all pupils; promote research, innovation and the exchange information and experiences and make the educational community and wider society aware of the benefits of ICT in SNE.

These four elements appear to be reflected in the various comments of most countries' contributions. These aims can be achieved through general or SNE specific policies, projects or programmes. The identified points of weaknesses in policies and hindering factors for teachers' use of ICT need to be positively addressed so that they become strengths and supporting factors. The contributions highlight the fact that policy initiatives need to reflect need and then support initiatives targeted to meet actual need at national, regional, school, teacher and pupil level.

Support for individual teachers in using specialist ICT can be provided at national, regional, local, school or colleague levels. Whilst this can lead to a range of flexible information, advice and practical support services it also presents problems in terms of split responsibilities, difficulties in accessing funding and potential lack of co-ordination in provision of information services. Co-ordination and rationalisation of support, again based on clear information about needs and requirements of teachers and their pupils, appears to be very important.

The central issue facing some countries (Ireland, Portugal) in relation to SEN and the use of ICT is the lack of coherent support structures – available to teachers, parents, support staff and pupils – underpinned by clear ICT in SNE policy. Such support structures require personnel with appropriate expertise (Belgium [Flanders], Ireland) as well as the appropriate resources at school and individual pupil level (France) and also at regional or support centre level (Portugal, UK). These elements can only be realised if there is a policy directing their implementation.

Policies need to redress the possible disparities in resources and support across an area (France, Ireland, UK) as well as at individual school and pupil level (France) and it is therefore important for them to be based upon a clear understanding of the ICT situation in the given area (Netherlands). For example, it would be useful for a policy to establish: an overview of hardware and software available for different SEN target groups; clear information about teachers' needs for products; what specific training in using ICT is required; information on models of ICT management in schools; general knowledge about integrating ICT in education (Netherlands). In relation to the provision of training for teachers and support staff, any policy would need to operate on two levels, the first being training the next generation of teachers whilst also implementing a programme of training the current generation of teachers and support personnel (Belgium [Flanders]). Primarily, the ICT in SNE policy would need to work developmentally towards establishing a satisfactory infrastructure of ICT in the area.

6 Emerging Issues

One of the crucial debates within the ICT research and development arena at present is the application of inclusive by design principles – that is the diverse range of users’ needs are considered at the outset of designing hardware or software; their needs are not considered later and met as some form of adaptation to the already existing product. In order to build a truly inclusive information society, educational approaches and appropriate technology must be developed that meet the requirements of all users, including those who have special educational needs. Access to appropriate ICT can reduce inequalities in education and *ICT can be a powerful tool in supporting educational inclusion*. However, inappropriate or limited access to ICT can be seen to reinforce inequalities in education faced by some pupils including those with special educational needs. The digital divide that could potentially develop within countries’ educational systems [7] can be seen to be particularly significant within the special education sector.

The *principle of inclusive by design needs to be applied* during the planning, financing and formation, implementation and evaluation of ICT policies, provisions and practices. The SEN-IST-NET consortium [9] argues that an inclusive approach to the development of a new learning culture in general and to technology-enabled learning in particular is required. As a starting point for this, it may be necessary to identify the elements of education, ICT, and ICT in SNE policies and practices that make some policies more inclusive in their impact than others.

It can be argued that there is a need for a shift in focus of ICT in SNE policies and programmes. Previously the emphasis has been upon establishing the means (infrastructure in terms of equipment and expertise) to enable ICT to be effectively applied in SNE settings. The evidence from this study suggests that practitioners in the field are now asking for *the emphasis to be placed upon the ends, the aims and goals, of using ICT in SNE and not just the means* of that use. Such a focus would help inform debates about the development of appropriate infrastructure, but would most importantly focus attention upon why and how ICT can be most appropriately used in different educational contexts. Significantly, this shift in emphasis would help *centre attention upon using ICT to learn in different contexts rather than upon just learning to use ICT in different ways*. Genuine inclusion of ICT in the curriculum for pupils with SENs will only occur when the full potential of ICT as a tool for learning is understood.

The development of ICT in SNE policies needs to consider how it can support and promote *co-operation between different groups of ICT actors*. ICT not only needs to be the focus or topic of increased co-operation, it needs to be more accessible to a wider audience as the means by which co-operation can develop. A major step towards promoting this increased co-operation has been taken by the European Agency as part of a consortium supported by the DG Information Society Technologies, developing the Special Educational Needs – Information Society Technologies – Network project [11].

7 Concluding Comments

Despite the practical – and sometimes political – issues relating to the front line application of ICT in classrooms with pupils with special educational needs, the contributors to this project were very clear about the importance of teachers and support professionals in SNE being involved in the process of developing policy, provision structures and even the technology that influences their work with pupils with special educational needs. Information from this survey suggests that their concerns and requests are not always being accounted for at an international (specifically EU), national, regional and even school level. If the dialogue between these various groups can be facilitated to a greater extent, then a real step forward will have been made towards achieving a genuine information society that includes all citizens.

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EUN Virtual School Special Needs Education

Walter Rainwald & Virtual School Special Needs Editing Team

Odilien-Institut, Leonhardstrasse 130, 8010 Graz, Austria
Walter.Rainwald@odilien.at
<http://www.eun.org/vs>

Abstract. The Virtual School Special Needs Education Editing Team creates a conference with a base of knowledge, which teachers from all over Europe can use and be inspired in their work with children and young people with Special Needs. We are promoting the development of special teaching including the use of ICT.

1 Instead of a Prologue

Computers cannot solve quite reliably the problems of disabled people. However computers can smooth the way of handicapped people to a more independent and more active participation in social and vocational life. So a modern and efficient computer instruction is also a base to light up these developments so that the disabled also can have a very clear look at the world.

For example for blind people the development of these new technologies opened an access to society and areas of life, which were not accessible, or at least not accessible without others' assistance. The PC became a device at work and in private life: texts, which were available only in ink writing till then, could be used by the application of scanner and OCR software; extensive data collections were digitised available on data carriers; Dictionaries, Lexica, Encyclopaedias etc. were effectively usable for the first time; the electronic data transmission opened new communication areas; an access to multi-media-technology, especially in the audio-area, is opened; a comfortable and efficient organisation of private and vocational information is possible.

Fascinated by the technical possibilities, which a computer offers, many people see therein 'the absolute solution' and forget that that can be actually only one precondition. The target is obvious: By the assistance of the computer disabled people should be able to lead their own lives more independent and more easily.

The computer can enrich and change enormously the life of humans with disabilities. That can be exciting, relaxing and happy hours. In addition it can be the base for a vocational existence.

Besides all that the computer becomes more and more important as an instrument of (Tele-) communication. E-Mail and homepage became standard also in the private computer use. In education, occupation, school, study, spare time and culture computers become more and more irreplaceable. The whole bandwidth of computer-assisted procedures are led (in-) distinctly before our eyes.

Computers are tools. More exactly said: tool-boxes whereby each program can be compared with a tool which helps us to process an exactly defined problem. The fact to possess a large tool - box does not mean that thereby all problems are already solved. The computer is a new tool and our society must learn to deal with the new tools of communication and learning. In fact this is one of the most enormous challenges of our time. The secret of the success is situated in the ability how I can use the tools.

2 Virtual School

EUN Virtual School has been existing since February 1999 and has experienced a rapid and successful development. The European Schoolnet is a unique international partnership of 23 European Ministries of Education developing learning for schools, teachers and pupils across Europe. We provide insight into the use of ICT (information and communications technology) in Europe for policy-makers and education professionals. This goal is achieved through communication and information exchange at all levels of school education using innovative technologies, and by acting as a gateway to national and regional school networks.

Currently Virtual School consists of 20 subject-related and thematic departments with an editorial staff of more than 120 teachers, heads, teacher-trainers and researchers from 23 countries all over Europe. The motto of the Virtual School is "For European teachers by European Teachers" and the overall aim is the same as for the European Schoolnet: encourage collaboration between European schools, support the use of ICT in schools and foster the European dimension in schools around Europe. EUN Virtual School does not compete with national repositories or resource centres, but wants to complement them, and above all EUN Virtual School offers a European added value to content and contacts.

The Virtual School is "for European teachers by European teachers", and is a virtual meeting place for teachers to discuss and exchange material and experience. It is an excellent learning resource, featuring online events, activities, selected sites and online course modules. Use the Virtual School to add a European flavour to school life. The Virtual School is open to ideas, and encourages cooperation and contributions from the educational community all over Europe.

The Virtual School is part of the European Schoolnet, and encourages collaboration between schools in Europe. We support the use of information and communications technology (ICT) in schools, to make cooperation between schools in Europe easier. At the Virtual School, you can find the pan-European content and contacts you need to get involved in international education activities and projects. Virtual School in short numbers: 20 Departments, 120 Teachers, 23 Countries, 1000 Visitors per day.

2.1 Basics

The "teachers" involved in the departments are a good mix of teachers, teacher trainers, researchers, etc. Teacher students could possibly also be involved.

EUN Virtual School is a “grassroots” activity, its collaborators are active in schools, universities and teacher training institutions. It is a human and electronic network of people with extensive networks of their own.

Resources and services might include lesson plans, didactical discussions, comparative studies, projects to join, suggestions for partnerships, online activities for pupils and teachers, contests.....

English is for the time being the working language but material in other languages can be found on the EUN Virtual School web site. The ambition is, in the future, EUN Virtual School will be truly multilingual.

EUN Virtual School is a Swedish initiative within the European Schoolnet.

The Working group – the board of the Virtual School – meets about two times a year and consist of representatives from the countries which take part in EUN Virtual school by hosting or being responsible for departments. Any new country would automatically have a representative in the Working group.

2.2 Tasks-Aims

The Virtual Schools offers a range of educational resources such as small pieces of software, freeware, parts of a course, online lessons and discussions. Teachers can use these for free, whether for teaching purposes or simply to learn from the examples. Editors select the best and most relevant online resources, often suggested by teachers around Europe, and maintain a regularly updated archive.

Activities involve teachers and their pupils for an hour or a day on a variety of curricular topics. Events demand more preparation and participation time, and are offered in the departments each term. Discussion fora focus on different tools, themes or services offered in each department. Teachers are welcomed to submit anything from ideas for activities or events to fully-fledged online lessons. The Virtual School editors and web team make sure the material offered is relevant, safe and useful. European teachers’ organisations are linked to departments and interdisciplinary approaches, activities and projects are encouraged. The unique collaboration between teachers around Europe makes Virtual School an important human network as well as an electronic network of networks.

2.3 Departments

The departments are run by the Co-ordinator in the way the responsible country finds appropriate. Goals, aims and objectives are discussed by the Editing Team and carried out by the Co-ordinators with the help of the management team.

Most of the departments are subject related, like English or Chemistry but there are also thematically organised departments like Environmental Sciences, Library and Special Needs Education. Departments also often co-operate in projects.

Since the Planning Teams consist of teachers from all over Europe the European added value is there from the beginning. Projects and activities carried out in the department enhances this aspect and very often find its way to pupils and students. Being part of a Planning Team also means mobility for the teacher and gives teachers the opportunity to experience school environment and meet colleagues in European countries.

Editing Team meetings usually take place in a school, university or other educational institution with Internet facilities – this means good working environment at a small cost for the hosting country. Members of Editing Teams normally arrange their travelling to the meetings on their own. The travelling costs are reimbursed by the education-ministry of the Editing Team Member. Accommodation is covered by the department hosting country. Using business partners is one way of securing funds for a EUN Virtual School department on a national level.

2.4 Steering Team

The EUN Steering Committee consists of representatives from the European Commission, ministries of education all around Europe and beyond. The management team is based in Stockholm with frequent contact to the Working Group and the EUN office in Brussels. The actual members are: Austria, Belgium, Denmark, Finland, France, Iceland, Ireland, Israel, Italy, Luxemburg, Marocco, Netherlands, Norway, Poland, Portugal, Slovenia, Spain, Sweden, Switzerland, United Kingdom;

3 Special Needs Education

Special Needs Education is a department and a community within the EUN Virtual School for teachers from all over Europe, working with pupils with special needs. Here we will discuss didactics, how ICT can enhance the abilities for the pupils and ways in which we can develop further European collaboration. The SNE-Department is hosted by Denmark and Sweden.

Special Needs Education and other special-pedagogical assistance is given to children, whose development requires special consideration or support. We know that Special Needs Education can be arranged in different ways - from Special Needs Education in one or more subjects as a supplement to the general teaching, special classes or special schools for children with special needs, or inclusive education – therefore we want to discuss all these items. The ICT-work space about Special Needs Education will, among other things, hold information about: Early Intervention, Minimal Interference, Research in Methods and Materials about Special Needs Education, Special Themes will be presented, Individual Teaching Programmes for children and young people with special needs, Development of Special Teaching – including the use of ICT in education. We also want to create a network of information concerning further education of teachers who work with children and young people with special needs and we are intending to create a network of newest information about research.

3.1 Main Objectives

Our main objectives are to initiate a discussion about the European guidelines and goals in special needs education. That means

- Information about pedagogic material and researches that are made in special needs education.
- Collecting and changing information of different types of pedagogical support given to children with special needs
- Cooperation (changing information of educational plans, good practises etc.) of persons dealing with children in special needs education.

We offer good examples, didactics, disability links and we also present SNE Schools. The SNE-Website is a great platform for discussion, information, support and collaboration for teachers and pupils in the field of special needs education. We are place where educators can get and share all kind of information how to support students with special needs in their studies. Teachers and their pupils will benefit of that way of European collaboration:

- Teachers can find new ideas and new motivation to work also with the “New Technologies”
- Computer-based learning-environment offers new methods in teaching and learning
- Personally selected material supports teachers and pupils in individual ways
- Pupils and their teachers are taking part in activities of the SNE-department and have in that way the possibility to share own experience of using ICT in their environment. Here is also a place for pupils who often cannot compete with others.
- The increasing pool of articles supports teachers in many ways; not only in the use of ICT.

On the SNE-Website teachers find contacts with other teachers working in the same area of special needs education. They can find new webmaterials and information. Here SNE-teachers exchange experiences and material. We have the possibility to find new contacts in European level and we are having the possibility to discuss and ask others' opinions how to support students with special needs in their own class.

We can change experience, get materials, get contacts and support. Direct and effectful collaboration between teachers is possible.

3.2 Actual Topics & Visions

Here is the area the Editing Team is presenting and developing the contributions on the SNE-Page. In this field we also want to present the visions of the European collaborators.

- "Join Europe" is a project for pupils with special needs all over Europe, a project focusing on the pupils possibilities and on communication. On the theme "Build a world without obstacles" the pupils scan their drawings and paintings, take digital photos, record sounds and write texts.
- "Articles" about different aspects of special needs education. Experts report their experiences.
- "General links" to Special Needs research, institutions, education, information.
- "Disability links" to organisations working for different disabilities.
- "Special Needs Education Today" is a discussion-forum on how education is for disabled is carried out in the different countries of Europe.

- "Didactics and Good Examples" is the part within the web-site where SNE-teachers can find good tips and hints for their lessons.
- "SNE Schools" presents schools for pupils with special needs all over Europe.
- "Community" is the communication platform for educationists working with disabled pupils.

Of course all parts of the SNE-Website are updated regularly and the contents is steadily increasing. So here is the place where teachers find information, offer information, find support and collaboration, offer support and collaboration in a friendly ambient.

3.3 The Editing Team

Proper information, collaboration and professionalism are very important guidelines for the Editing Team. At the moment this team consists of 12 members: Maja Bodotter Myrup, Sweden (Co-ordinator) - Per Skov, Denmark (Co-ordinator) - Leonor Barroso, Portugal - Alexandre Font Bonastre, Spain - Barbro Oxstrand, Sweden - Walter Rainwald, Austria - Jyri Anttila, Finland - Pirjo Turunen, Finland - Ronald Kemeling, the Netherlands; Department Network: Marisol Illana, Spain - Irene Nilsson, Sweden - Karin Ohlis, Sweden. The main tasks of the Editing Team are

- Update the information (add articles, quality URLs, research, reports, ...)
- Provide the discussion in education and special needs
- Provide the national materials that are suitable for European level
- Contribute material
- Keep the web updated
- Keep the ,community‘ updated
- Offer European activities for students of SNE
- Offer collaboration

The Co-ordinators are the link between the management and the Editing Team and they set arrangements like team meetings or meetings with other thematic or subject related teams within EUN Virtual School.

4 Final Remarks

If life becomes better, it becomes harder – as we express it. We have more material prosperity, more liberty to communicate, more possibilities to travel more and more opportunities to operate our desires. But our options are more difficult, our responsibility is larger, the forces, which change our lives became more extensive and savage. Modifications would open new horizons, but also would wake fears, what is situated behind these new horizons. These modifications have deeply accessing consequences for the population, for the state and for politics. Technology and global financial markets change our economics. One would welcome that modifications and would be afraid of them at the same time. People require more assistance of the state, in order to master these modifications. The fight between capitalism and socialism is dead and buried. However renewed was the idea of collective values and common

tasks. The key to the accomplishment of the modifications is called reform. Reforms however must hold step with the modifications. I call the new economy the largest challenge. I think the most important property today is not oil any more as before twenty years, but information. Education is the all and everything in a society which is dominated by information and knowledge. Not only in schools and at universities, but occupation-accompanying the whole life. And this occupation-accompanying learning must be accompanied by crucial steps - particularly for people with special needs.

In the 1st half of the 21st Century there are many fundamental and categorical compressions of thinking concerning the digitisation of human beings: The occurrence of complex connections between reality and virtual reality, of consciousness, neural systems and computers. The understanding of human beings and society change basically. The categories "reality-virtuality-vision" become less distinguishable. Learning and operating in the Cyberspace develop to a new information and communication process. Existing institutional and - particularly for the blind - visible boundaries are exceeded or even resolved. And I think that is actually the "integrating power" of the computer. In this way the new technology receives larger priority for the integration for the handicapped in general and especially for the visually impaired. I mean independence and topicality are the principle terms in our considerations. Last not least the successful integration in education, formation and into the job market is one of the most important demands of our society.

The basis of this new policy must be to support people with special needs in the new economy - not to protect them but to give over them the possibility to move independently in this economics as active users.

I think it is also a part of a global and again new social problem: How does a society deal with minorities? How is society responsible for their special needs and how does society handle this task? Finally a handicap is always also a social problem.

Our systems of education are very different so therefore our ways of coping with students with special needs must also vary enormously. By Virtual School/SNE we can share ideas and experiences. The intention of the Special Needs Education Department of Virtual School is to offer a forum for teachers to learn from each others' experience.

In all aspects we want to make clear on the website that Virtual School/SNE is open to all teachers. The role of the Planning Team is the role of editors and facilitators and the aim is to reach as many teachers as possible and to encourage them to cooperate and take part online.

In this century I think we have the chance to create an open world, an open economy and an open global society with possibilities for humans with handicaps we have never had before. However we only will be successful, if this open society and economy are supported by strong ethics of mutual responsibility.

Tutorial Systems to Teach Standard Applications to the Learning Disabled

Michael Pieper

Fraunhofer Institute for Applied Information Technology (FhG-FIT)
Schloss Birlinghoven,
D-53754 Sankt Augustin
michael.pieper@fit.fraunhofer.de
<http://www.fit.fraunhofer.de>

Abstract. Educationally-conditioned differences in computer use increase dramatically. Technology and society critics in this regard object the progressive informatization of all areas of life to lead to a new social splitting. Like all end-users of computer systems, pupils also approach new application software with different technological experiences and different insight ability. Some need only few minutes, in order to intuitively understand the improved handling possibilities of a new user interface, a new system version, or a completely new application system. Non-intuitive and especially learning disabled pupils need more time. In this regard, first of all further research efforts are required in order to be able to offer ability and talent-adapted help systems and accordingly adapted dialogue interfaces.

1 Introduction

In the mid-90's of the last century German society and politicians became aware of the important role of the educational sector for the development towards an Information society. Consequently, a large variety of activities have been started to prepare pupils for this future. Most of these ongoing actions are performed in public / private partnership.

The first bundle of actions, to a large extent publicly acknowledged because of many government publications and PR-activities, is focussing on IT-infrastructure in schools, e.g.:

Schools on the Net: Sponsoring InterNet access and activities. Very recently, the German Ministry of Education has communicated the successful completion of this program; by the end of the year 2001, 99% of German schools will have access to the InterNet (as against only 15% three years before) (see ComputerZeitung, 2.11.2001);

Market place for schools: Sponsoring second-hand PC equipment. There is still a wide gap between the large demand from thousands of schools and the small number of used PC's offered for free by private companies;

Electronic Classroom initiatives: Different actions, often limited to few selected sites or only one school; e.g. equipping a school with mobile units consisting of 4 PC's, or with a notebook for every pupil.

A second bundle of actions, less known in the public and even among teachers, is orientated towards software equipment and applications, e.g.:

SchoolWeb: An InterNet portal for all types of schools, offering learning materials and communication features;

NetDays: A competition and exhibition of school projects, organised as a virtual event on the Web, but until now limited to some of the Bundeslaender (German states);

Learning Software development and distribution: Also very recently, the German Federal Ministry of Education has (ed that this will become the focal point of future actions; more than 300 Mio. Euro are provided for this purpose (see ComputerZeitung, 2.11.2001).

Current evaluations of these ongoing actions predominantly show impacts on graduate schools. Special schools like those for the learning disabled are largely out of concern. The reasons for this disadvantageous development might be different:

Public awareness of special schools for the learning disabled is smaller and they are not so attractive for education politicians as well as for private companies whose sponsoring activities often depend on image aspects;

the actors of special schools for the learning disabled (administrators, teachers, parents) have internalised their modest role of a "silent minority" and don't assert their needs in the same way as the actors of graduate schools;

even if these special schools reach the normal hardware standard, they cannot make use of the offered software because it is not adapted to the special educational needs of the learning disabled.

Thus the well-meant measures for promoting IT at schools contain the risk to intensify the Digital / Educational Divide to the debit of the learning disabled. To avoid this risk it seems necessary to examine more closely their special situation and needs.

2 Learning Disability: The Invisible Handicap

In contrast to other disabilities, like blindness, vision-, motor- or even mental impairments a learning disability does not become immediately obvious in daily life. Thus normally public awareness of this problem is deficient because a learning disability lacks overt symptoms of physical or mental illness.

Nevertheless, learning disabilities occur more frequently than assumed and affect different cognitive and sensu-motor skills, e.g.

- perception;
- memory;
- concentration;

- motion;
- reading / orthography;
- math skills etc.

Often a learning disability becomes a complex problem when several of these handicaps bundle in one person and nearly as often other (social) problems contribute to or result from learning disabilities, e.g.

- low income household resp. unemployment;
- lower class neighbourhood;
- broken family;
- foreign cultural origin (language / religion).

Regularly learning disabilities have a negative impact on...

- school career;
- social acceptance;
- chances on the labour market;
- and (last but not least) self-confidence of the young person.

It is obvious that – under the circumstances and demands of the upcoming “Knowledge Society” – especially the learning disabled are suffering from a key handicap to which the society must pay more attention than ever.

3 Transferring Knowledge How to Apply Standard Software to the Learning Disabled

Applying computers in special schools for the learning disabled is exposed to expectations, which reach beyond pure transfer of school knowledge thereby recovering learning impairments. It considers the value of the computer in our society as a means of communication and work – social domains which are especially problematic for the learning disabled.

Because of its over years further widespreading use the InterNet offers possibilities of including the computer into almost all learning areas. Thus, the school is no longer an isolated learning place, but may be included by the world open-endedness of this new medium into the surrounding society.

Simultaneously school again becomes interesting and attractive for pupils, who have lost fun and interest in school learning. The highly motivated readiness to learning, which is evoked by computers as a learning tool can hardly be obtained from other learning media. Therefore the computer itself can most easily be used to advance learning disabled pupils' basic IT knowledge.

Of primary importance in this regard is knowledge of how to control keyboards, Windows® GUIs, text processors as well as knowledge about meaningful and responsible use of the InterNet.

However, because commercially available instruction programs are too extensive and their dialogue structure is too complicated they are not oriented towards the special needs of learning disabled pupils. Therefore it appeared meaningful to develop a plat-

form independent HTML-based instruction program which could be offered off-line as well as in an InterNet-based teleteaching environment and which is one hand adapted to the learning disabled pupils' special needs and on the other hand as much as possible based on generally acknowledged criteria for learning software (Humboldt Universität 2001).

3.1 A Tutorial System for Standard Software Competence Extension for the Learning Disabled

Because textprocessing is still the predominant standard application, the Gutenberg School selected "Word for Windows©" (Microsoft) as an example for such a tutorial systems to introduce standard applications to the learning disabled

The necessary tools to design such a tutorial program are either available on PCs with standard office applications (e.g. InterNet Browser with HTML wordprocessor, text processing program) or can be downloaded as Freeware from the InterNet (e.g. "Hot Potatoe[®]" for designing query sequences, "Snap program" to integrate illustrations into sequences of subject learning).

According to the already mentioned criteria of learning software a HTML-based tutorial system, is to a large extent linear organized by hyperlinked instruction sequences for subject learning. Nevertheless there are possibilities of branches within a hyperlinked tree structure which allow e.g. repeating a knowledge query at a self-chosen point in time. The basic structure however remains linear. Thus, pupils have only limited possibilities to deviate from the general learning sequence, which in the case of the learning disabled is intended to avoid confusion caused by getting lost in complicated Human-Computer Interaction structures.

Structurally the tutorial is divided into two parts. First it presents learning resp. teaching-subjects, afterwards it checks comprehensibility of these subjects. Thus a typical learning sequence of the tutorial system exists in the presentation of teaching-subjects, which is graphically supported. Graphics however relate only to substantial constituents of subject instructions. They are partly also additionally explained by textual circumscriptions.

Subsequently, comprehensibility of taught subjects can be checked. In this context the freeware program "Hot Potatoe[®]" was used, which offers different possibilities to check knowledge by asking to fill in or allocate gap text, solve corresponding cross word mysteries, answer multiple choice questionnaires etc. Because it follows the same HTML-structure on its application layer "Hot Potatoe[®]" can easily be integrated with the teaching-subjects module.

Afterwards pupils' responses are analysed. False responses are indicated with possibilities to either return to the subject-presentation module again or repeat the comprehensibility check. Subsequently, the next subject-presentation unit can be accessed.



Fig. 1. Presentation of learning-subjects concerning “Word for Windows[®]” main menu “Views”

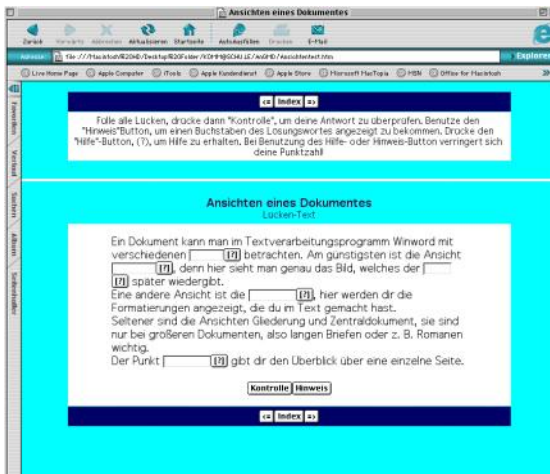


Fig. 2. “Word for Windows[®] –“Views”” comprehensibility check with “Hot Potatoe[®]” form filling requests for ‘gap text’

Above all, it is important that single distinctive learning steps have a limited amount of learning subjects and that well defined training objectives are attainable and recognizable for the pupils. This kind of evolutionary target-achieving learning is of high value for learning disabled pupils with many frustrating learning experiences.

However, the advantages of evolutionary target-achieving learning become effective only if the tutorial system complies to appropriate software ergonomic standards, which apply to instructional education of learning disabled-pupils in general (see.

Stolze, 2000). First of all these design standards refer to the dialogue structure and HCI modalities, e.g.:

easy operability of the entire program
 consideration of childlike learning modalities
 clear task description
 easy to understand examples for exercises
 economic use of animation programs for additional assistive instructions only
 multimodal content representation (image, text , speech)
 clear (multimedia-) instructions
 Context sensitive help
 UNDO/REDO everywhere and anytime
 INTERRUPT (Pausing) everywhere and anytime
 Adjustable Length of the learning sequences
 adjustable learning speed
 different degrees of difficulty
 Immediate feedback after (sub-) task accomplishment
 personalized achievement protocol / achievement related enquiry options
 conventional instruction handbook to the program

For the special target group of learning disabled pupils it furthermore turned out to be of relevance that user interface design of tutorial systems is compliant with certain standards for display ergonomics and content adaptation, e.g.:

- clear and unique screen layout
- cleared up desktop organization
- neutral, eye-friendly colours of the background
- large enough fonts
- read-friendly, short texts
- clear pratical sentences, no hypotactical sentence structure
- no termini technici or other understanding barriers

Accordingly, it should be avoided to use most current plug-ins to attract pupils by vivid and fancy multimedia animations as it has become common in large parts of the InterNet. It is rather necessary to return to simplicity in software and user interface design. Each additional information disturbs the learning process, which – in the case of the learning disabled is anyway burdened by missing mental flexibility, deficient vocabulary, and deficient evaluation of different syntactic and semantic meanings of letters and words according to their position in a sentence. Much of the multimedia possibilities which fascinate an average user are thus wrongly applied in learning environments of learning disabled pupils.

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The Vickie Project

Visually Impaired Children Kit for Inclusive Education

Dominique Archambault^{1,2} and Dominique Burger²

¹ INSERM U483 / INOVA, Université Pierre et Marie Curie
9, quai Saint Bernard, 75 252 Paris cedex 05, France

² Laboratoire d'Informatique du Havre, Université du Havre
BP 540, 76 058 Le Havre, France

Dominique.Archambault@snv.jussieu.fr

<http://inova.snv.jussieu.fr/vickie>

Abstract. This paper provides a general introduction to the Vickie Project, aimed at facilitating the inclusion of visually impaired pupils and students. An unified user interface will allow the pupils and students to access documents with specific devices, and a synchronised graphical display will supply sighted teachers with a view of the same document. A set of tools will allow compatibility with existing school contents and services. This paper describes the general orientations inferred from a users' needs study.

The social and cultural inclusion of handicapped persons is one strong objective of European social policies. Inclusion in school and universities is therefore an essential step in this direction. In some countries, like Italy and Sweden for instance, the integration of handicapped students in mainstream education has been a general rule for many years. In other countries, like France, there is a trend to encourage this movement in developing intermediate structures in which young children are prepared to join ordinary schools (the French "*Handiscol*" program[1] for instance). In the future, these orientations should characterise most of educational policies over European countries.

Vickie's main commitment is to provide a technological environment facilitating the inclusion of a visually impaired student in the mainstream education.

Vickie is a R&D project funded by the European Commission, on the Information Society Technologies Programme, including research organisations, industrial companies and user organisations from three countries: France, Ireland and Italy. The Vickie Consortium includes: *Inserm U483 INOVA*, *Université Pierre et Marie Curie* (France), co-ordinator, *Association BrailleNet* (France), *Regina Margherita National Library for the Blind in Monza* (Italy), *Centro di Ricerca, Sviluppo e Studi Superiori in Sardegna* (Italy), *Daumas Informatique* (France) and *St-Joseph's School for the Visually Impaired* (Ireland).

In this paper we will introduce the objectives of the Vickie project. Then the users' needs study will be summarised. Finally the general orientations for the software developments, which were extracted from the resulting data of this study will be presented.

1 Objectives of the Vickie Project

1.1 To Help Visually Impaired Children into the Digital Age

Visually Impaired Persons have to master new technological tools to be capable of playing fully their role in the Information Society. Therefore early training in computer activities has to be set up from primary schools and during all the educational process. For instance, Vickie will provide simple services allowing children to communicate by electronic mail with other children, family members, teachers...

Vickie will work out new concepts for the progressive learning of standard computer systems. This includes strategies making possible for children or beginners to smoothly approach the access technologies. This involves the identification of users' profiles and the development of personalisation tools.

1.2 More Accessible Learning Documents

In the information society, most of the learning materials are produced in a digital form from their origin. Moreover, the generalisation of standard and structured electronic formats constitute a suitable basis for the production of document files for non visual presentations. These files can be read on a Braille display, by means of a speech synthesiser, on a computer screen, printed with the suitable size font, or embossed on a Braille printer.

Vickie will develop a set of tools and an environment making possible a better co-operation between various professional ranging from publishers to transcription/adaptation specialists. Vickie adaptation tools will make possible to create an adapted document from the electronic source focusing only on the part that has to be redesigned for the special needs of the visually handicapped (images, graphs, tables...). The integrity of original documents will be maintained and their trace will be monitored precisely throughout the adaptation process. This will contribute to lower one of the major barrier currently encountered by schools and transcription centres in getting authorisations from publishing companies.

A standard structured format will be used. It will suit the great variety of documents that students have to access at school/university: course material, books, notebooks, administrative information, Web pages. This format will be based on XML and will allow to produce different output formats according to the use (for instance printed Braille, or VoiceXML, or HTML that can be read by a textual browser — respecting the WAI accessibility recommendations).

1.3 To Make Transparent the Written Communication

Written communication is central throughout education. An argument for the creation of special education was that the blind use a different system for reading/writing. In fact, Braille is a special font and a set of rules for abbreviating words. Thus, technology can make this difference totally transparent thanks to well designed interfaces and personalisation tools. As Vickie will propose a

unique format and a standard interface, it will be very simple for visually impaired students to create documents that sighted teachers can read, and to read the corrections made by teachers. Also, students will have facilities to communicate with their peers. The editing tools will be used for the creation of accessible material. Sighted teachers will easily create documents that can be printed or read indifferently on a screen, a tactile or audio device.

1.4 Co-operation between Teachers

The inclusion of handicapped children in ordinary school means that a part of the experience that teachers of special schools had may be lost. The development of technological networks opens new ways for sharing and reinforcing expertise among professional actors. For instance, teachers can take part in discussion groups, in net meeting, or follow long distance training. Vickie will explore this direction with the objective that teachers having a specific experience may assist colleagues and improve the common experience. The accessible interface of Vickie will make possible sighted teachers to receive/bring assistance from/to their visually impaired colleagues. For instance, a teachers would not have to be an expert in Braille, provided he/she could benefit from the experience of others. Vickie will also provide a software architecture and a unique service interface in order to encourage exchanges in software teaching tools among the teaching community. This architecture will be open as to allow the upgrading of services through the Vickie network. New services will be easily added, as well.

1.5 Multi-linguality and Cross-Culturality

Vickie will take into account the multi-cultural aspect of the project. Particularly the different policies in the different countries will create suitable condition for designing several models of teaching networks. The project will put an emphasis on the exchanges between schools among the three countries concerned. The evaluation methodology will be discussed in full detailed among the partners concerned with education in the different countries and the results will be shared, as well.

1.6 Effective Diffusion

The approach to effective diffusion is to produce a pre-industrial prototype that will be proposed to schools, training centres and companies employing visually impaired persons as soon as the project is finished. Tests carried out in schools will put an emphasis on usability by naïve users in order to reach a user-friendly product at the end of the project.

2 Users' Needs Study

The users' needs study is split into 2 parts. A first part, during 6 months, was planned to produce a report based on analysis of existing systems and on the

experience and requirements of end-users. This report is the basis of software developments. Then the users' needs study will continue during the 12 next months in order to produce a final Users' Needs Report. This study cannot be considered as an end-point. It would not be realistic to pretend that all the features of the future Vickie system can be thoroughly described from these inputs only. Rather, this study proposes directions for designing the Vickie system and defining its functionality. Finally the development process follows an iterative development paradigm involving permanent interaction with end-users so that technical decision can be updated during the project.

The study was conducted by *Biblioteca Regina Margherita* which has been playing a pioneering role in supporting the integration of visually handicapped children in Italy for nearly 30 years. *Biblioteca Regina Margherita* co-ordinates a network of 13 resource centres in Italy. In France it was run by the *BrailleNet Association*, which involves many schools and resource centres as well as associations of/for the visually impaired persons. In Ireland it was run by *Saint Joseph's School for the visually impaired*, which acts as a national supports centre for integration and as the National Braille Production Centre.

2.1 Three Types of Users

The users' needs focuses on three types of users. The first type concerns visually impaired students and pupils (*VISP*), from various ages and with various levels of visual impairment. The study describes the features that are requested to allow them to be integrated in an inclusive classroom, to work using their particular display, during the main activities that happen in a classroom. It includes all the documents that they need to access, like school books, dictionaries and documents provided by teacher, etc. The second type of users are teachers. The study describes the features enabling the teacher to access to the work of the *VISPs* and to give them feedback, the tools that they should access in order to prepare documents in an accessible way. The third type of users are professionals who transcribe school books for the blind. The study deals with the tools they need to prepare documents for the Vickie system and tools that facilitate the distribution and the storage of documents, and the co-ordination of work.

2.2 Methodology

This study took into consideration different sources of information:

- *The analysis of existing systems*
 - specific software existing in Italy: *Erica*[2] and *Omnibook*[3];
 - the use of computer in several special schools in France;
 - the tools developed in several transcription centres in France;
 - a review of existing school mainstream portals and electronic contents.
- *The experience and requirements of end-users*
Two questionnaires were prepared (one for teachers, one for students) in order to identify:

- the current use of technology among students and teachers;
 - what technology is commonly used for in the educational setting;
 - successes and failures of current technology;
 - expectations concerning the proposed Vickie system.
- *Technical recommendations* elaborated by *Biblioteca Regina Margherita* on the basis of their experience
 - *Legal definitions* of visual impairment in the different countries.
 - *Three “Use Cases”* — corresponding to the three types of users defined previously. They describe concrete situations where the Vickie environment should provide solutions to identified problems.

3 General Orientations

From the analysis of these data, general orientations for the software developments were extracted. These orientations concerns the user interface, the services that should be provided, the software architecture, but also a few features like secure access to data.

3.1 A Document Oriented Metaphor

The aim of the metaphor is to allow the teacher to communicate with the *VISP* in the same way he/she communicates with the sighted pupils. The interface should display objects that symbolise the physical objects that can be found on a physical pupil display: books, notebooks, dictionaries, a diary... Then it should be coherent with statements given by the teacher, like for instance: “open your book of math on page 25”, “open your English notebook” or “write in your diary the following exercise: ...”. It should also allow the *VISP* to deliver documents to the teacher, or the teacher to give the *VISP* a document he/she has prepared for all pupils.

A lot of specific features should be provided like for instances the possibility to copy a part of a document into another, the access to virtual libraries, with secure access to books with intellectual property right. For instance, it should also give access to the local school computer services (if any), as well as school portals and school contents that can be found on the Web.

3.2 Software Architecture

To allow these features, the software architecture should be modular and interoperable. It has been decided to use an architecture of services that can be accessed through a unified user interface (see section 3.3).

Each service is dedicated to a specific task which correspond to a specific kind of object. These objects often correspond to documents: book reader, dictionary, notebook... But it can also be a game or the desktop. In the case of documents, the architecture identifies the service that should be used to access a given document, then to launch it. The architecture manages all objects. At any time

only one object is displayed, but many can be opened and it is possible to switch between them, to close one or to open a new one.

The currently displayed object is processed by its corresponding service and the data that describes one reading unit is sent to the user interface. A reading unit refers to what should be displayed on the teachers display, for instance one page of a book or a notebook, one entry of the dictionary. The data exchange between services and user interface uses a specific XML-based format.

The software architecture is distributed: the services are published on a service portal and deployed from an application server. The particularity is that once a service has been deployed from the application server, it can be stored in a local cache to be used when the computer is disconnected (for instance at home if the pupil uses a laptop that he bring back home). In this case, a light version of the application server is launched locally. Obviously this concerns only the services which do not need access to network resources.

A full description of the software architecture is given in another paper in this volume[4].

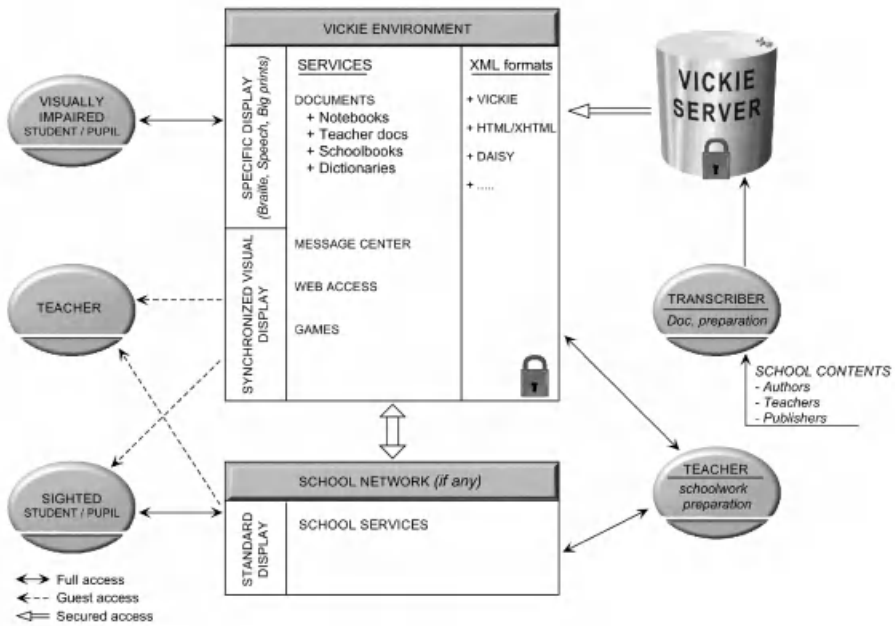


Fig. 1. The Vickie Environment

3.3 Dual Display User Interface

The user interface for *VISPs* in the Vickie environment should provide two synchronised displays: the first one is used by the *VISPs* and the other one allows sighted persons in the classroom to access to the *VISPs*'s work.

The *VISP* display is specific and allows all necessary settings to fit a user profile. Three different kind of output devices are considered:

- Braille displays
- speech synthesis
- screen for adapted visual display (size of the prints, colours of the foreground and the background, space between characters and/or lines...).

The visual display will allow to show the *VISP*'s desktop in the same way that the physical desktop of sighted pupils can be seen. It will display the content of the current document that is been read by the *VISP*, localising the part that is currently viewed on his specific display. In the case of partially sighted pupils, the best situation would be to have two physical screens but this can be simulated either by the possibility to switch between the 2 displays or to divide the screen in 2 parts.

The input devices will include standard devices as well as specific ones: standard keyboard; Braille keyboard; standard mouse; Braille cursor routing keys.

3.4 Compatibility and School Preparation

Compatibility with existing systems and formats is a very important issue. Several cases should be taken into account:

- internal school networks allowing to access to some services;
- existing electronic mainstream formats available for school contents or electronic books;
- existing electronic specific formats (like DAISY[5] for instance).

In the case of existing school network services, it is mandatory that these services respect some accessibility guidelines (in the case of Web-based systems for instance, the WAI[6] should be respected).

In the case of mainstream documents, specific adaptation is often necessary for some graphical or complex elements , like pictures, graphics and tables in a book of geography. These adaptations are usually developed by professional transcribers that work in resources centres or special schools. Vickie will provide tools allowing to annotate the contents with adapted contents and to coordinate the works of professionals.

The Vickie environment will also provide tools to be used by teachers for their work out of the classroom (school preparation or exercises assessment), and professionals that transcribe school contents. One very important concern is that users should be able to use the same tools they usually use. For instance if a teacher usually designs the documents he/she gives to pupils with a given word-processor, he/she should do the same if one of the pupils uses the Vickie environment. Then he/she should be supplied with tools that make the transcription into a document format that can be accessed by a Vickie service.

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More information about the Vickie project can be found at:
<http://inova.snv.jussieu.fr/vickie>

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¹ The contents of this paper is the sole responsibility of the authors an in no way represents the views of the European Commission or its services)

Using Adaptive Hypermedia to Evaluate Basic Arithmetic Skills in Special Education

Jaakko Kurhila and Hanna Varjola

Dept. of Computer Science, PO Box 26, FIN-00014 Univ. of Helsinki, Finland
{kurhila,varjola}@cs.helsinki.fi

Abstract. An adaptive system AHMED is designed to serve as an environment for learning in special education. The system has also support for teachers or other experts involved in the education for observing and evaluating the learning processes of individual learners. The paper describes the system and presents the test material for evaluating basic prerequisite skills for learning arithmetics, namely number word sequence skills. The results are reflected against the standard neuropsychological tests.

1 Introduction

Although the use of computer software in special education is well-reported, the use of adaptive systems in special education is not common. Standard one-size-fits-all systems have been useful, but the special setting could benefit more from an individualization provided by adaptive learning environments. One possible approach to design an adaptive learning environment is by using adaptive hypermedia. Adaptive hypermedia means supporting the navigation by recommending the links or choices individually to the user, or by presenting the material to the user in different forms [2].

AHMED is a research project and a system that uses a novel form of adaptive hypermedia to provide individualized learning experiences for every learner [3,4]. The organisation of the material to the learning material space and the tracking of the actions of the users in the material provide a way to use the system in a different manner compared to many existing adaptive hypermedia-based learning environments: the progress of every learner can be derived from the use of the system for evaluational purposes.

2 The System Description of AHMED

Intended users of AHMED are learners with deficiencies in mental programming [3]. Deficiencies in mental programming mean, for example, difficulties in organizing tasks into meaningful parts, figuring out problem solving strategies, or keeping up the attention throughout the task [8]. The deficits occur often with developmental disabilities. However, the applicability of AHMED to other contexts is clear since the problems in mental programming are present to some extent in each of us.

AHMED relies on two principles: adaptation to individual learning processes and domain-independence of the learning materials. Adaptation is based on the actions a learner makes during a learning session in the learning environment. Domain-independence is assured by separating the adaptation mechanism completely from the domain knowledge, and allowing the learning material creation by a generic structured documentation language based on XML.

The key issue in our learning environment is to lead the learner through the hypermedia learning material (which we call a *learning space*) so that the most suitable learning material is exposed to the learner. To activate the learner, the material typically consists of various *tasks*, not just information items.

The learning space in our framework has a certain similarity with an n -dimensional hypermedia structure or the vector-space model for information retrieval [7]. The learning space has nodes (which we call *learning seeds*) that have a distinct position in the learning space. The difference between the learning space in our framework and the standard hypermedia is that there are not (necessarily) links between the nodes (seeds) in the learning space. Instead, the seeds have their position in the space, defined by a numerical parameter for every dimension. As a simple example, a learning space consisting of arithmetic exercises might have two dimensions, namely Addition and Subtraction. In such a case, the first exercise "What is $1+1$ " might have a position of $(0, 0)$ along these dimensions. However, the seeds can include hypermedia elements, i.e. texts, multimedia etc, as well as interactive elements such as games, simulators, quizzes, exercises, tests, as well as links to URLs.

The learner is represented by a point in the learning space at a given time. The *action* or the *choice* a learner can make within a seed moves the learner to the seed that matches the learner's previous point in the space added with the effect from the last action. Thus, if a learner in the learning space is located at point (x, y) and makes a choice with an effect $(+1, +0)$, the learner is taken to a point $(x+1, y+0)$. If there is no seed in that particular point, the learner is taken to a point where the Euclidian distance to the point is the shortest. It should be noted that the choice in a seed can be other than answering a multiple choice question, such as selecting a subset from the given choices, even specifying their order.

Continuing the simple example above, a seed with a question "What is $1+1$ " can have action (answers) "1", "2", and "3". The action "2" for the question could be parameterized to have an effect of $(+1, +0)$ to the learner's position $(0, 0)$ in the learning space. In this particular case, the learner is considered to be ready to proceed in the dimension for "Addition skills" but subtraction skills cannot be evaluated from the answer so the effect for the "Subtraction skills" dimension is zero.

During a session, the learner's actions are recorded. Not only the most recent point is saved but also the whole history, so this record of a learner forms the individual path through the learning space. Therefore, the learner is not modeled as a mere point in the space but as a trail through the space. This recorded trail

is a *profile* of the learner, which can be represented visually and can be used for evaluational purposes.

An additional feature is that every seed in the learning space can consist of an arbitrary amount of seeds within that seed, connected to each other with traditional hyperlinks. This approach is chosen because it adds to simplicity when authoring the learning material, but also because it enables easy preparation of ready-made sub-problems to original problems that might be too challenging for the intended users. Supporting subtasking of problems is in harmony with supporting mental programming of the learners.

3 Study Setting

3.1 Description of the Test Material

The functionality of AHMED's learning space schema was tested empirically¹ by constructing a learning space for evaluating two of the key components for number word sequence for children with cerebral palsy. Number word sequence skills are prerequisite skills for elementary arithmetics. We call the constructed learning space the *test space* from here on.

Authoring a learning space to AHMED is technically relatively easy using the description language designed for the purpose. The difficulties lie in the conceptual design and are amplified by the freedom for the learning material author: there are no restrictions for what kind of dimensions to use, what the positions of the seeds in the learning space are, what the actions within the seeds are and what the effect of every action is [4].

The test space was deliberately designed to be small and simple to make the evaluation of the use of the learning space schema more straightforward. Only two dimensions were chosen for the test space and the size of the space was only 5-by-5 seeds. The dimensions had a certain "metric" and were enumerative, i.e., there was a clear order for the seeds in both dimensions.

Although number word sequence skills are said to be including at least four sub-skills [6], only two of them were chosen to be included in the test space. The sub-skills chosen to be dimensions in the test space were "The capability of the working memory" and "Step-size for enumeration". In the scope of this study, working memory means the group of systems associated to the short-term memory functions [1]. The capability is essential in many cognitive functions, such as reasoning, learning and comprehending. The step-size for enumeration means the capability of enumerating strings of numbers forward in different step-sizes, for example 1,2,3,4,... or 1,3,5,7,... where the step-sizes are 1 and 2, respectively. Using these dimensions for the test space has two benefits: they are easily ordered along the dimensions, and they are independent of each other.

¹ The authors wish to thank the neuropsychologists, special teachers and the learners at the Ruskeasuo School for their help and understanding in designing and organizing the tests, as well as neuropsychologist Pekka Räsänen from the University of Jyväskylä for the original idea.

Because the author of the material has the freedom to choose the effect for every action, two types of effects were tried out. For both test spaces, the correct answer had an effect of $(+1, +1)$ for both dimensions. However, the "optimistic" test space never drops the position of the testee, even in a case where there is an error regarding both of the dimensions $(+0, +0)$. In a case where there is an error regarding only one of the dimensions, the value for the other dimension is raised $(+1, +0$ or $+0, +1)$. The "pessimistic" test space raises the values only when the answer is correct regarding both the dimensions (effect of $+1, +1$), and drops the value in case of an error for one dimension $(+0, -1$ or $-1, +0)$ or two dimensions $(-1, -1)$.

3.2 Descriptions of the Testees

All the testees are motorically disabled and use wheelchairs. They have cerebral palsy and they are all male. The description of every testee (below) considers the aspects that are relevant to the use of the test space. The descriptions are based on personal neuropsychological evaluations conducted by a professional neuropsychological tester, but they are abridged and simplified. The neuropsychological tests have been carried out during the testees' school years, and the most recent test results are from January 2002.

Testee 1 has significant difficulties in gazing; the gaze "drops" easily and starts again arbitrarily. This leads to difficulties in reading, when the testee has difficulties in staying on the line and return to the most recent point after the gaze drop. The testee also has deficits in mental programming. However, the testee does not have difficulties in perception. The testee also has learning difficulties and difficulties concerning the memory. The testee's working memory is volatile to outside impulses, but the size of the auditive working memory is up to six units forward.

Testee 2 has difficulties in reasoning when given oral or written instructions and the vocabulary is limited. Visual reasoning is difficult and failing to complete a task is especially hard. The testee can concentrate for a long period of time. Auditive working memory is a size of five units forward. Visuo-spatial perception is difficult, especially finding the essential in visual exercises. The testee understands oral assignments and is capable of remembering given instructions.

Testee 3 has learning difficulties but learns best via the auditive channel. Using the gaze is also difficult. The thinking is impulsive. As in learning, associations help also when memorizing. The testee has difficulties in arithmetic exercises and in logical reasoning, e.g. has not been able to learn multiplication table or more complex addition (e.g. when two additives form round numbers as in $23+77$). Instructions and things learned are easily forgot. The testee is motivated and tries hard to succeed.

Testee 4 has difficulties in attentiveness. The use of language is good but processing the language is difficult (i.e. to take instructions, memorize, and recall). The testee gets tired easily. Visual ability suffers from persevering: the gaze can be "stuck" to a point. The concept of time and numbers have been difficult. The

most notable difficulties concern perception and mathematical abilities. Numbers "rotate" easily and comparing the greatness of numbers is also difficult.

3.3 Test Setting

In every session, there were two testers present and the testee. One tester stayed with the testee by the computer, and the other tester stayed silent in the background taking notes. If the testee had trouble reading the instructions, the tester by the computer read the instructions out loud once. If the testee had difficulties using the mouse, different input devices were used, including a track ball and a single-switch input device. If it proved to be too consuming to find a usable input device, the tester used the mouse to pick the objects according to the instructions given by the testee. The testees were free to quit at any point.

The tests were carried out twice for each testee to find out the effect of different input devices and the different test spaces ("optimistic" and "pessimistic" test spaces). Other than that, the test setting was exactly the same. There was roughly a month between the first and the second round of tests.

4 Test Results

The test results from AHMED are shown visually in Fig. 2. The upper row ('A') presents the first round of tests and the lower row ('B') presents the second round of tests. A black rounded rectangle represents a test question with a correct answer from the testee to both of the dimensions or for just one dimension. A patterned rounded rectangle represents an answer which was wrong for both of the dimensions. Empty rounded rectangles are test questions that were not visited by the testee.

The test space was organized so that if a testee answers all the presented test questions correctly, the testee traverses along the diagonal from the point (1,1) to the point (5,5) and answers only to five questions altogether. If the testee cannot answer correctly, he or she will diverge from the diagonal. The interesting issue to watch is to which part, upper (stronger in working memory) or lower (stronger in step-size), the testee will diverge.

Testee 1: The first round of tests was conducted using the pessimistic test space. The instructions were read once to the testee and the choices were made according to the instructions given by the testee. On the second test round, optimistic test space was used and the testee used a single-switch input device. This time the testee was able to progress better, since the test space was less punitive. For both the tests, the testee was showing more progress to the working memory dimension.

Testee 2: At the beginning of the first test round, the testee stated that "it is very hard to read from the screen" but had no trouble seeing the objects or reading the instructions when they were short enough. For more complex test questions, the instruction was read to the testee. The testee was highly motivated to succeed and was tired after the test. On the second test round, the testee was

not motivated since the test appeared to be the same. The testee was not happy with any of the input devices, so the tester used the mouse according to the instructions given by the testee. When comparing the two test results (both with optimistic test spaces), it was clearly shown that the second time the testee was not as motivated anymore. The testee still went on answering the questions but was willing to quit sooner when the questions became more difficult. The result from the first test showed very good capabilities for the test. Testee 2 is the only one not biased towards the working memory dimension.

Testee 3: The first test was conducted using the pessimistic test space. The progress was not as rapid as during the second test round when optimistic test space was used. The early mistake in point (2,2) during the second test was an involuntary mistake caused by the deficiencies with the accuracy of single-switch input and scanning of choices. As is the case with testee 1, the results for testee 3 tend to be more emphasized on the working memory dimension. The instructions were read out loud by the tester.

Testee 4: The optimistic test space was used for both of the tests, and the trails are much the same. The stronger dimension is clearly the dimension for the working memory. The instructions for both test rounds were read out loud, and for the second test round, the testee used a single-switch input device.

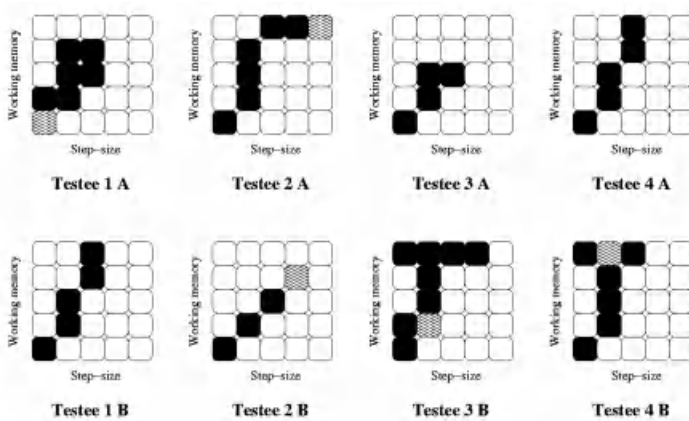


Fig. 2. Figure of trails of the testees

However, it is advisable to take the test results with a grain of salt. As stated in [4], in reality the learning spaces are rarely homogeneous in terms of similar metrics for every dimension. For example, the test space had apparently an enumerative working memory dimension, but is there a direct mapping from the memory units to memory units on the screen, since different variables (shape, colour, location on the screen) were used for the same purpose in the working memory dimension? And, is the metric for the step-size dimension comparable to

the working memory dimension (a step in step-size is the same level of achievement as a step in working memory)? However, when the learning space is used for giving additional information rapidly and not a basis for some critical evaluation, the use of a test space can bring benefits by giving comparable guidelines for a teacher.

5 Conclusions

Using a computer as a tool to test human abilities is possible when the limitations of a computer are acknowledged. The computer does not possess such sense for nuances as human experts for interpreting subtle cues as facial expressions. The key issue is to rely on and exploit the benefits offered by a computerized environment. The test environment with a computer is value-free and the computer acts the same for every testee regardless of the interpersonal or other issues involved in situations where there are two humans present. The computer is not affected by the long hours spent in a testing situation. It might also be possible that using a computer for neuropsychological testing can reveal issues missed in standard face-to-face neuropsychological testing.

The value of the learning space schema to the evaluation of learner's abilities is that the evaluator (teacher) can see the overall picture of the testee by a glimpse at the test results. The challenge is to prepare material that gives information that is usable and accurate enough. It is clear that the test results should not be used as standardized test results, but more as a guideline for the non-expert of neuropsychology so that he or she can benefit from the results. For example, a special teacher in mathematics could use the information during the teaching process. Similar systems for testing exist for special teachers, but the content is often fixed. The power of AHMED is that the same system can be used as a platform for learning as well as testing, and only different learning spaces have to be prepared (see [5] for an example). When using AHMED as a learning environment, the same ease of using the trails as basis for evaluation applies to assessing learning.

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ICT and Assistive Technology in Teachers Education and Training

Ewald Feyerer¹, Klaus Miesenberger², and David Wohlhart³

¹Pädagogische Akademie des Bundes in Oberösterreich
Kaplanhofstraße 40, A-4020 Linz, Austria
FeyererE@pa-linz.ac.at

²Universität Linz, *i³s³*
Altenbergerstrasse 69, A-4040 Linz, Austria
klaus.miesenberger@jku.at

³Pädagogische Akademie der Diözese Graz-Seckau
Georgigasse 85-89, A-8020 Graz, Austria
dwohlhart@pze.at

Abstract. There is a growing recognition that an appropriate up to date preparation of all teachers and other educational personnel working with people with disabilities has to focus on Information and Communication Technologies (ICT) and especially on Assistive Technologies (AT). Numerous activities and projects related to teacher education and training have been performed the last years. Also the field of AT made a lot of efforts to towards training an teaching. Often both fields do their own approach to the topic and do not co-ordinate their activities. In this paper activities will be presented to integrate modules on AT into mainstream teacher training programs.

1 Introduction

„Appropriate preparation of all educational personnel stands out as a key factor in promoting progress towards inclusive schools.“ (Salamanca Framework of Action 1994)

Inclusive education is part of the regular school system in many European countries. However, it seems that teacher training institutes did not take any notice. There was no coherent curriculum for inclusive teacher development in Europe. This situation gets more critical when modern Information and Communication Technology (ICT) and the possibilities of Assistive Technologies (AT) are taken into account. The term Assistive Technology (AT) basically describes all kind of tools, devices or systems enabling a person to (easier and safer) perform a task.[1] This includes “low technology” but the term today is of course very much related to complex, “high technology” electronic and ICT tools.

People with disabilities can be seen as one of those user groups benefiting most from the movement towards the Information Society. Due to that they always were pioneers in employing new ICT based on their AT tools which give them access to computer based systems and services.

Due to this technology push in the target group other people working in close co-operation with them often were not able to catch up with these fast developments and changes in the style of working and also learning. Almost any teacher training system faces the problem that developments in these fields are that fast that

1. teachers can not cope with these challenges at an individual, self organised level as well as that
2. teachers training organisations are not able to adapt curricula accordingly and to offer training possibilities.

Teachers, trainers, therapists and others have been confronted with clients being ahead in using AT as a new basic cultural skill like reading and writing. Very often an integrative situation risks to fail because basic ICT and AT support is missing; possibilities for integration in school and at the labour market are not known, can not be taken into account or are ignored. This outlines the critical lack in teachers training concerning ICT and AT.

Today the pedagogical field as well as the field of AT start to answer this need from their own point of view. It seems to be obvious that both groups should work in close co-operation. The market for education and training in this field is rather small very fragmented. Programs are very profession or subject specific and do not offer a sound knowledge base in AT addressing the necessary breadth and depth. Building training programs therefore tends to be very expensive and also very difficult due to the missing basic knowledge in AT. This asks for co-operation in defining the skills in AT and for exchange of staff, experiences and materials.

In the following we will discuss three projects in the field of teacher training and education and how ICT and AT aspects should be incorporated. These three international projects intend to set up a modern and flexible structure of modules which can be offered at different places. The plans for the modules on AT and possibilities to include different actors and projects form the field of AT professionals will be discussed later on. The open structure of the INTEGER, EUMIE and ODL:Inclusive approach therefore should be used to foster the communication and co-operation between both fields.

2 INTEGER

The Pädagogische Akademie des Bundes in Upper Austria together with 6 partner universities applied for the SOKRATES ERASMUS project INTEGER in 1996. Between 1997 and 2000 a curriculum was worked out by 16 universities from 11 European countries. It offers individualised, active and reflexive learning and consists of 5 basic modules, 22 optional modules and some teaching and learning materials. Furthermore a glossary with the most important terms related to inclusion and a corporate workspace for international co-operation and common learning activities from different places were developed. For dissemination in 2000/2001 further financial support was approved by Brussels.

The project INTEGER is primarily an innovation of contents for inclusive teacher development which allows full implementation in the existing program structures of various teachers training organisations. It can also be used for in-service training

courses. The organisational and methodical realisation is the main responsibility of the training organisation whereby the principles of INTEGER have to be the dominant factor. All partners committed themselves on implementing the basic modules and some optional modules into their study programmes with a scope of 20 ECTS points. The module B4 includes the ideas of Assistive Technology in order to “Enabling personal autonomy and independent living”. [2]

The results of INTEGER are open for all interested people and the INTEGER consortium would be very pleased if many teachers training organizations join in the further activities to spread and develop the INTEGER curriculum in order to implement inclusive education in all teacher training programs of Europe. In order to be able to run the courses there is also a need that organizations specialized in AT get in contact and co-operate with the teacher training field that excellent programs for these parts of the curricula can be offered.

3 EUMIE

EUMIE is a masters program within the guidelines of Sokrates in order to develop a study program for an “*European Master in Inclusive Education*”. The main goal of EUMIE is to structure a post graduate study based on modules. This study programme will end with the qualification as regards content of a comprehensive inclusive teacher and the academic qualification of a “Master (MEd) in Inclusive Education”. According to the modular structure the training will end with the master’s degree after 90 ECTS Points (ECTS means “European Credit Transfer System” and 1 ECTS point corresponds with a student’s workload of about 26 hours). Intensive arguments with the varying structures of the study also aims at awarding two intermediate post graduate diplomas: a Certificate in Inclusive Education after 30 ECTS and a Diploma in Inclusive Education after 60 ECTS points.

The structure of the modular study programme also makes possible a varied cooperation with different partners and flexible structures as well as flexible possibilities of participation with a guarantee of quality at the same time. The participating training organisations cooperate together with the following objectives:

- Developing an overall recognised European Master of Inclusive Education according to a common European study programme.
- Developing a common curriculum based on single modules.
- European wide recognition of pre-studies, modules and courses for Inclusive teachers.
- Developing study materials, which will be provided to participants by means of open and distance learning.
- Developing a common European perspective towards an inclusion of handicapped people.
- Awarding the above mentioned academic qualification as well as the qualification as regards content based on the common developed curriculum.

EUMIE is now in the first project year. The following structure is agreed:

Table 1. Structure of EUMIE

Understanding ideas (Core modules)	Education for all – Evolving concept of inclusion considering diversity 7.5	Research methods and paradigms 7.5	Inclusion in Europe – international perspectives 7.5	Educational science – Advanced module 7.5	30
Living ideas (Optional modules)	I: Leadership and management II: Specific psychological and sociological themes III: Developing and evaluation of inclusive life and action as early childhood, work, Health and care, ... IV: Multicultural learning V : Assistive Technology VI : 15		Workplace study: From observation and describing ... to an data based analyses and synthesis (maybe abroad)	15	30
Contributing to ideas	Masterthesis				30

- *Certificate in Inclusive Education*: 30 ECTS points = 4 modules, at least 2 core modules
- *Diploma in Inclusive Education*: 60 ECTS points = 4 core models, 2 optional modules and the workplace study
- *Master in Inclusive Education*: 90 ECTS points = Diploma and Master Thesis

Again the modular structure of the study program enables the incorporation of modules on ICT and AT to guarantee that a “Master in Inclusive Education” has the basic skills to manage the complex situation of employing and teaching ICT and AT in class. The possibility to specialize in these fields by choosing an optional intensive course in AT should be made available.

By integrating basic ICT and AT knowledge into compulsory modules as well as by offering optional in depth modules EUMIE should help to overcome the lack of skills in managing integrative situations in terms of technical, pedagogical and social necessities. The modules will be offered at different places and by different organizations. This should result in a concentration of top competence of a new area of science within the common curriculum.

4 ODL:Inclusive

The Socrates/Minerva project ODL:Inclusive develops a teacher training course on Inclusive Education. The course will be offered as a coherent series of Open and Distance-Learning modules running on the platform “eLearningSuite” (HyperWave). A self-study edition on DVD complements the online-offering with richer multimedia material. [3]

The main target of the course is to provide a thorough understanding of the principles of Inclusive Education. It thus can serve as a starter course for frameworks like INTEGER and EUMIE. The modules of ODL:Inclusive are:

- Introduction: Realising Inclusion in contrast to the current educational reality
- Chapter 1: From description to recognition - a methodological fundamentum
- Chapter 2: Selection/segregation and their social function - a view on the current educational system and its institutions
- Chapter 3: The 'deficiency model' and the category of 'normality' - the personal and individual consequences of segregation and their diagnostic legitimization
- Chapter 4: The 'competence model': from isolation to dialogue - developing a view on disability that is based on co-evolution
- Chapter 5: 'General pedagogy', a didactical model based on the logic of development – principles for inclusive education
- Conclusion: Planning your life and your profession, a professional, personal and political decision.

The project does not directly target knowledge in the field of AT. Nevertheless it will contribute to this field in two ways: a) It will provide teachers in the field of inclusion with practical experience of the use of ICT in the learning process by using a rich set of tools (communication/cooperation/simulations) and b) it will make it easier for people with disabilities to participate in teacher training courses on inclusion by providing high standards of accessibility.

5 Integration of an Module on AT

As outlined above handling ICT and AT is already accepted as a basic skill for all people with disabilities. The same must be the case for those offering them services in their educational career. This asks for an integration of AT into teacher training programs what is planed by INTEGER and EUMIE.

5.1 Background and Planed Context

INTEGER and EUMIE are based on existing courses offered at teachers training institutions. Courses and programs in AT have to fit into this structure and have to be integrated or at least accepted and certified by these institutions. Due to the lack of AT training courses and due to the specialty of the subject as well as the costs for setting up such courses and materials there is a need to co-operate with existing and planed activities and programs and to consider them as suppliers of courses or as trainers for courses. Here are some examples of activities showing the state of the art:

TELEMATE: The EU funded project TELEMATE [1] set up an European wide network for trainers and students in AT. The aim of this network is to ensuring that users of AT as well as professionals and service providers have best provision and information. By offering access to harmonized curricula, sample courses, methods, tools, course materials and especially a platform for co-operation and exchange

TELEMATE is an ideal point of access and a partner for co-operation for teachers training programs like EUMIE, INTEGER or ODL. As a European wide network partners in different countries are available to set up and run the modules. TELEMATE by its nature wants to encourage involvement and networking in education across the EU. TELEMATE will introduce the concept of education and training in Assistive Technology for all professionals and users within the overlap personal experience (AT users) and the basic disciplines of medicine (clinicians), administration (managers), and engineering (engineers, technicians and scientists). This framework aims to provide a common platform for the exchange and development of training packages in all European countries, with the objective of allowing exchange of knowledge and personnel to the benefit of users.

ACTCAP: The Center on Disabilities at California State University, Northridge (CSUN) runs an Assistive Technology Applications Certificate Program (ATACP) offering 100 hours of a wide-range of practical Assistive Technology (AT) applications and information. ATACP includes Internet and live courses as well as a certificate project. ATACP covers 10 Continuing Education Units (CEUs). [4] ATACP made several efforts to co-operate with partners in other countries to set up training programmes fitting into the organisational and regional situation.

EMATA: Based on the experiences described above members of EUMIE and INTEGER take part in a project proposal “European Module on Assistive Technology Applications”. The project and the outcomes of this project, although planned as a stand alone program, should follow the structure of INTEGER and EUMIE.

5.2 Framework of the Module

According to the structure of EUMIE and INTEGER described above two areas for AT will be made available:

- in the “compulsory” section in the range of – 6 ECTS
- in the “optional” section two dedicated modules on AT in the range of two time 7,5 ECTS (that means about 200 respectively 400 hours workload)

For the compulsory part of the program 40 – 50% of the courses should be made available online. 10% of the time should be reserved for a small practical project. For the two optional modules 30 – 40 % of the program should be made available online. 20 % of the time will be reserved for a practical project.

5.3 Objectives

The module will focus on the educational needs in the field of Assistive Technologies including up to date Information and Communication Technologies (ICT) of teachers working towards the integration and the support of people with disabilities. It will include the many topics and skills required by teachers working with students with disabilities using Assistive Technology. The module will be outlined independent from the background or professional speciality (standard teacher, supporting teacher, special school teacher, ...) of teachers. Applicants should

- develop awareness and understanding of Assistive Technology and its benefits
- identify a wide range of applications for AT (e.g. home, school, workplace, community environments)
- develop the necessary basic medical and psychological knowledge
- learn about and be able to apply AT products and services
- be able to manage the assessment process of AT for people with disabilities
- be better-informed about available services and activities
- be able to implement practical knowledge in educational situations
- be able to network available resources and actors

5.4 Contents

According to the need for networking with actors and organizations already working in the field structuring the contents for the module will follow the TELEMATE approach. This concept itself follows and extends previous approaches, is proved and can be seen as a common view of the field throughout Europe. Following this concept also eases the co-operation with the AT/ICT field to start from already existing programs and courses and to avoid multiple efforts in a field with low competition and straggled demand at local level. The goal of these activities is therefore to enable a multiple usage of existing materials and thereby to foster interdisciplinary exchange [1]. The following rough list therefore only wants to give an idea of the areas which should be covered the AT modules.

Fundamentals and Examples of AT.

- Vital functions: e.g. heart pacemakers, breathing, incontinence, anatomy
- Cognition: decision support software, cognitive diseases, neurology
- Vision: displays, alarms, magnifiers, optical system, optical diseases,
- Hearing: alarms, hearing aids, hearing diseases
- Mobility/manipulation: environmental control, building accessibility, ergonomics, posture and seating, biomechanics, muscular-skeletal diseases
- Alternative and augmentative communication: in/output, predictive tools, language/symbol systems, language learning
- Current and future trends in AT

People with Disabilities in Their Contextual and Individual Setting.

- The measurement and assessment process
- The service delivery process: People with disabilities as clients
- Areas of application: school/work/home
- Special AT for the teaching/learning process
- Managing/networking existing resources and managing the process: leadership
- Actors in the field and areas of influence
- From a medical to a social approach
- Legislation
- Empowerment
- Interdisciplinary co-operation

5.5 Tools, Methods, Materials

A module on AT in its nature has to use modern and today well known ICT tools for teaching, learning and managing the process. There might be doubts and problems as this ICT and AT focused approach not only in content but also in the program itself as they could be seen as too technology driven. There might be concerns that this may fail in addressing the needs of the pedagogical field and their approaches.

Training and education in the pedagogical field may not be based on a sound and solid basis on ICT in general from where this module could start from. The knowledge in ICT will differ considerably what has to be taken into account when setting up the modules and developing materials and tools. In any case applying AT asks for a sound basic knowledge in using modern ICT.

The modules on AT will take care that accessibility and design for all principles are taken into account in this project as well as they will use the results.

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Bridging the Information Gap between IST and SEN – A Practical Approach on European Level

Jørgen Greve and Harald Weber

European Agency for Development in Special Needs Education,
Teglgaardsparken 100, DK-5500 Middelfart, Denmark
{jg, harald}@european-agency.org
<http://www.european-agency.org>

Abstract. The presentation addresses the problem that certain groups of learners are at risk of not being fully involved in new ways of learning due to social disadvantages or disability or both. In order to build a socially inclusive Information Society based on participation for all, new pedagogical approaches and appropriate technologies must be developed and applied. However, the two relevant communities, namely IST and SEN, are lacking a common platform to meet and complement each others expertise. The SEN-IST-NET project provides such a platform.

1 Introduction

In all areas of education, new media, including the World Wide Web, Information Society Technologies (IST) and digital broadcasting, are beginning to open doors to new ways of learning. Yet the opportunities which new technologies can offer in terms of richer educational experiences, wider curricula and individually tailored learning are not generally available throughout Europe, nor are they always usable or accessible to all learners.

On the other side, certain groups of learners are at risk of not being fully involved in new ways of learning, either because of their social disadvantages or their disability – or both. This issue presents pedagogical and technological challenges of the highest order. In order to build a socially inclusive Information Society based on participation for all, new pedagogical approaches and appropriate technologies must be developed and applied to suit the learning requirements of all children and young people, including those who have special educational needs (SEN).

2 Providing a Common Platform to the SEN and IST Communities

With their differing constituencies and frames of reference, the two communities – namely the IST and SEN communities – have hitherto lacked easy, open and direct

access to the knowledge and networks of the other. SEN-IST-NET, a project funded within the 5th RTD Framework Programme by DG IST, addresses these and other research questions in an ongoing fashion by providing a common platform – delivered through a Thematic Network – for discussion and debate, not only on the development of technologies per se but also on the fundamental questions concerning pedagogy and technology-enabled learning. SEN-IST-NET presents a vision and a plan to establish a European Network of Excellence to share knowledge between two communities:

- “IST” – researchers and developers working in the field of Information Society Technologies and
- “SEN” – researchers, professionals, policy-makers, industrial enterprises and NGO’s in the area of Special Educational Needs.

3 Objectives of SEN-IST-NET

The objective of the SEN-IST-NET project¹ is to provide support for the two communities such that learners with SEN will have access to the benefits of leading edge technologies and that the IST programme ensures the development of inclusive technology-enabled learning systems and materials for the future.

This is a matter of importance not only for the end-user but for all stakeholders in the chain of provision, from the IST researcher to the developer, the industrialist, the investor, the SEN specialist, the educator, policymakers and parents. SEN-IST-NET seeks to:

- Add value to the activities of the IST programme by linking to the SEN community and establishing a platform for these partners for shaping current RTD and future European R&D frameworks;
- Integrate individuals and institutions from SEN and IST in a common communication and information net via a dedicated SEN-IST-NET Web Portal;
- Add value at the European level by encouraging common approaches to problems of a generic nature;
- Raise awareness of the SEN user requirements and the commercial opportunities which are offered by designing for the diversity of abilities and use situations;
- Ensure relevance of R&D for the interests and requirements of the diverse user groups by including NGOs in the networking process;
- Promote new partnerships for research work, practical application of results, policy development and industrial exploitation;
- Showcase best practice and new, accessible systems, and tools for SEN.

The poster presents the approach taken by the SEN-IST-NET Consortium, and gives an overview on first project outcomes after one year of operation of this network of excellence.

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Evaluational Study: Training with Animated Pedagogical Agents

Yehya Mohamad¹, S. Hammer², F. Haverkamp², M. Nöker², and H. Tebarth³

¹ Fraunhofer Institute for Applied Information Technology (FIT.HEB),
Schloss Birlinghoven, 53757 Sankt Augustin, Germany
mohamad@fit.fraunhofer.de,
<http://access.fit.fraunhofer.de>

² Universitätsklinikum Bonn, Adenauerallee 119
53113 Bonn, Germany

³ Klinik am Schlossgarten, Schlossgarten 1,
48249 Duellen, Germany
Tebarth@web.de

Abstract. Training with Multimodal lifelike agent interfaces is a promising new style of training especially for children with disabilities. In this paper, we present the evaluation results of our training agent system called TAPA (Training with Animated Pedagogical Agents), which has a realistic moving body and body language features. TAPA is web based, it can be accessed via a Web Browser. TAPA allows children to access the training sources over the Internet through a user-friendly multimodal interface similar to natural human communication.

1 Introduction

Main component of this project is a special Human Computer Interface that is based on the so-called animated pedagogical agents [6]. These little animated characters combine their behavior as lifelike virtual fellow and their role as individual trainer (especially suitable for children). The Agents aim to influence the emotional and as a result the motivational training experience of the users.

Recent neuropsychological research assumes, that children with learning disabilities and memory deficit e.g. caused by neurological disease can benefit by special training of meta-memory strategies [1]. Though this kind of memory training requires a specialized coach who performs an individual and motivational support that is not often possible neither under educational nor school conditions.

In the consequence we have designed and developed an autonomous tele-training system called TAPA (Training with Animated Pedagogical Agents) that is primarily determined by dynamically interconnected diagnostic and training modules [16]. Basically the whole TAPA-system is designed for a web-based use with an individual and autonomous training at home, which is necessary to obtain a prolonged effect in large numbers of affected children.

However, to achieve direct motivation it is necessary for the system to receive information about the current attention status of the user as valid as possible. Therefore we are experimenting to capture the physiological values: electrical skin conduction, muscle tension and electrical fronto-temporal activity and cross check them with user's task reply. In neuropsychological research these values are correlated with level of physiological arousal, can be expected to give indirectly hints about emotional excitement and are used in other terms in the polygraphic examination [17].

As a method to receive additional information about motivational status of the user we have designed a motivation panel (called fun-o-meter), on which the child could tell the system about his current level of motivation.

Responding to the risk of misinterpretation of these input data we developed some prototype scenarios that include different communication situations. The agent's job in this regard is to verify either falsify the interpretation of these input data by so-called repair questions or dialogues.

These repair questions were developed systematically with respect to the socio-psychological concept of meta-dialogue and can be expressed in formalized pattern [13]. A logical model for the development of meta-dialogue was developed and tested.

As important for therapeutic effectiveness TAPA aims to improve the children's perception of their self-efficacy. One of the immanent problems in the delayed cognitive development is a distorted perception of self-efficacy/performance [12]. Due to repeated and continuous feedback by animated agents the child could learn to estimate her own performance more realistically.

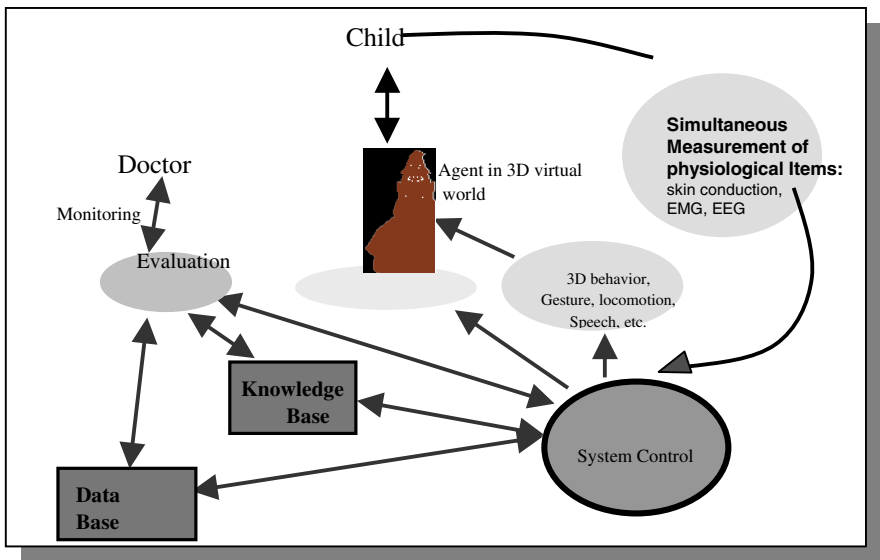


Fig. 1. System's Overview

2 Architecture of TAPA

2.1 Psychological Training Concept

As elaborated on 6th ERCIM-Workshop [16] [9] meta-memory means to know about the own memory functioning. Under positive conditions children develop in the age between 8 and 10 years some kind of knowledge about their memory and how it works [3].

Children with cognitive disorder or development delay often have the risk of not developing these working-strategies [15]. Especially in children with learning disabilities clear delays and even lacks of the meta-memory development can be observed. From that point it was exiting to find that these children can benefit from an instructional coaching and are able to catch up with their contemporary playmates [3][4].

The here developed TAPA is based on four main training components and considers the last research result. All steps are introduced, explained and supervised by animated pedagogical agents.

1. Specific memory strategies and learning strategies
2. General meta-memory knowledge
3. Feedback for an appropriate perception of performance/self-efficacy
4. Attention and concentration training

To impart these contents in an attractive and playful way to children we embedded the training in an exiting and fairytale contextual story:

The child is invited to help the little gorilla Bonzi and the magician Merlin to rescue their friend Peedy the parrot who was kidnapped by the terrible Zorgo-Skeleton. On their way to Zorro's creepy castle they have to survive several adventures as there are buying some ingredients for a magic soup in a witch shop, opening an enchanted gate with the help of an thousand year old turtle, defeating the terrible Zorgo and liberating Peedy out of its dungeon. All adventures contain memory tasks that require the correct use of meta-memory strategies. The whole story consists of sequential episodes involving the several agents. Different scenic graphics are combined to a virtual world, which helps to tell the story.

Leading agents (Bonzi and Merlin) introduce themselves to the child and interview the child regarding learning-self-concept and estimation of own cognitive performance and abilities. The child's answers are used for adaptivity and evaluation. In the training scenes tasks will be offered by different side agents (e.g. Zorgo). The child has to solve them under the assistance of the leading agents. Later this kind of tasks should allow a transfer to every day tasks using the learned knowledge in real situations [3].

Regarding the emotional modelling we had to define and variegate gesture, gaze and facial play of the agents. In different situations the agents have to show different emotions e.g. to be happy and to show that in gestures to the child. So we built a model with all possible emotional states. Those emotional states should be applied in an optimised way to the current situation.

Furthermore we had to integrate the individual agent into its environment to keep a consistent and closed training context. All agents communicate to each other and to

the virtual world and its objects. This allows them to react to any change in this world and to perform finally an adaptive behaviour to the child.

2.2 Emotion Modelling

The TAPA system is determined by the pedagogical interface agents architecture, an immersive story playing in a virtual world, where the training units are encapsulated into the story. The agents in that virtual world have their emotional states (artificial) based on status of their environment and on the goals they want to achieve. The goals of the agents depend mainly on the training units, the user's preferences and emotional status (natural).

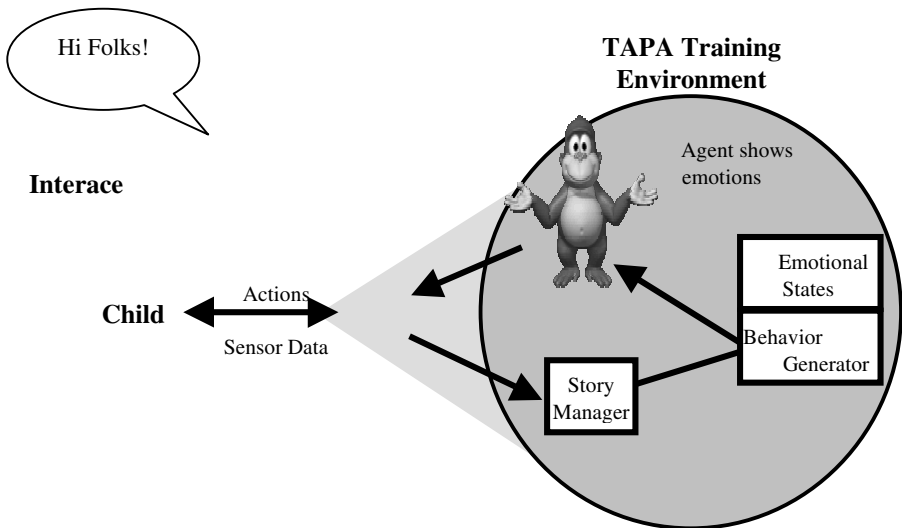


Fig. 2. Agent's 'Emotionality'

The main issue here is how to model the emotions and to derive behavior depending on them. It is very important to distinguish between the emotions of the agents that might be called 'artificial emotions' and how to model them and derive behavior depending on them and the responding 'natural emotions' on the user's side which could be captured through sensors and verified by input data entered by the user himself or third person.

Artificial emotions mustn't be complaint in their complexity and diversity to natural emotions, because their primary aim here is to improve the motivational rule of agents to avoid indifference on user's side.

The here-applied cognitive model of emotions is based on the OCC model [10] and the agent personality model FFM [7].

The emotional states are expressed in the system by vectors (emotion, value) e.g. (happy,0.73). We used Microsoft Agents [8] to implement the agents bodies.

2.3 Technical Description of TAPA

The TAPA system can be divided into two subsystems, the authoring subsystem and the run time subsystem.

The authoring system allows the Author (Designer) to combine multi modal items (sound, natural language, agents, images, buttons, etc.) and build up the story in a suitable way for children. The output of the authoring tool is an XML file for every training unit, the XSLT files have to be created at the moment manually.

The run time subsystem (interpreter) is javascript based, it reads an XML training file, XSLT files and the user/device profile.

The training unit can be invoked over the Internet from an IE explorer (> Version 5.0) and the user can enjoy the training.

The user profile and the tracking data are stored in an MS Access database.

3 Results

At the hospital for children at the university of Bonn we confronted in a first evaluation step 10 children with a seizure disease and 5 healthy children with the prototype of TAPA. With respect to the small number of participants the statistical evaluation has to be considered as on case study level for the time being.

While working with TAPA the children's behavior were observed through a psychologist. Here was essentially focused on the emotional mimic expressions and finally rated regarding affective quality and quantity. The reply-behavior of the children concerning the instructed memory tasks was recorded in the TAPA-database.

Further information about perception and experience of agents were charged in a subsequent questioning of the children. Beyond that parents were asked through questionnaire for their children's learning and performance behavior and ability of self-estimation. As demonstrated in recent psychological research the here investigated children with seizure disease showed a poorer memory performance than the healthy children (see Table 1). Furthermore there was found a tendentious higher risk of mis-estimating of own cognitive performance in the children with epilepsy. Interestingly within the group of epileptic child this ability of self-perception was correlated significantly high with the every-day-memory performance (Kendall- $\tau = 0.8^{**}$ (sign. on $p=0.01$). Further remarkable but not unexpected significant correlations of these two items were found to average school degrees (Kendall- $\tau = 0.7^*$ (sign. on $p=0.05$).

Next to the verification of described cognitive characteristics of epileptic children the pre-study was mainly aimed to evaluate the functionality of the different basic communication situations as there are:

1. *Diagnostic interactions*: measuring child's meta-memory performance
2. *Therapeutic interactions*: child's profit of agent's instructions
3. *Motivational interactions*: influence of agent setting on child's motivation

Concretely it was here important to find out how the children perceive the agents and especially if they accept the agents as virtual teacher. With respect to the other items of interest we investigated furthermore the level of motivation during the TAPA-lesson and the effectiveness of the instructed memory strategies.

Table 1. Characteristics of Test Participants

	Children with Epilepsy (n=10)	Healthy Children (n=5)
Type of Epilepsy	7 with rolando 3 with absence	
Average Age	11.9	11.2
In years	(sd=1.5)	(sd=2.4)
Sex	6 male	3 male
Every-Day Memory Performance	3.2*	1.4
	(sd=1.0)	(sd=0.6)
assessed by parents (5 point-Likert-scale, 1=very high to 5=very poor) ¹		
School Degrees	2.6	2.0
	(sd=1.0)	(sd=0.7)
NUMBER OF FRIENDS	2-3	4-5
Child's Ability of Self-Perception assessed by parents		
stimulation of own Cognitive Performance	3.0	2.0
	(sd=0.9)	(sd=1.4)
(5 point-Likert-scale, 1=very adequate to 5=very inadequate)		
Frequency of Overestimation	2.2	1.6
	(sd=0.8)	(sd=0.9)
(5 point-Likert-scal, 1=very low to5=very high)		
requency of Underestimation	1.5	1.0
	(sd=0.9)	(sd=0.7)
(5 point-Likert-scale, 1=very low to 5=very high)		

As demonstrated above TAPA performed an effective treatment instructing the children how to use memory strategies successfully. Based on only a small number of test persons this important result has to be verified in further studies. There are also hints that the specific memory tasks examining the meta-memory performance are especially difficult for the children with epilepsy as expected.

The child's' statements about their motivation to have another lesson (11 of 15) as well as their fun working with TAPA showed that there is especially in the handicapped children an acceptable but not optimal grade of motivation.

¹ Table 1 p=0.05 significant different to control group

Table 2. Treatment Effectiveness and Child's Perception of Agents

	Children with Epilepsy (n=10)	Healthy Chil- dren(n=5)
Childs ' Motivation		
<i>Children were asked for motivation and fun working with TAPA.</i>	7.1 (sd=2.6)	5.3 (sd=3.7)
(10 point-scale, 1=low to 10=high)		
<i>Instructional Effectiveness</i>	1 of 10	3 of 5
Number of children who solve memory tasks before agents' treatment.	9 of 10	5 of 5
Number of children who solve memory tasks after agents' treatment.		
Childs' Perception of Agent HCI		
Agent's Liveliness/Genuineness		
Number of children who believe agents		
Are still active when TAPA is off.	6 of 10	3 of 5
Agent's Personality		
Number of Children who recognize		
Agent's characters correctly.	6 of 10	5 of 5
Agent's Transparency		
Number of children who interpret		
Agent's behaviour/emotions correctly.	9 of 10	5 of 5

With respect to unwanted high age we see here an explanation confirmed by correlation between age and child's estimation of age appropriate of TAPA (Kendall- $\tau = 0.4^*$ (sign. on $p=0.1$)). 8 of 15 children were of the opinion that TAPA is a program developed for younger children (as there are actually intended an average age of about 10 years). Regarding the child's' perception of agents we have to note furthermore that TAPA realized a satisfying transparency of behaviour, but personality/character as well as liveliness are suboptimal obtained.

4 Conclusions

Despite the low number of test participants the first results seems to give a promising perspective for the further development of TAPA. We could show that even a prototype of TAPA is able to obtain a clear training effect in the intended sense. Concerning the acceptance and suitability of agent's Interface, there can also be drawn a positive conclusion however the criteria were not reached optimally in every respect.

Nevertheless for the future it will be necessary to perform a more complex evaluation design to enable the not yet realized technical integration of physiological emotion measuring. In this connection it has to be pointed out that this prototype was managed without an actual adaptive control in the emotional regard.

The up to now considered input via 'motivation' panel did not give enough base to obtain the aimed motivational adaptivity. The next developmental steps involve these technical extension and their integration in a further developed β -version of TAPA.

Evaluational design is planned to be realized in a number of about 50 children with learning impairment.

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Usage of Modern Technologies – A Chance for People with Special Needs?! – Pedagogically Relevant Criteria for the Review of Educational Software Exemplified by “*Step by Step 3*”

Barbara Prazak¹ and Mathilde Niehaus²

¹ARC Seibersdorf research GmbH, Viktor Kaplan-Strasse 2, 2700 Wr. Neustadt, Austria
Barbara.Prazak@integranet.at

²Universität Wien, Sonder- und Heilpädagogik, Institut für Erziehungswissenschaft,
Universitätsstrasse 7, 1010 Wien, Austria
Mathilde.Niehaus@univie.ac.at

Abstract. Educational Software is widely used in the field of special pedagogic to promote the development of people with special needs. In this connection you have to think about the evaluation of educational software for this target group. “*Step by Step 3*” (working title, now “*Mr.Step*”), a software developed by ARC Seibersdorf research GmbH, aims to be especially suited for the area of cognitive development of children with special needs and for physically handicapped children. Based on theoretical findings and results of our analysis we develop common criteria for the evaluation of educational software from a pedagogical point of view.

1 Introduction

In the field of special pedagogic the computer is used for learning and as an aid in therapy. Under this point of view we consider that educational software can be a possibility for the favourable development of people with special needs. The question in that context is how to judge this kind of software. Furthermore it will be discussed if there is a need for “extra” criteria for the evaluation of software in the field of special education or if it is enough to adopt existing criteria [6].

2 Exemplary Description

In this section the concept of “*Step by Step 3*”¹ will be shortly characterised. At the time of this evaluation the software was developed by the ARC Seibersdorf research GmbH [4]. In that software the needs of children with disabilities, particularly the needs of children with physical handicaps should be considered [1], [7]. “*Step by*

¹ “*Step by Step 3*” was the working title, now the name of the software is „*Mr.Step*“, but in this text we use the working title, because the study was performed on a prototype at this stage.

Step 3” should stimulate the development of cognition and perception for children in the preschool age. On the one hand “*Step by Step 3*” should be a tool for therapists to work with a program which can be adapted to meet the individual needs of a child. On the other hand the software should be a whole package of exercises to stimulate children with disabilities either at home or at an institution.

3 Set and Structure of the Study

The general question of this research project was: Which elements are relevant for the design from “*Step by Step 3*” so that the software can fulfil the pretension of furtherance? In the following we had to ask which conditions are necessary so that the needs of the target group can be satisfied. The objectives of this evaluation were on the one hand the improvement of the software and on the other hand the results should be useful for the formulation of criteria for the evaluation of educational software. The first step was to perform a Pre-test. This Pre-test was based on a formative evaluation [2], [8]. The data were collected and analysed with qualitative methods. The Pre-test had the purpose to get relevant information for the main study. Test subjects were adults in the categories: with no experiences in using educational software, experiences with general educational software, experiences especially with “*Step by Step 2*”.

4 Results of the Pre-test and Conclusion of the Pre-test for the Further Development of “*Step by Step 3*”

Firstly it was planned that there should be only one version of the software, but the results of the Pre-Test have shown that it is necessary to develop two different versions. The majority opinion was that there should be one version for parents, which is not so complex and one version for therapists.² But all of them demanded that the software should be user-friendly and the configuration tool should be easy to handle.

The conclusion of the Pre-test flew into the further development of “*Step by Step 3*”. The Pre-test provided relevant information about the construction and evaluation of educational software gathered from different points of view. Exemplified criteria for the evaluation of a software can consist of universal criteria, pedagogical-didactical criteria and computer-specific criteria. For the field of special education it is necessary to adopt universal standards, so that relevant aspects are regarded for this field in the evaluation of a software. Criteria are only a skeletal structure which should always be matched with the individual situation [3]. Furthermore we realized after this study that there are many educational software for children with special needs, but you hardly find games for this target group. This provoked the question if only “normal” children are allowed to play with the computer?

² In this text the group of therapists includes all people with a pedagogical education.

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Social Innovation in the Information Society – Take It Easy –

Cordula Edler

in(p)but integrative Beratung und Unterstützung
Teckstrasse 23, D-73119 Zell u. A.
cordula.edler@t-online.de

Abstract. This contribution concentrates on the importance to gain competence in using ITC as a tool. People with special learning needs also need to gain competence in Using ITC in order to access the new learning technologies as soon as possible

1 Starting-Point

The acquisition of information, knowledge, abilities and basic skills in using the ICT will more and more decide on the chances the single person will have in the information society. Slow learners or people with other handicaps, people with low education or with social problems, migrants, illiterates and elder people, they all are willing to take part in the information society and they are right in that justified. But it is often too difficult for them to understand the ordinary computer handbooks or computer courses because these are using special terms on a much too high intellectual level. There is almost no teaching material that one could use to teach the basic skills of ICT. Thus the gap between those who can use and those who can't is widening and one has started to speak of "Digital divide".

2 Take It Easy

People with special learning difficulties need an IT-education with new learning methods and didactics. They need different learning materials in an easy to understand language written along the European Guidelines for Easy Reading [1]. The contents must be underlined with lots of additional pictures and screenshots (Design for all).

The experiences in special education or in special adult education have shown us, that people with special learning difficulties more and more are interested how to use the computer for themselves. It more and more becomes obvious that people with special learning difficulties are able to learn this if they get special learning supports.

3 Three Examples

1. Netzwerk People First Deutschland. e. V., a self organised association of people with learning difficulties, organizes itself and has their own office. They manage a lot of things using by computer (sometimes with assistance), but this “special” staff had first to learn. Now they use the self learning tool “Der Klick mit der Maus” [2].
2. Three years ago we began a new computer project in a special school for pupils with learning difficulties . We started with a group of 5 pupils. They were not good in writing or reading, but now they are using different computer programs like MS-Word, MS-PowerPoint, MS-Paint, the Internet and E-mail. They creat presentations from their school, about Europe or about things they are interested in. In the moment they create little texts and pictures for a virtual booklet about future. How did we worked? We offered a workshop with exercises out of the context of the pupils. We created new learning materials, first in form of papers and now as power-point-presentations with animation - step by step how to do....
3. A home for people with – so called – mental retardation asked for teaching two of their people. First this was an adventure. They needed support one to one. But after a short time they knew the hardware, how to start the computer, the program Paint or a toy. Both were absolute happy using a computer. That is our understanding of “participation in the information society or the term “mainstreaming”. Everybody should be able to use a computer independent from his intellectual capacities.

4 Conclusion

Each new situation to teach people with special learning handicaps gives us a new challenge to find out individual approaches how to use the computer as a tool. All these are different. But for all participants the most important is to be successful. Nevertheless it is necessary to have computer learning concepts for basic skills a available in easy to understand language with the following context as example:

1. Introductions for teachers and assistants, description of the target groups, special questions, best practice, information, exercises, examples
2. Teaching materials (guideline and CBT) with basics (like hardware), using PCs and managing files (MS Windows 2000 and MS Paint), using word processing (MS Word 2000) and using Internet and E-mail.
3. Self learning materials in the form of booklets or CBT teaching basic skills.
- Take it easy - will be such a variable tool for practical learning and teaching basic computer skills with a “Design for all”.

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ODL:Inclusive – Improving Inclusive Teaching through Online Training

David Wohllhart

Pädagogische Akademie der Diözese Graz-Seckau,
A-8020 Graz, Georgigasse 85–89, Austria

Abstract. ODL:Inclusive is a Socrates II/Minerva project that aims at improving inclusive education by producing an online introductory course on inclusion based on the eLearning Suite (Hyperwave). This short paper gives an outline of the course and deals with the enhancements to the eLearning Suite that were necessary to provide a full-fledged online teaching and learning environment.

1 The Project ODL:Inclusive

ODL:Inclusive is a project in the Socrates/Minerva-framework of the European Union. It is financed by the European Union, the Austrian Ministry for Education, Science and Culture and the participating institutions. [2]

The consortium. Pädagogische Akademie der Diözese Graz-Seckau (coordinator), Pädagogische Akademie des Bundes in Linz, Pädagogisches Institut des Bundes in Graz, University of Derby, Hogeschool of Arnhem and Nijmegen, Hogeschool Edith Stein Hengelo, Universität Bremen, Universität Koblenz-Landau, Charles University Prague, Eötvös Lorand University Budapest.

Project status. The project started in September 2000 and will be finished in February 2004. The first year was used to develop a content concept, the second year for the definition of a prototype, the adaptation of the eLearning platform and (at the moment of writing) the production of the prototype. In the third year the whole course will be produced and evaluated.

2 Course Content

ODL:Inclusive develops a teacher training course for inclusive education. This course is targeted at beginners in the field of inclusion. It aims at the development of professional attitudes of the students in their respective areas of work. [1]

The course starts with an overview over the field of inclusive education in the areas of kindergarten, school and vocational training. On the basis of the students' experiences it lines out the necessary knowledge and techniques for successful inclusive work. It starts at the current situation of prevailing segregated

education, lines out the negative consequences for the pupils, contrasts the ‘Deficiency Model’ of disability with the ‘Competence Model’, describes handicap in terms of the competence to live and learn under the given preconditions and develops the consequences for an inclusive educational system. Thus the course gives a solid orientation for the students on which their professional decisions and their further education can be based.

The chapters of ODL:Inclusive are:

- *Introduction*: Realising inclusion in contrast to the current educational reality
- *Chapter 1*: From description to scientific findings
- *Chapter 2*: Selection and segregation and their social function
- *Chapter 3*: The ‘Deficiency Model’; categories ‘normality’ and ‘segregation’
- *Chapter 4*: The ‘Competence Model’; categories ‘isolation’ and ‘dialogue’
- *Chapter 5*: ‘General education’ and didactics oriented at the logic of development
- *Conclusion*: Life and career planning: a professional, personal and political decision

3 Technical Implementation

The experience of the first implementation phase shows that current eLearning infrastructures are by far not complete in terms of methods and facilities when applied to teacher training in general and to inclusive teacher training in special.

Current systems are best suited for courses with a high percentage of presentation. They are easily adapted to technical subjects and subjects with high degrees of facts and fixed information.

Teacher training on the contrary is primarily concerned with the establishment of attitudes and techniques and this is traditionally done in a highly cooperative and communicative environment.

3.1 The Platform: A Modified eLearning Suite

Hyperwave offers the eLearning Suite (eLS) and the Hyperwave Server at no cost for academic communities and non-commercial purposes. [4] The system features a role based approach (trainee, trainer, author, administrator), user, group and course management, annotation functions, synchronous (chat) and asynchronous (forum, email) communication facilities. The services of the platform are well integrated and easy to use for the students and the trainers.

The course-structure of ODL:Inclusive is

- *complex*: There are different types of student activities in all modules: Analysis of video examples, interactive simulations of theoretical relations, structured discussions, workspace-based student/group contributions, classroom and peer-group activities.

- *non-linear*: Students may choose between different tracks based on their experience or their professional orientation. There are compulsory and non-compulsory parts and tasks, self tests and tests used for assessment.
- *transaction-based*: Certain parts of the course are only accessible to the student after a pre-test, the submission of a contribution or a written exam. This limitation of access was chosen deliberately to ensure active participation of the student.

Modifications. Given this course structure we had to modify eLS in the following directions.

- *Navigation*: The overall course-structure has to be visible at any time. The students must be able to see their choices, their suggested paths and their achievements throughout the course. The tree-structure of eLS-contents has been replaced by a hierarchical directed graph structure.
- *Dependencies*: Navigation is based on preconditions. Any node of the navigation graph can be linked to a set of preconditions that have to be fulfilled to gain access to the node. This also applies to prestructured discussion forums and to the search function.
- *Assessment*: Automated assessment facilities had to be supplemented by traditional forms of assessment: Written exams, contributions that have to be assessed by tutors. A work-flow has been developed to ensure notification of students and tutors and to integrate conventional assessment in the classroom. Interfaces for students and trainers provide them with an overview over the assessment process.

Further developments will target the following topics.

- *Cooperative workspace*: A basic set of joint editing features for group contributions are currently not present in eLS and will be implemented.
- *Discursive Networking*: A new discussion forum type based on cooperatively built semantic networks is currently discussed in the consortium. [3]
- *High volume media*: The examples in ODL:Inclusive are primarily based on video material. These videos will be distributed on CD/DVD. The interaction between DVD and online course has to be established.

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Accessible E-learning: Infrastructure and Content

Norman Coombs

.CEO,EASI Corp

22196 Caminito Tasquillo, Laguna Hills, CA. 92653 USA

nrcgsh@rit.edu

<http://www.rit.edu/~easi>

Abstract. E-learning is the fastest-growing technology application in university education and business training. Making these electronic systems accessible to students and faculty with disabilities requires attention both to the courseware infrastructure or learning platform and to the content or subject material that the instructor places in that learning space. Increasing attention is finally being focused on making the courseware accessible. Because most systems are Web-based, this is usually a matter of good Web design and of designing a platform that facilitates faculty designing accessible content. Next, work is needed in assisting faculty to understand and design accessible content and in persuading institutions to develop institution-wide policies to support accessibility to e-learning for students with disabilities.

1 Introduction

In the past, education has been a local activity. Now, however, e-learning is emerging as a global activity, and it is important that its providers recognize this fact. EASI provides online courses, which have included students from over three dozen countries and from six of the world's seven continents. More information can be vied at <http://www.rit.edu/~easi/workshop.htm>. Our concern for access to e-learning systems for users with disabilities also needs to reflect this global perspective. Both accessibility advocates and assistive technology technicians from one country can learn from their peers in another country. EASI is looking for accessible e-learning experts who will join us in our planned center for accessible e-learning at <http://easi-elearn.org>. Providing an effective accessible e-learning system requires attention to a four-pronged approach: the adaptive technology used by the user, accessible courseware hosted by the provider, accessible course content and institution-wide planning and policies.

2 Adaptive Computer Technology

Anyone who is uninformed on adaptive computer technology can find an introduction and popular overview at <http://www.rit.edu/~easi/pubs/heath.htm>. Others who are familiar with the technology are aware that just as Internet communication technologies are regularly improved or upgraded, the adaptive technology is constantly changing both to improve and to catch up with the changes in mainstream software. The World Wide Web Consortium's Web accessibility Initiative has a committee, the User Agent Working Group providing guidance to adaptive technology manufacturers. Its work is on the Web at <http://w3.org/wai>, and the better the adaptive technology becomes, the more the other accessibility problems will fade away.

3 Accessible Courseware Interface

Courseware to facilitate the creation of online learning comes in different forms. In the 1980s courseware was text-based and included products like Digital's VAX Notes. Recently, all courseware products have migrated more and more towards a Web type interface. In a paper presented at the Accessing Higher Ground Conference and on the Web at <http://snow.utoronto.ca/access/saga/index.html>, Laurie Harrison reported on a survey of courseware systems by the University of Toronto. The general result showed progress towards accessibility by the major systems reviewed: WEBCT, Blackboard, E-college and Prometheus. However, the survey highlighted the fact that technical accessibility is very different than genuine usability. Courseware systems are burdened with having both multiple frames and a large number of navigation links that complicate the user experience making the interface needlessly complex.

The US Department of Education Fund for the Improvement of Postsecondary Education (FIPSE) is sponsoring a grant Specification for Accessible Learning Technologies (SALT). The National Center for Accessible Media (NCAM), at Boston public broadcaster WGBH, is leading the project working closely with the IMS Global Learning Consortium in developing technical specifications for online learning. Establishing foundational technical standards should enable future courseware to better interface with software systems.

4 Accessible Course Content

The challenge in improving the accessibility of course content is mainly a human and not a technical problem. Most faculty will not have technical know-how and will not want to develop it. The bulk of what is put online will not pose serious accessibility problems. Faculty who eagerly accept the opportunity to do innovative technical uses of the Web for learning constitute a different group with different needs. However, there is a need to develop guidelines and tutorials to assist faculty in knowing how to

create course content that will provide an effective learning environment for all students including those with disabilities.

The most important help a teacher can provide to a student with a disability is to be a good teacher and to develop good communication skills. Faculties who enjoy using technology will inevitably become involved in using streaming multimedia to enrich their instruction. Online PowerPoint, audio, video, Flash and a growing number of other media tools provide exciting opportunities to make e-learning an engaging and exciting way to learn and teach. Most of these formats can already be made accessible to users who are deaf, blind or have other disabilities. MAGpie, <http://ncam.wgbh.org> generates captions and descriptive video.

Unfortunately, some content at present cannot be transmitted effectively online to users, especially the visually impaired. These are technical problems for researchers to solve. Advanced math can only be clearly understood by students who are blind when they have hard copy Braille math. Similarly, maps and drawings require hard copy tactile drawings. The California Community College system established a document on producing alternate media. This document can be viewed at <http://www.htctu.fhda.edu/amguidelines/am33000.htm>.

5 Institution-Wide Planning and Policy

The US Department of Education Office for Civil rights (OCR) has complained that many colleges attempt to isolate all support for students with disabilities in the office for disabled students. OCR made it clear that support for students with disabilities is a campus-wide responsibility. The California Community College system has also established a document on distance learning, and it is available at <http://www.htctu.fhda.edu/dlguidelines/final%20dl%20guidelines.htm>.

Faculty and staff need a policy outlining what is demanded of them as well as the availability of training to enable them to develop the necessary know-how to provide fully accessible e-learning for students with disabilities.

6 Conclusion

Providing support for accessible e-learning involves a network of both technical and non-technical faculty and staff who stay informed about the changes in operating systems, courseware, multimedia applications and adaptive technology. EASI (Equal Access to Software and Information) is initiating a clearinghouse to share relevant technical and accessible content ideas and to do this on a global level through a Web site on accessible e-learning. The task is too big for anyone to do alone, and EASI is inviting interested partners to join us in developing an Internet global clearinghouse.

Addizionario: Words in Your Pocket

Giovanna Turrini, Laura Cignoni, and Alessandro Paccosi

Istituto di Linguistica Computazionale
Area della Ricerca del CNR
Via Moruzzi, 1 - 56126 Pisa, Italy
{giovanna,cignoni,a.paccosi}@ilc.pi.cnr.it

Abstract. This paper describes *Addizionario*, a multilingual hypermedia laboratory for native language learning, addressed to children of nursery and primary schools. The features of the tool, which is child-centred, flexible, easy-to-use and interactive, make it suitable not only for normally skilled users, but also for those presenting more or less severe learning difficulties linked to both physical and cognitive impairment. The software, patented by the Italian National Research Council (C.N.R.), is used in numerous schools in Italy and abroad.

1 Introduction

In recent years, there has been a strong need, especially on the part of nursery and primary school teachers, for new strategies, resources and activities aimed at facilitating the pupils' learning process.

Information technology has tried to meet these requests, offering powerful means to improve language and social development, to expand critical thinking, increase motivation and self-esteem, and encourage imaginative creation and social interaction among learners [1], [2].

The software *Addizionario* presented here is an example of the ways in which technology can be used in classrooms with younger pupils [3].

The product is a hypermedia linguistic laboratory for children aimed at the study of languages. This tool adapts to one's personal capacities and makes it possible for even the most reticent child to be actively involved in his own learning process not only as user but also as author. Through exploration and discovery, through collaboration with teachers and peers, children can master tasks generally considered difficult and boring. *Addizionario* reflects a new, non-traditional approach to the study of language and to the use of the dictionary. It is an interactive and flexible tool, centred on the child, who gradually constructs and organizes his lexical knowledge.

2 The Software

The teaching environment we have implemented includes two correlated multimedia modules:

- a) the Core Dictionary, a dictionary for children written and illustrated by the children themselves, whose name *Addizionario* has been extended to include the whole system;
- b) an Activity Book, which consists in a creative module by which children can play and reflect on language.

The Core Dictionary contains the definitions, examples, drawings and free associations that 400 children of primary schools from various regions of Italy have produced for around 1,000 words. These were extracted from a list of the Italian words most frequently used by young pupils, and included both concrete and abstract nouns, adjectives and verbs.

The Activity Book, the more interesting device of the system, allows the Core Dictionary to be extended and constantly enriched. It differs from the Core Dictionary (which is a non-modifiable block) in that the words, definitions, sounds, drawings, etc. can be introduced, modified and grouped by the users, according to their personal criteria. At the onset, it is an empty archive, which can be filled progressively: new words, definitions, examples and drawings can be introduced directly, or copied and moved throughout the Activity Book by means of the “copy” and “paste” commands, using either the information available in *Addizionario*, or other external material which can be accessed by the computer.

The system also provides a menu of icons suggesting the activities that can be performed. These icons are generally self-explanatory, and thus lead children to identify their correct meaning after a few trials and to understand the opportunities offered (an on-line help is, however, available). No specific order is requested when performing the various activities, nor is it necessary for all the tasks to be carried out. Therefore, work within the Activity Book is an appealing and friendly task that children can perform as if it were a game.

The software *Addizionario*, patented by the Italian National Research Council (C.N.R.), was implemented by the Institute of Computational Linguistics (I.L.C.) of Pisa and the Department of Computer Science of Turin University.

3 Addizionario: Users with Special Needs

The features of *Addizionario* which is child-centered, easy-to-use and appealing, flexible and strongly interactive, make the tool particularly suitable not only for normal users, but also for those with special needs.

Although not originated as a specialized product, the program can be easily tailored to the needs of all users, impaired or not, who are given complete access to all the functions of the system. As a matter of fact, in *Addizionario* the levels of use are not fixed *a priori*, but it is the child himself who “establishes” his personal limits and therefore, assisted by the teacher or carer, discovers how far his capacities allow him to go. The idea of a non-limited access to the program has in some cases given excellent results because numerous children manage to perform activities which at the outset had been considered too difficult for them [4]. We think that among the reasons of success of the program there is the fact that the software can exploit appropriately all the possibilities offered by technology with regard to motivation and involvement on the one hand and richness of stimuli on the other. The tasks that can be performed in the laboratory range from the more simple ones (like activating a sound by a click of the mouse, browsing through the images contained in the drawings archives, selecting and colouring them according to one’s tastes, etc.) to the more complex ones (providing the definition of a word, examples in-context, writing a text starting from and stimulated by a particular image, etc.), so that each child succeeds in performing some kind of task, discovering in himself unexpected capabilities. Children generally use *Addizionario* with great pleasure and are enthusiastic about the challenges proposed by the tool.

The software is currently experimented in Italy and abroad in many specialized centres for the rehabilitation of subjects with more or less severe physical or cognitive impairment (deaf, low vision, Down children).

The material produced by these children and the comments about the tool sent to our research group by educators, carers and assessors confirm that *Addizionario* is a valid support in their everyday activities. However, the software seems to be particularly useful in schools where, alongside the relatively few pupils with severe handicap, there has been an increase in the number of children presenting various types of learning difficulties (those who are immature, those scarcely interested in school activities, those lacking attention, emotional stability, social skills, etc.) [5].

At present the tool is supplied with the interface in five languages (Italian, English, French, German, Spanish), but it is possible for each user to construct easily a new interface in his/her own language. This also makes the program particularly useful to facilitate inclusion in the schools of immigrant children who can study the language of the host country with less difficulty, interacting with *Addizionario* in the language of their native country.

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Virtual Travel Training for People with Learning Disabilities Accessing Employment Including the Introduction to the Special Thematic Session “Virtual Reality”

N. Shopland, J. Lewis, D.J. Brown, and H.M. Powell

Interactive Systems Research Group, The Department of Computing and Mathematics,
The Nottingham Trent University, Burton Street, Nottingham NG1 4BU, United Kingdom.
david.brown@ntu.ac.uk, Fax: +44(0)115 848 6518

1 Background

The purpose of this project is to develop a Virtual Learning Environment to assist in the travel training of a group of people with learning disabilities to enable them to gain access to training and employment opportunities. To achieve this a realistic Virtual Travel in Sutton Package will be developed to assist people with special needs to learn independent travel skills, and to assess the effectiveness of the software in achieving this aim.

This is not the first virtual reality based travel training environment to be developed [1]. VIRTRAN was developed for a Supported Employment Scheme in the United States [2]. This has been followed by a virtual learning environment developed within the Virtual City, to teach independent living skills to people with a learning disability [3]. Currently a package is being developed called Virtual Travel Training to the Millennium Dome as part of the Enter 2000 Conference initiatives. Other initiatives have been developed in Europe for the provision of independent travel support for people with a disability

2 User-Centred Design Methodology

A user-centred design and evaluation methodology will be employed which has proven successful in other travel training projects for use by people with a learning disability (Brown, 1999). The steps of this methodology will be:

1. Form Project User Group: Users from Sutton with learning disabilities will input their ideas on the design of the travel training package working together with a facilitator.
2. Storyboarding: The design ideas of the User Group will be converted to storyboards to guide the development of the travel training package.
3. Implementation: The storyboards will be converted into a Virtual Travel Training Package.
4. Evaluation: The Virtual Travel Training Package will be assessed by members of the Sutton User Group to check its usability and effectiveness.

5. Refinement: The results from the evaluation process will be used to refine the Virtual Travel Training Package to ensure that it will be fit for purpose.

The input of the User Group for the Virtual Travel Training Package to the Millennium Dome has indicated the importance of realism in the travel training simulation. The virtual travel training environment proposed for Sutton is therefore one that is custom-built, in a photo-realistic manner from maps, aerial photographs, site visits and hundreds of photographs. Video will be integrated within the environment to assist in the overall aim of creating a realistic simulation of the environment around which the users will be expected to navigate. Important local landmarks have been shown to significantly aid route finding.

3 Learning Outcomes

Learning objectives may include:

- develops independent travel skills
- promotes transfer of experience to real world abilities
- encourages self-directed activity
- provides motivation
- encourages independent use of public transport to access employment and training.
- Promotes self-esteem and cost-savings in regard to the above issue.

4 Evaluation

Of particular importance will be the evaluation of the transfer of skills from the virtual model to real world experience. Previous evaluation studies have shown that there is excellent transfer of virtually learnt skills to the real world in people with learning difficulties using the Virtual City (Brown, 1999). This has potential implications for users in this project in terms of greater self-esteem, increased independent travel and greater access to work and training.

5 Constructivist Learning

There has been a tension in the development of virtual learning environments for people with learning disabilities between providing the necessary support in using them and them becoming over-prescriptive in nature. To prevent the learners simply learning the layout of one virtual travel-training environment, at the expense of component travel training skills, this environment has been constructed so that it can be uniquely configured at the start of each training session. In this way the traffic density, position of road crossings and training routes can all be set. The interface to uniquely configure each training session is shown in Figure 1.

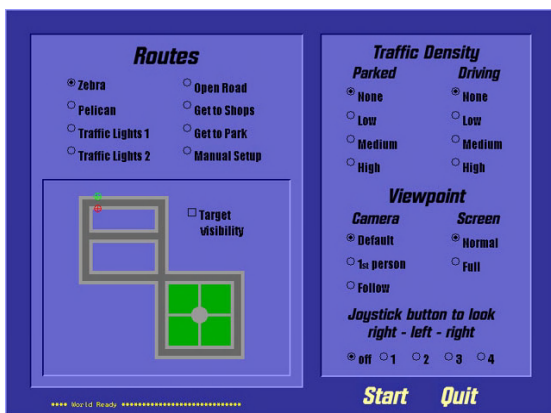


Fig. 1. The configurable interface from the travel training environment.

A snapshot from the travel-training environment itself is shown in Figure 2.



Fig. 2. A road crossing within the virtual travel training environment

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Assessing Virtual Reality as a Tool for Support Imagination

F. Alcantud¹, G. Herrera¹, G. Labajo², I. Dolz¹, C. Gayá, V. Avila¹, A. Blanquer¹, J.L. Cuesta³, and J. Arnáiz³

¹University of Valencia

{Francisco.Alcantud, Gerardo.Herrera}@uv.es

²Centro de Diagnóstico e Intervención, (Valladolid)

Gabriel.Labajo@terra.es

³Autismo Burgos (Burgos, Spain)

autismoburgos@retemail.es

Abstract. One of the major developments of the second year of human life is the emergence of the ability to pretend (Leslie, 1987). Many children with autism use no pretend play or are impoverished in the quality of their play (Baron-Cohen, 1989). The key factor of our Virtual Reality Software in relation to Pretend Play is the possibility to really show the object transformations we propose when pretending. We hope those technics to drive people with autism to a better understanding of pretense and to enable them to develop a play with more quality.

1 Kinds of Pretending within Our Virtual Reality

Alan M. Leslie (1987) sets out three fundamental forms of pretense in real life. These are related to *reference*, *truth* and *existence*:

- Object substitution (reference)
- Attribution of false properties (truth)
- Reappearance / disappearance or imaginary objects (existence)

Almost all the pretending included in our VR system shows “object substitution” (around 80%) sometimes combined with little reappearance/disappearance (10%) or false properties attribution (10%). For example we can find a box of washing powder who could act *as if* it is skipping, we can also buy with an invisible trolley, etc.

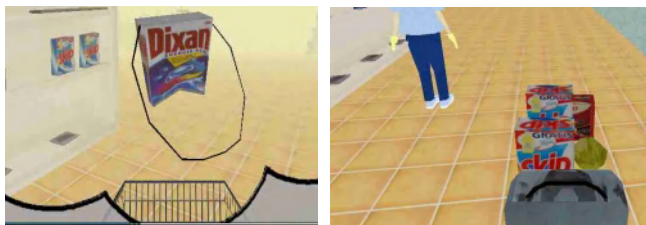


Fig. 1. Object substitution (left) and disappearance (right)

2 Instruction & Experimental Design

Before getting the user with autism in this program, we test if he or she knows the functional use of each object (as well with the real object as with the pretended one). When teaching the user to pretend using virtual reality we will use the following tools, accompanied with meaningful narrative and visual structuring:

‘Use Mode’: if this mode is activated, when selecting an object the system triggers a video sequence displaying the culturally preferred uses of the object.

‘Imagination Mode’ (Pretend play): When activated, the user can touch a product with his/her “magic wand” and then the product (*e.g.* a packet of biscuits) automatically starts working as if it were another object (*e.g.* the packet as a train wagon with biscuits as wheels).

We have developed up to ninety imagination sequences to be used within the instruction process. The complexity of the sequences increases throughout the programme. They are classified taking into account different criteria as if the pretended context or the agent of the pretense appears, etc.

We have chosen a N=1 experimental design because, although we have searched for a regular sample, the differences among its components could still be really significant. Each user will follow the steps shown below (2nd and 4th step are counterbalanced):

Table 1. Steps of testing

Step 0	Previous Assessment (PA)
1st step	Base Line Establishment (BLE)
2nd step	Instruction using Virtual Reality as explained above (counterbalanced) VR-I
3rd step	Follow-up assessment (FUA)
4th step	Instruction using paper-based equivalent material (counterbalanced) PB-I
5th step	Follow-up assessment (FUA)

3 Conclusions

This communication has been written just when starting to use our software with people with autism. The outcome of our research will be published when experimental data have been obtained and analysed.

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Literacy and Numeracy Edutainment Packages for Disaffected Young Learners

D.J. Brown, M. Yazdanparast, J. Lewis, N. Shopland, and H.M. Powell

Interactive Systems Research Group, The Department of Computing and Mathematics,
The Nottingham Trent University, Burton Street, Nottingham NG1 4BU, United Kingdom
david.brown@ntu.ac.uk
Fax: +44(0)115 848 6518

1 Introduction

The UK Government has conducted research into skills gaps within the UK population. It has concluded that there is an alarmingly large proportion of the population with low literacy and numeracy skills.

We are currently engaged with our research team in the development of a series of '*edutainment*' games to teach literacy and numeracy skills to people with low skills levels. These games are designed to motivate people who have been failed by traditional educational institutions and are hence disengaged.

2 Development

The main pedagogic approach of this research is to investigate whether gaming strategies can motivate disaffected young learners. To this end we have produced a number of prototype '*edutainment*' type games, based on the type of computer games the target population may enjoy and are actively engaged in playing.

The first game is '*Bomb Squad*' (Figure 1). The aim of this edutainment package is to teach numeracy skills to disaffected young learners. The numeracy related learning objectives are taken from Entry Level Three of the UK Government's Basic Skills Agency Curriculum. The aim of the package is to locate and diffuse a series of bombs within the Metropolis. In order to achieve this the players (learners) must diffuse the bomb by answering a series of numeracy-based questions within a certain time limit. At any stage the player may use the Help function to review the basic learning objectives (in this case simple additions, subtractions, multiplications and divisions).

The second game is '*The Virtual Night Club*' (Figure 2). The aim of this edutainment package is to teach literacy skills to disaffected young learners. Again, the literacy related learning objectives are taken from Entry Level Three of the UK Government's Basic Skills Agency Curriculum. The aim of the package is engage various people in the night club in conversation, by actively listening to what they are saying and then responding appropriately. This relates to the literacy learning objective of listening and comprehension. Each of the people in the night club the player meets has an associated mood variable. Appropriate responses to the conversations held with the night clubbers results in an improvement in their mood

and more lengthy conversations. Inappropriate responses which demonstrate a lack of comprehension result in a worsening mood and conversations which are terminated. The goal is to achieve as many successful conversations as possible, and all exchanges are humorous and culturally appropriate.



Fig. 1. A screenshot from “Bomb Squad” combining a simple arcade style game with basic mathematical tasks



Fig. 2. A screenshot from “Virtual Nightclub” focusing on comprehension and literacy

3 Evaluation

Initial evaluation of these edutainment packages with disaffected young learners (16–25 years old) at a local project for homeless people has been positive. Usability level of usability has been low and there have been high levels of motivated use of the packages.

The next stage of experimentation will build on these initial results. Evaluation metrics will include numeracy and literacy abilities before and after exposure, together with length and nature of use of the packages compared with testers experience of other, more traditionally didactic packages teaching the same skills.

4 Instructional Plan

Once each package has been developed and evaluated it will be placed in the ‘Knowledge Café’ in Redditch, the West Midlands, UK. This is a European Social Fund sponsored project, with over 1500 beneficiaries with low levels of literacy and numeracy. Longitudinal tracking of beneficiary performance will help us to judge the true impact of these gaming strategies on motivating disaffected learners.

Control of Virtual Environments for People with Intellectual Disabilities

P.J. Standen¹, S. Battersby², and T.L. Lannen²

¹University of Nottingham Medical School, Nottingham, NG7 2UH
p.standen@nottingham.ac.uk

²Interactive Systems Research Group, Department of Computing and Mathematics, The Nottingham Trent University, Burton Street Nottingham NG1 4BU
david.brown@ntu.ac.uk

Around 25 people in every thousand have mild or moderate intellectual disabilities and about four or five per thousand have severe intellectual disabilities [1]. In theory the distinction between the levels of disability are based on IQ scores but in practice people are assigned to these categories on the basis of the level of support they need with daily living and the presence of challenging behaviour. Although children with mild and moderate learning difficulties are increasingly receiving education in main stream schools, like their more disabled peers, when they leave school they are unlikely to enter employment or to achieve the level of independence expected by the rest of society. Adults with intellectual disabilities will have the option to attend some form of college or day centre, the role of which is to provide training programmes relating to the development of daily living, social and educational skills.

Initial work suggests that virtual environments, displayed on a desktop, are effective in facilitating the acquisition of these skills for example shopping, navigating new environments and learning Makaton sign language [2] in children with severe intellectual disabilities. The development and improvement of these skills for both children and adults would facilitate community inclusion. However, many people with intellectual disabilities have fine motor difficulties and therefore find the devices difficult to control. This has now been confirmed in several studies (eg [3]). Until this access problem is solved, exploiting the benefits of virtual environments for this client group will be problematic.

Although a variety of devices exist for navigation through and interaction with the environments, evidence [4][5] suggests that for this user group for navigation, a joystick limited to two simultaneous degrees of freedom is better than keyboard and mouse. The more functions available to them the more difficult it becomes so that they frequently become lost when using a space ball with six degrees of freedom. For interaction tasks, the touch-screen and mouse were equally effective although the touch-screen was difficult to calibrate.

However using the joystick for navigation and a standard two button mouse for interaction there are still difficulties and this is because of their level of cognitive ability [3] and their level of motor control [6]. Many people with intellectual disabilities have fine motor difficulties as they suffer from conditions where They concluded that many of the difficulties users experienced were due to physical ability and device construction rather than to the user's understanding of how to use each device. Additionally, difficulties arise as a result of the design of the virtual environments so that physical help is required to complete some tasks.

With problems like these, users can become frustrated and demotivated. Until this access problem is solved, we are limited in our ability to exploit the benefits of virtual environments for this group of people.

The aim of the study is to develop a usable control device or devices for virtual environments that also meets the requirements advised by [5] that they should be operable by people with fine motor difficulties, modifiable, robust, easy to calibrate and affordable.

Employing a user centred design cycle (eg [7][8]) we are recruiting 40 people with learning disabilities aged over 18 years all with sufficient visual ability to be able to see the display. The sample will include individuals who obtain scores from the lower end of the range of verbal and non-verbal intelligence and fine motor ability.

In order to document the difficulties users experience with the recommended input devices virtual environments have been constructed to include the challenges that lead to the difficulties with the input devices noted in earlier studies. These include turns through ninety degrees, passing through doorways and the combined need for both navigation and interaction. Environments are designed in the form of a game with increasing levels of difficulty where the user receives feedback on their performance. In order to gradually introduce the user to all of the navigational and interaction tasks some environments control one or more tasks so that the user only has to manage one when they first start.



Fig. 1. The Temple



Fig. 2. Dolphin Race

For example, one environment, *the temple* (see Figure 1), only requires the user to move in one plane and has no interaction as doors open as soon as the user is within a certain proximity. Another, *Dolphins* (see Figure 2), provides forward movement requiring the user to move in the vertical plane. The supermarket requires both movement in the horizontal plane to move around the supermarket and interaction to take the item off the shelf and place in the trolley. Because the user has to move in three dimensions as well as interact with the environment.

Participants use the virtual environments on a desktop computer alongside a researcher who is there to help them if needed and to offer encouragement. Measures are derived from three sources:

1. The software collects data on collisions, distance travelled and time to complete each level of the game.

2. Video recordings provide information on how often the person is distracted (engagement), the frequency of unproductive actions (effectiveness) and help given and the content of any user comments and reactions.
3. The researcher completes a log book to record any additional qualitative information.

Having reviewed existing devices, which with adaptation could provide a potential solution, prototypes are developed and evaluated in the same way so that the joystick and mouse have been. This information is used to modify the prototype(s) which are assessed in the same way until a design solution is reached bearing in mind the criteria provided by [5].

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Online Gardening to Promote Social Inclusion

S.J. Battersby¹, N. Kelly², D.J. Brown¹, and H.M. Powell¹

¹ Interactive Systems Research Group, Department of Computing and Mathematics, The Nottingham Trent University, Burton street, Nottingham NG1 4BU, United Kingdom
david.brown@ntu.ac.uk

Fax: +44(0)115 848 6518

² Thrive, The Geoffrey Udall Centre, Reading, United Kingdom

1 Background

There are several European initiatives aimed at producing rehabilitation and associated technologies, in response to a strong North American market created through Disability Act Legislation [1]. In the past we have developed projects that provide vocationally based work tutors to teach a range of horticulture, IT, catering and soft skills. These projects include the provision of virtual reality and multimedia based materials to develop the first of these vocational skills - horticulture.

These projects were aimed at training people with a learning disability. The use of ICT in supporting people with learning disabilities in an industrial setting is not a new idea [2]. It is recognised that these ICT based tutors cannot be used in isolation [3], and that mentors will support their use within Small and Medium Sized Enterprises (SMEs).

2 Online Gardening

An essential component of this project is to establish an e-learning portal accessed via a website, as part of the UK Government's National Grid for learning (NGfL), that will attract people with disabilities and other individuals with few or no qualifications into learning horticultural skills and onwards to further training.

To satisfy usability criteria the site needs to be appealing and easy to use, utilising the latest multi-media techniques to aid the trainee's learning experience. In addition to horticulture, the acquisition of numeracy, literacy and communication skills will be promoted within the portal, with the purpose of encouraging the trainee to pursue and engage in further learning. It will be linked to other projects, such as the Knowledge Café, to utilise innovative multimedia software to promote the active engagement of disaffected learners using gaming strategies.

2.1 Standards to Be Met

- The design and construction of portal must satisfy the overall aims of the project – i.e. they must be attractive to and motivate people not accustomed to learning and be 'easy to use.'

- Compliance with technical specifications outlined in www.ngfl.gov.uk/ and the Web Accessibility Initiative www.w3.org
- It is also necessary to achieve compatibility with the wider NGfL community of web sites.

2.2 Learning Outcomes

The Interactive Garden project refers to the development of 10 horticulture based educational elements contained within an On-Line Virtual Learning Environment. The project is financed by NOF and aims to investigate use of Computer Aided Learning, for the socially excluded and those with learning disabilities.

Elements in development are:

1. Sowing seed in trays
2. Filling trays with compost.
3. Mulching
4. Pricking out into pots
5. Growing a Hyacinth indoors
6. Watering
7. Labelling plants in containers
8. Weeding
9. The identification of weeds
10. Taking cuttings

Developed from the Back To Basics gardening reference sheets produced by Thrive, each element is designed with an emphasis on accessibility for all.

3 Implementation

The development of the portal is being undertaken collaboratively by Thrive and NTU. Ten elements of horticultural-related course material have been designed by the team in consultation with pilot projects and the steering group. So far, eight of these have been implemented on the portal using Macromedia Flash. An additional element will provide an introduction to the essentials of operating a computer.

Some snapshots of the implemented outcomes are shown in Figure 1 below.

After formative and summative evaluation with the testing group, refinement of the learning material will take place to ensure usability.



Fig. 1. Screen Shots from the Gardening Package

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Selective Phoneme Spotting for Realization of an /s, z, C, t/ Transposer

D. Bauer, A. Plinge, and M. Finke

Institut für Arbeitsphysiologie, Ardeystr. 67, 44139 Dortmund, Germany
bauer@ze3.de

Abstract. Hearing impaired people with severe sensory deficit urgently need a perception-based replacement for inaudible fricational features of /s, z, C, t/ (beyond NR and speech enhancement) - to restore high-level breakdown of speech connectedness. Today, shortcomings of past designs can be overcome by digital processing, introducing naturalness and selectivity in the synthesized stimuli. The ears' lost selectivity may partially be substituted by the functionality of a dedicated phoneme (class) spotter - based on statistical feature recognition. Sub-serving transposition, simplified spotting procedures yield sufficient quality of classification, which provides a valid basis for implementation on wearable low-power DSPs of today.

1 User Needs

Our typical user has severe sensory hearing deficits with a total loss of hearing beyond frequencies of about 2.5 kHz. Typically, if through extensive high quality speech training under noise-reduced ambient conditions the mother tongue has been acquired with conventional high-power aids, often auditory communication is not easy and additional lip reading is necessary. High-power hearing aids cannot enhance speech selectivity and intelligibility sufficiently and usually cannot restore missing speech features. As a result, at the perceptual level, numerous gaps seriously disrupt the natural speech stream. To perceptually decode such a gapped stream requires additional mental top-down processing effort that can not be delivered fast enough in actual conversation or cannot be performed at all: Auditory speech communication breaks down, so that our user is forced to fall back onto lip-reading alone.

In order to be able to supply an add-on technical building block that would reduce this mental effort by refilling the gaps, we are developing a /s, z, C, t/¹ transposer. This approach is intended to transpose the most salient speech features or elements, which typically are inaudible if sensitivity is completely lost beyond 2.5 kHz.

¹ SAMPA notation

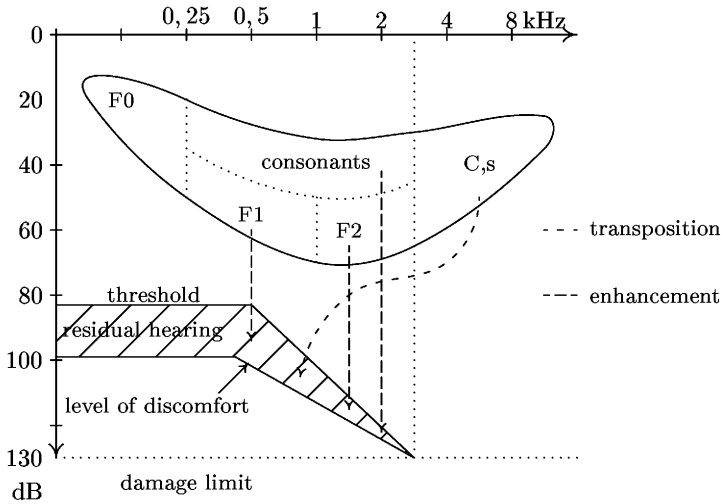


Fig. 1. Typical case of severe sensory hearing deficit. Speech features up to a frequency of about 2,5 kHz are candidates for *enhancement*, features beyond that frequency have to be *transposed*

1.1 What Should – and Can – Be Done

Older approaches of transposers were probably not very successful because several conditions that must be met to yield a good acceptability were more or less ignored:

- The requirement of good wearability has not been met sufficiently.
- Perceptual constraints of good natural replacement stimuli, which would be easily integrated into the stream of the original speech, have been ignored.
- Often, the process of transposition was not made selective; i.e. transposition was continuously active, which often would introduce heavy perceptual masking.
- Highly complex analogue circuitry often introduced problems of electrical stability and with high part count, an impractically high need of assembly and testing.

Today, we are in a position to address these (and other) shortcomings: A dedicated phoneme (class) spotter is being introduced into the complete design to reintroduce auditory selectivity, which is typically lost. The classification process can be used to control various processing algorithms: the idea is to introduce phoneme-specific enhancement or replacement. Control of the transposer function by the classifier would restore not only salient missing phonetic information at the correct locus (gap) but also switch off transposition where only noise or irrelevant information is transposed. In this way additional perceptual masking is avoided.

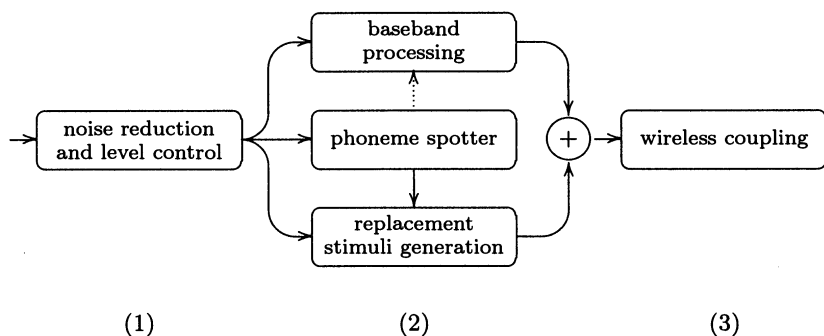


Fig. 2. Overall System

The detected /s, z, C, t/ frications must and can be replaced by comforting synthetic natural-sounding stimuli which would be easily integrated into the stream of the original auditory phonemic images within the audible range.

Naturalness depends on the structure of the signal itself, and on the fact that a controlled amount of non-stationary is introduced. Here, this feature is realized through the introduction of a transformation of articulation changes into parameterized changes of the new sound. Individual adjustment offers the chance to transform changes of articulation into perceivable changes of the synthetic stimulus [1].

Another condition, which must be met for perceptual integration, is correct temporal alignment of the synthesized sound within the gaps of the natural temporal sequence. Furthermore, the detection and replacement have to be done within a tolerable delay in real time to maintain perceptual synchrony with lip-reading.

To realize such functionalities in a technically feasible wearable add-on device, digital processing in a low power integer DSP offers a new chance. Using an fixed-point DSP together with A/D and D/A codecs gives us the freedom to implement all functionalities that are the minimum requirements for a perception-based effective frication transposer.

1.2 Overall System

The overall system (Fig. 2) consists of a front-end for noise reduction and level control (1), the actual speech processing center (2) and the wireless-coupling to the hearing-aids unit (3). The central speech processing center (2) contains three sub-units: the base-band processing (enhancement) unit, the phoneme spotter and the replacement stimuli generation. The baseband processing has to provide best possible reception of speech features within the residual auditory range. (Today, the functionality which is feasible in wearable design here, is still limited by today's DSPs' MIPs.)

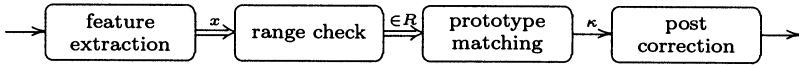


Fig. 3. Four-step phoneme spotting algorithm

The novelty in hearing aid design is the introduction of *artificial selectivity*, here realized in a phoneme spotter. At present it is used to control only the frication transposer.

The output signals of the base-band unit and the transposer unit are combined - after temporal alignment - and sent to the hearing aids [2].

2 The Phoneme Spotter

The classifier to be implemented in a wearable DSP has to be done with comparatively low processing power. We therefore investigated several means to reduce the processing cost while keeping the quality of recognition sufficiently high. To create a flexible recognition evaluation system from which a “minimum-processing-effort” implementation can be easily derived, an outlining four-step recognition algorithm was developed; this consists of

1. feature extraction
2. pre-decision by range check (conjunctive windows)
3. classification by evaluation of precalculated probability densities
4. post processing.

Different implementations of the four step classification process can be evaluated using a dedicated software, which also allows us to omit any of the latter three steps, and which defines the parameters.

The specific functions and transformations that will be finally chosen, determine the computational effort in the on-line classification process. Since a Gaussian-Mixture-Density-approach and full-fledged covariance distance measures may not be the best approximation to reality (and are rather costly), we thought it worthwhile to test computationally cheaper alternatives. Instead of using mixture densities, the use of multiple single maximum densities for /S/ and /C/ yielded better results. Covariances have been omitted to save increased processing cost, however the results are acceptable.

2.1 Feature Extraction

The features extracted from the speech stream are spectral energies, zero-crossing count, pause length, and rate of rise (ROR).

The spectral energies are calculated using a set of FIR filters for a small number of perceptually spaced frequency bands. Energy ratios are calculated that are the best indicators of spectral features to provide a sound base for a

phonetic-feature oriented classification. The zero-crossing counter has its own FIR prefilter. A simple pause detector is used to find 15-50ms pauses - plosive closures [4]. This detector is a low-processing-cost alternative to other approaches, which may use the complete level statistics of the signal. The ROR is calculated as log energy difference for detection of plosive bursts [5]. After pre-filtering the spectral-invariant range of the plosive burst, the ROR feature is very prominent if the plosive is articulated sufficiently distinctive (canonical).

These features form a feature vector x that is fed into to a two-step classification with post-processing.

2.2 Range Check

As a simple decision rule, we define the feature ranges R_κ for all classes κ of phonemes. A class can only be present when all components of the feature vector fall into the range for that feature.

$$x \in R_\kappa \Leftrightarrow x_i \in R_{i\kappa} \forall i \in I \quad (1)$$

This stage allows us to model binary decisions for any feature / class combination. Thus conditions like “*there must be a pause of at least 15ms before a /t/*” can be modelled. Furthermore, these hard decision boundaries allow us to exclude non-phonetic events and phonemes with negligible likelihood - i.e. those which are situated in regions of the feature space far from the candidates looked for.

If the ranges are set to e.g. $\mu \pm s$ of a normal distribution, effect of the range function can be compared to a density threshold. If we modify the probability function so that it is zero for values outside the range, the conjunction of the range function becomes equal to a product of probabilities greater than zero.

$$x \in R_\kappa \Leftrightarrow \bigwedge_I p(x_i) > t \Leftrightarrow \prod_I p(x_i)^* > 0 \quad p(x_i)^* = \begin{cases} p(x) & p(x) > t \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

The amount of processing which is necessary for classification is minimized, since the number of classes whose probability density functions have to be evaluated is reduced. In many cases the vector lies outside all ranges (e.g. vowels) or in the small overlapping range of a few classes (e.g. /C/ and /S/).

2.3 Prototype Matching

Second, for the remaining classes, a likelihood-based classification - approximated by alternatively selectable distance or probability functions - is done.

Since $p(x)$ is constant, and we assume that $p(\kappa)$ is equal for all classes κ , since we have no decision context, we can reduce the maximum a-posteriori probability (MAP) classification to the maximum likelihood (ML) by Bayes rule.

$$\operatorname{argmax}_\kappa p(x|\kappa) = \operatorname{argmax}_\kappa \frac{p(\kappa|x)p(\kappa)}{p(x)} = \operatorname{argmax}_\kappa p(\kappa|x) \quad (3)$$

Based on univariate normal distributions, a Mahalanobis distance function can be derived:

$$dm_{\kappa}(x) := \sum_I \left(\frac{x - \mu_{\kappa i}}{\sigma_{\kappa i}} \right)^2 \quad (4)$$

Replacing the square operation by an absolute and the division by a multiplication (since σ is constant at run-time), we get the fast-to-compute distance function dl , a variance-weighted “cityblock-distance” (which could also be derived from the Laplacian distribution).

$$dl_{\kappa}(x) := \sum_I \sigma_{\kappa i}^{-1} |x_d - \mu_{\kappa i}| \quad (5)$$

The detection decision is the minimal distance.

$$\operatorname{argmin}_{\kappa} d_{\kappa}(x) \approx \operatorname{argmax}_{\kappa} p(x|\mu_{\kappa}, \sigma_{\kappa}) \quad (6)$$

2.4 Post-processing

The feature vector - when seen as a function of time - will sometimes jump between several classes even if centred on the actual phoneme. In order to eliminate this “decision noise”, the result of the recognition is stored for a frame interval of the last 10ms. The final recognition result is the class with the maximum number of point-detections in that interval.

Further means of temporal correction will be investigated.

3 Training and Evaluation

To learn the parameters for the two-step classification unit, we can use the full processing power of a stationary machine. A Personal Computer with 1800 MHz CPU clock was used to evaluate multiple hundred words of labelled speech material spoken by several different speakers in 30 min. Dedicated software was written in C++ under Windows for that task. It evaluates all features available to the classifier. Several strategies were tested to derive the ranges and prototype values from subsets of the evaluation data (typically 150-300 words from 3 different speakers).

3.1 Ranges

To derive sound values for the ranges instead of using the mean \pm standard deviation, a median equivalent was used. The values at e.g. 30% and 70% of the sorted array of feature values from one utterance are interpreted as range, and the classes range is calculated as the union of those ranges. ²

$$R_{\kappa,j} := \bigcup [a_j[n(0.5 - \delta)], a_j[n(0.5 + \delta)]] \quad (7)$$

² The expression $a_j(n)$ should be read as the n th element of the sorted array of all x_j , the component j of the feature vector.

Decreasing the range size by using smaller values of δ can be used to yield fewer false alarms. The ranges actually used as binary decisions (plosive closure, ROR etc.) are fixed.

3.2 Prototypes

The parameters for phonemes represented by only one class can be calculated by a statistical analysis of the training data, i.e. mean and standard deviation.

The feature values of /S/ and /C/ are strongly altered by coarticulation, the average spectra can even become nearly identical in some cases. So, in order to distinguish /S/ and /C/, both phonemes are assigned several detection classes, each representing a certain articulation. To find good prototype values for these classes, different strategies were tested.

The first approach was to select different utterances with strong coarticulation (/YC/, /IC/ ...), to initialize the prototypes with their mean and deviation and thereafter “expand” these prototypes. All feature vectors in the training data were assigned to the class with the highest likelihood, forming sets (clusters) of data for each class. From these sets, the final prototypes were calculated by mean and standard deviation.

Another approach was based on the Expectation Maximization (EM) algorithm. The EM algorithm calculates parameters of those probability density functions with a maximum likelihood. Using univariate normal distributions as a model, we calculated the optimum multiple maximum representations of /C/ and /S/. In the case of /C/, the separation of the feature data into 3 different prototypes gives a very good fit. In the case of /S/, 2 different prototypes were sufficient to suppress false /C/ detection.

3.3 Expansion

The detection parameters defined in this way can be “expanded” to adapt the detection to different speakers etc., without having to run the EM algorithm again.

4 Results

To validate the above model assumptions, we now present selected results. The ranges and prototypes were derived via median and EM from about 30-40 utterances (10,000 feature vectors) per phoneme spoken by three speakers. In tables 1-4 rows represent a segment of speech data labelled as the given phoneme, recognition classes are given in the columns. The numbers are the percentage of labeled segments mainly classified as the given class.³ The burst and frication of /t/ were labeled separately and trained the classes t_b (burst) and t_f (frication). The necessity of a distance function for separation of /S/ and /C/ is illustrated

³ Note that affricatives (/tS, tC, ts.../) were labelled accordingly and are not shown.

Table 1. Recognition rates (%) using only ranges

	S	C	s	z	t _b	t _f
/S/	91.8	0.0	0.0	0.0	0.0	0.0
/C/	52.6	44.7	1.3	0.0	1.3	0.0
/s/	0.0	0.0	100.0	0.0	0.0	0.0
/z/	0.0	0.0	0.0	91.4	0.0	0.0
/t/	2.2	0.0	0.0	0.0	49.5	35.2
/h/	0.0	1.9	0.0	0.0	0.0	92.6

Table 3. Recognition rates (%) using ranges and distance functions

	S	C	s	z	t _b	t _f
/S/	91.8	0.0	0.0	0.0	0.0	0.0
/C/	15.8	82.9	0.0	0.0	0.0	1.3
/s/	0.0	0.0	100.0	0.0	0.0	0.0
/z/	0.0	0.0	0.0	91.4	0.0	0.0
/t/	2.2	0.0	0.0	0.0	49.5	35.2
/h/	0.0	1.9	1.9	0.0	0.0	92.6

Table 2. Recognition rates (%) using only distance functions

	S	C	s	z	t _b	t _f
/S/	88.7	3.1	0.0	0.0	0.0	0.0
/C/	23.7	75.0	1.3	0.0	0.0	0.0
/s/	0.0	0.0	100.0	0.0	0.0	0.0
/z/	0.0	0.0	3.7	87.7	0.0	0.0
/t/	4.4	4.4	4.4	0.0	58.2	16.5
/h/	1.9	5.6	1.9	1.9	22.2	63.0

Table 4. Recognition rates (%), more speakers

	S	C	s	z	t _b	t _f
/S/	86.8	1.4	0.0	0.0	0.7	3.5
/C/	12.8	77.6	2.4	0.0	0.0	7.2
/s/	0.0	0.0	98.3	0.9	0.0	0.0
/z/	0.0	0.0	0.0	90.4	0.0	3.5
/t/	1.5	0.0	3.8	0.0	45.8	32.1
/h/	0.0	2.7	1.4	0.0	0.0	90.4

in the first two tables. It can be seen that there is almost no separation if only the range check is applied⁴ (table 1), and better separation if a distance function (dl) is used (table 2). The next two tables show results using both ranges and distance functions for 80-100 utterances of the same three speakers (table 3) and for six speakers (table 4).

5 Conclusion

Preliminary results show that by making the procedures and models simpler (but not too simple), calculation costs can be reduced without giving away too much quality. The implementation of the /s, z, C, t/ transposing algorithms into a low power DSP is possible.

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A Multimedia Based Software for Non-Japanese to Learn Japanese Sign Language

Flavio Oliveira¹, Iwao Kobayashi^{1,2}, and Mitsumasa Sugawara¹

¹ Graduate School of Software and Information Science, Iwate Prefectural University,
152-52 Sugo, Takizawa, Iwate, 020-0193 Japan

`g231a031@edu.soft.iwate-pu.ac.jp`, `{iwan,sugawara}@soft.iwate-pu.ac.jp`

² Adaptative Technology Resource Centre, University of Toronto, 130 St. George
Street, Toronto, Ontario, M5S 3H1 Canada

Abstract. We have designed a multimedia based system to teach basic Japanese Sign Language (JSL) to non-Japanese people under the concept of self-learning, through the functions of two modules (a Lesson and a Search module) and extensive use of multimedia. We report the prototype of our system, with which the user can work through a progressive series of lessons, or look up JSL equivalents of English words, and refer to sentence examples and grammar explanations.

1 Introduction

In recent years, Japanese society has shown a high interest in sign language. Although many materials exist to teach JSL to Japanese people, there are few to support people who have little or no understanding of the Japanese language. The only materials currently available to these learners are dictionaries with English translations of JSL signs [1]. The purpose of this paper is to report our new educational software to teach JSL to non-Japanese people.

2 System Concept

The system is designed to support people who understand English in learning basic JSL. Neither knowledge of Japanese nor of sign languages are prerequisites for its use. We paid special attention to aspects of JSL which are particularly difficult for non-Japanese speakers to understand, e.g., JSL expressions derived from Japanese expressions or words. The system is also designed to be a source of reference to JSL signs and expressions.

To realize such objectives, we developed a Lesson Module and a Search Module. In the former, the user can learn JSL through a series of lessons. They start at a basic level and include increasingly advanced grammar and vocabulary. In the latter, the user can look up JSL signs by inputting English words and refer to grammar explanations and sentence examples.

Both modules extensively use multimedia, which is recognized as an effective tool for sign language learning [2]. In particular, videos are used to show JSL expressions, allowing the user to clearly view hand shapes, facial expressions and other aspects of signs. With each video, a text explains how to perform the signs.

3 Prototype Development

3.1 Implementation

We implemented the system prototype under Windows platform, using Microsoft Visual Basic 6.0 and Access 2000. The prototype has data corresponding to three lessons, including approximately 300 videos of JSL signs and expressions. We use databases to organize the flow of data, such as video file paths and the text of grammar explanations. The videos were recorded using a video capture board (Canopus MTV 1000), and exported to a computer. We obtained the final video streams, in mpeg format, through the use of Adobe Premier 6.0.

3.2 Learning Modules

Lesson Module. The Lesson Module has a series of lessons, each with a specific topic. Each lesson starts with an overview. This is followed by a number of sections containing JSL vocabulary, grammar explanations and example sentences. Finally, the user can take a number of multiple-choice exercises, in which s/he selects the English equivalent for a given JSL expression, or vice-versa. Feedback is given if the user selects an incorrect answer.

Search Module. In the Search Module, the user can input English words to look up their JSL equivalents. In response to the input word, both a video showing the sign and an explanation of how to perform it are displayed. A history frame allows the user to quickly consult the last ten searched signs. For additional information on how to use the searched sign, the following three types of reference are provided: (1) a list of related words, such as synonyms and words that are component of expressions, (2) a list of example sentences containing the searched sign, (3) relevant explanations of how to use the searched sign.

4 Conclusion

In this paper, we designed a system to teach basic JSL to non-Japanese people. The system is composed of two modules, and it makes large use of multimedia. We developed a prototype of the system and reported its features and functions. An evaluation of the system and required improvements based on it will be made, so that the system can be accomplished and put to practical use.

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The User Interface Design for the Sign Language Translator in a Remote Sign Language Interpretation System

Hiroki Minagawa, Ichiro Naito, Nobuko Kato, Hiroshi Murakami, and
Yasushi Ishihara

Tsukuba College of Technology
4-3-15 Amakubo, Tsukuba, Ibaraki 305-0005 Japan,
{minagawa, naito, nobuko, hiroshi,yasushi}@a.tsukuba-tech.ac.jp,
<http://www.tsukuba-tech.ac.jp/>

1 Introduction

In recent years, broadband networks have spread quickly and sufficient communication bandwidth for sign language video communication is now available. Because of this, remote sign language interpretation carried out in real time through networks, from distant locations, is being realized in Japan.

There has been a great debate on the video quality of sign language video communication, (quality of image, frame speed etc). However, if we assume that this type of communication will eventually be implemented, it will be necessary to consider how to use the system, investigate the ideal operating conditions, and so on.

2 Experiment System

Therefore, we constructed a virtual remote sign language interpretation experiment using NTSC video signal, to design a user interface for a remote sign language interpretation system.

More specifically, conversation participants' room (a deaf person and a hearing person) and a sign language interpreter's room were placed in adjacent, and cameras, microphones, and monitors were put in each. Video cables were installed, and conversation was conducted through the cameras, microphones, and monitors.

A sign language interpreter translated the conversation between the deaf person and the hearing person using video and voice (the deaf person's sign language was spoken out while the hearing person's voice was changed into sign language).

3 Evaluation

This experiment system was used in the following situations, and an evaluation experiment was conducted.

- With one deaf person and one hearing person
- Using a lecture (the lecturer being a hearing person while students were deaf)
- Using a lecture (the lecturer being a deaf person while students were hearing)

In each situation, an evaluation experiment was conducted, examining the following points.

- What was the optimum number of cameras and monitors?
- Where should cameras and monitors be put?
- Is there any subject on system use?

4 Results

The following results were obtained by experiment.

- For interpreters, the exact image of the remote location was useful as well as the image of the deaf person.
- It is important for interpreters to see the eyes of the subject. Poor eye contact results in impaired communication.
- More information is given to interpreters in a remote place than usual.
- When an interpreter is in a remote location, deaf persons and hearing persons can communicate without being aware of the interpreter.

Furthermore, an experiment was also tried in which an image from a sign language interpreter booth was actively chosen using a camera which could employ a network to control pan, tilt, and zoom.

The See-through Head Mount Display as the Information Offering Device for the Hearing Impaired Students

Tomoyuki Nishioka

Tsukuba College of Technology
4-3-15 Amakubo, Tsukuba, Ibaraki 305-0005 Japan,
nishioka@a.tsukuba-tech.ac.jp,
<http://www.tsukuba-tech.ac.jp/info/staff/nishioka>

1 Introduction

Augmented reality (or Mixed reality) is a natural extension of virtual reality. Information acquired by external sensors is displayed overlap with physical world. This extend human cognition of physical world.

The framework of the augmented reality, acquiring information about current situation of the physical world by non-human sensors and offering collected data with natural display, is also useful in the context of offering equal accessibility for the people with disabilities. From this point of view, we are interested in information offering using augmented reality technologies. In this paper, we examine see-through head mount display as the information offering device for the hearing impaired students.

2 ST-HMD Device

The display device we evaluate is optical See-through Head Mount Display(ST-HMD) using holographic optical element. Optical ST-HMD combine physical and computer-generated image on user's eyes. The high transparency of the device ensure overlapping offered information with physical world easily.

The device just looks like ordinary glasses. The weight of the display is only 25g. (Core unit of the display is 5g weight.) Because of this lightweightness, it does not disturb daily life. At the typical case of the information offering for the hearing impaired, offered information is displayed apart from what the user want to see. The viewpoint of the user makes round trip. Using the transparency the user may not need to change his viewpoint so frequently.

The resolution of the display is 320x240(QVGA). This comes from size of LCD panel built in the display. The image of the display floats 1 meter apart. The size of the image is just same as 12 inch computer display 1 meter apart or PDA display on user's hand. The display has green monochrome color with 8bit depth.

Image projection area has only 3mm diameter. Sometimes subjects need to adjust the position of display to fit projection area to their pupils.

3 Experiments

We evaluate the device with two different circumstances; lecture at classroom and address in auditorium. Image materials displayed on ST-HMD are text(caption) and realtime movie of sign language interpreter.

3.1 Lecture at Classroom

The evaluation is done under lecture of paper airplane with practice. The subjects are students of Tsukuba College of Technology who are hearing impaired. In this situation, the subjects have to change their viewpoint between lecturer, interpreter, and their hand frequently. Using ST-HMD, the subjects can see lecturer and interpreter simultaneously. Moreover, the subjects can receive lecturer's description (via interpreter) even they watch on their hands.

The brightness of the classroom is enough to read lecturer's lip.

3.2 Address in Auditorium

The brightness of the situation is not so bright. But the lecturer, that is the viewpoint of subjects, is rather bright because he gets spotlight. So just like at classroom, offered information displayed on ST-HMD may interfere.

4 Results

4.1 Lecture at Classroom

Compare with 5 inch LCD display on desktop, the subject can not get benefit from ST-HMD because of lack of brightness of the ST-HMD. In this case, darkness of ST-HMD overcomes freedom of viewpoint and merit of simultaneously viewing.

About materials of image, text(caption) gets high evaluation than movie of sign interpreter. Some subjects reports that they have to concentrate to the movie to understand so they can not aware things behind movie(i.e.,physical world).

4.2 Address in Auditorium

On the contrary to the classroom, the subject report that the image on the display looks very clearly. The caption on the display can read easily and the sign language played by the interpreter displayed on ST-HMD is easily understandable.

Another benefit is that the subjects do not have to fix their viewpoint to the lecturer.

As concluding remark, ST-HMD we evaluate is valuable in the situation of address in auditorium.

Digital Speech Signal Processing to Compensate Severe Sensory Hearing Deficits: The /s, z, C, t/ Transposer Module in Simulation – An Overview and Examples

D. Bauer, A. Plinge, and M. Finke

Institut für Arbeitsphysiologie, Ardeystr.67, 44139 Dortmund, Germany
+49-1084-265, Fax +49-1084-265, bauer@ze3.de

We start by considering the needs of users who until now cannot receive badly needed technical compensation for their auditory deficit – because of a lack of efforts to develop special assistive devices for the smaller populations within mainstream industrial development: These patients are characterised by the existence of severe sensory deficits; they are often unable to draw sufficient benefit from conventional hearing aids nor are they candidates for cochlear implants. If we consider the possibilities of residual reception of sensory information within this group - particularly when the auditory cortex has received good training, substantial chances of improvement of speech reception can be identified - if current technical shortcomings could be eliminated. Today, unacceptable limits to verbal speech communication exist in too many communication situations. Technical requirements, arising from user needs on the background of users' residual physiological processing, are the starting point of our approach. The goal should be to effectively replace the lost auditory functions by external processing: Not only a compensation of losses in spectral sensitivity and spectral dynamical ranges is required to make feature information audible; we must also direct our attention more specifically to the compensation of *losses of selectivity* in phonetic cortical pattern recognition. The concept of various technical functions of a “speech processing system”, which may be added to hearing aids, are outlined: dedicated technical functionalities are grouped into a “front end”, a “baseband processor”, a “phonetic-element-replacement module”, and a “wireless-coupling to the hearing-aids” unit. The definition of an appropriate choice of matched functionality is discussed, which must be considered as being absolutely necessary to achieve an acceptable “minimum” compensation of the typical severe sensory auditory deficit within the constraints of current technical feasibility. Our aim is to provide a technical basis that may be acceptable as a minimum standard for efficient social and occupational integration.

The digital realisation of the selective speech-feature or speech-element replacement module is treated in more detail. It is considered to be indispensable within a speech processing system for our user group, since it is the only means to amend broken auditory Gestalten, and to re-establish connectedness. The module makes salient speech features audible, which without such assistance would be lost to the cortical “speech scene” analyser; i.e. would be perceptual gaps in the speech stream -which barely can be compensated by mental “top-down” processing. To specify the current status of development we call this module the “/s, z, C, t/ transposer”, a device designed to restore as many as possible of the deteriorated natural segments. To match transposition to perceptual requirements, actual transposition is done by a two-step process: 1. It is decided specifically in time when

to replace what and 2. which new audible artificial “replacement sounds”, which are parametrically controlled by the original sound, are generated. This is done through a process that consists of a phoneme recogniser/spotter, which is paralleled by a synthesiser that re-encodes the frications of /s, z, C, t/. In order to ensure proper integration into the speech stream, several perceptual conditions have been identified: the synthetic stimuli must not only be audible again but must also possess a certain degree of naturalness. Pre-adjustment of perceptual roughness and parametrical control by the speaker’s articulation are important preliminaries. In contrast to other design approaches, the phoneme spotter ensures that transposition here is performed selectively; perceptual masking through continuous transposition of high frequency energies is avoided. In this way, selectivity within the lost part of the ear is restored in the residual hearing area as an inherent property of the transposition. Fortunately, through the advanced status of automatic speech recognition, the task of phonetic classification was alleviated by adapting suitable approaches, which are described in the literature as “phonetic classifier” or “recognizer” or “phoneme-spotting procedures”. However, what makes a difference to us are our specific boundary conditions: 1. to do the whole processing within a limited temporal delay which would ensure perceived synchrony between auditory channel and visual channel used for parallel lip-reading, and 2. to do all processing (baseband and transposer) at a limited cost of processing that would lend itself for implementation into a wearable fixed-point DSP. Therefore, to be able to test the feasibility and efficiency of various phoneme-spotting configurations, it was necessary to develop several simulation tools with dedicated GUIs. They all have been written in C++ under Windows. Our goal was to find that spotting procedure which would provide a sufficient recognition precision while keeping the processing costs low. Quality of the spotting process, which here must be defined by high hit rate and extremely low false-alarm rate (which would perceptually be very annoying) can be investigated. *A description of the dedicated procedures is given in the paper presented by the same authors in this conference.* Some variations of the spotting method, which differ by their total computational costs, are compared. The simulations done so far show that even simpler procedures can lead to quite useable spotting results; the rather costly statistically optimum processing can probably be avoided.

The second part of the transposition task is to provide “quasi-natural“ integration of the replacement features into the baseband signal (of which the original spectral component are not altered). We have already discussed¹ how perceptual boundary conditions should be considered. Here, the extension of the concept by meaningful transposition of /C/ and of /t/ is exemplified through presentation of signal graphs of phoneme combinations with and without processing.

Conclusion: The selective inclusion of /t/ and /C/ beyond /s/ and /z/ -frication in the transposition process can succeed without introducing too much additional processing cost, if the main allophonic variations are targeted. Implementation in current DSP technology is considered to be feasible and is attacked as the next step.

¹ Bauer et al. & Plinge et al. In: AAATE’01, Assistive Technology – Added Value To the Quality of Life, Eds. Crt Marincek et al., IOS Press, Vol.10; pp 449–458

Computers for the Development of Young Disabled Children

Introduction to the Special Thematic Session

Dominique Archambault

INSERM U483 / INOVA, Université Pierre et Marie Curie
9, quai Saint Bernard, 75 252 Paris cedex 05, France
Dominique.Archambault@snv.jussieu.fr
<http://inova.snv.jussieu.fr/vickie>

Abstract. The use of specific user devices, and specific software, may allow disabled people to perform independently some task they could not otherwise. In the case of young children they can be used in the way of stimulating cognitive works to help their development. In this session various experiences conducted with children with various kind of impairments are presented. These experiences are characterised by a few similarities like the importance of focusing on the possibilities of the children instead of the impairment, the necessity to use adjustable and attractive interfaces.

Computers have taken a very strong importance in the industrialised countries. Indeed it allows to improve the quality and the fastness of our works. It is still rare that it allows to perform a task that we could not do without it, but very slowly. For a lot of impaired people it is not rare: they could not do independently any of the tasks they can do using technology. More and more it appears that children could benefit hugely of these technologies.

The use of specific user devices, and specific software, may allow disabled children to play independently. For some of them, it will be the first time in their life. In this session various experiences conducted with children with various kind of impairments are presented: from computer games to education, via technical assistance and training. A few similarities that can be found each in several of these papers can be extracted.

1 Focus on the Possibilities

First a very important point that I picked up from the paper of Anita Hildén[2]: “...*focus on opportunities and possibilities for young disabled children instead of disabilities*”. In the paper of Daniela Tuparova and Vaska Stancheva-Popkostadinova[3] this analysis of capabilities also appears. But this will not be understood as a limitation of what will be proposed to the children. On the contrary the objective is to allow him/her to start from what the child can do and then to help him/her increase his ability.

The use of specific devices and hardware enlarges the possibilities that are offered to the children. A single motion can trigger any relevant feedback that will stimulate the child. It may help for instance for learning the simple relation between reason and effect (see the paper of Paul Panek and alii[4]).

2 Adjustable and Attractive Interfaces

A second aspect is highlighted in most of the papers: the necessity of adjustable interfaces allowing to suit a user profile. Depending to the children, it may be the adaptation of the graphical layout (Chi-Nung Chu and alii[1]) or the adaptation of hardware devices[4].

The user interface should also be attractive. It is important that the child have fun with the computer and appreciate to use it. The use of sound will be very motivating for children with visual impairment. For children who can see, even a little, it is important that audio output is synchronised to a visual response.

In the TiM project, dealing with computer games, we use a game engine that manages the use of the various devices that are available according to a device independent scenario and a user profile. The paper of Aurélie Baud[5] introduces elementary game scenes that can be adapted in a generic way and suit many game situations, and the paper of Antoine Dutot[6] present a programming language aiming at making transparent the use of the various specific and standard devices.

[2] reminds us the fact that motor skills and cognitive or affective development are not necessarily at the same level. For instance a teenager with several impairments may not be interested by a computer game that deals with fairy tales even if its functionalities are accessible to his motor skills or cognitive ability!

Adjustable means also that the system settings should evolve in the time with the same user [4], because of the evolution and training of the user.

3 Stimulate Cognitive Work

Then attractive interfaces stimulate the child's cognitive work according to various perspectives:

- ability to use the devices and software;
- capacity of reasoning;
- accumulate intuitive experiments.

Moreover, it can help the affective development of children. Indeed the status of object that have the computer helps to reduce the frustration or shame when failing, that encourages the child to try again. Then it is possible to regain trust in their capacity to learn, to think, to communicate, and finally to improve their own self-image. Another point is the feeling of appurtenance to the same world: adults and other children use computers.

4 Online Contextual Help

Another interesting concept is the possibility of supplying the user with on-line help, that is help that can be proposed automatically or semi-automatically by the system if the users has difficulties (pop-up symbols in [1]). It can also use an alternative modality (speech synthesis) to read the current text.

The interface can display, in an adapted form, all necessary help for the user. This is important in the way of autonomy.

5 Identifying Problems

Each tool, whatever great advantages it comes with, may have negative aspects. [3] proposes a discussion about advantages and possible negative effects in using technologies with children with mental retardation. It is important to find out these negative effects in order to identify if they are really inferred by the tool or by the way it is used, and to find solutions to shorten their importance.

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Multimedia Games for Visually Impaired Children

Aurélie Buaud^{1,2}, Harry Svensson³, Dominique Archambault¹,
and Dominique Burger¹

¹INSERM U483 / INOVA – Université Pierre et Marie Curie
9, quai Saint Bernard, 75252 Paris Cedex 05, France

²Laboratoire de recherche en Génie des Systèmes Industriels
ENGSI-INPL, 8 rue Bastien Lepage, BP 647, 54010 NANCY, France

³Tomtebodas Resource Centre, Tomtebodagavaden 11A, SE-17125 Solna, Sweden
Aurelie.Buaud@snnv.jussieu.fr

Abstract. The TiM project intends to develop and to adapt computer games for visually impaired children. To describe the user's needs is the first step of this project. This analysis will allow us to define two important points: the soft architecture & the authoring tools and the computer Human Interface for children and the resources (audio, tactile,...). This paper presents TiM's approach concerning to human dimension and the advance concerning adapted games.

1 Introduction

1.1 Objectives of the TiM Project

The overall aim of the TiM project is to offer to young visually impaired children of various levels of psychomotor development the possibility to play computer games in an autonomous way.

Currently, blind and severely visually impaired children cannot access multimedia games existing on the market independently because they cannot use the mouse and these games are based on a graphical interface. Moreover, the systems of adaptation such as enlarging software or screen readers are incompatible with these games [1].

TiM aims to develop adapting tools which allows to design computer games using different kinds of special devices (tactile, audio, adjustable screen displays) from existing contents.

The TiM project is founded by the European commission (IST programme). It involves researchers from various disciplines from human sciences (ergonomic specialists who study the usability, therapists specialised in handicapped people or visually impaired children, educators, teachers, psychologists specialised in toys) to technical fields (computer science), from 3 European countries: France, Sweden and United Kingdom.

1.2 Adapting Tools

These software adapting tools are composed by a game platform and authoring tools for creation and adaptation of computer games. The game platform will facilitate the use of sound and different specific devices. This platform manages automatically the use of the different devices (standard devices as well as specific ones) connected to the system according to an user profile and according to generic game scenarios (which are independent from devices).

1.3 Designing Steps

This project will follow four iterative steps (Fig 1):

Step 1: Description of technical and user's needs

Step 2: Development of

- the software environment (adapting tools)
- adapted games

Step 3: Evaluation of the adapted games so as to improve the adapting tools

Step 4: Dissemination of

- adapting software
- designing Guidelines
- adapted games

This paper describes the first step and the approach to adapting games from users oriented perspective.

The development carried out by TiM highlights the importance of taking into account the human dimension in order to better understand the needs and the final expectations of the user (children with visual impairment and future designers of games). Indeed, the adapting tools must use interfaces adjusted with the physical characteristics of the children and their competence (cognitive).

2 User's Needs

The study of users needs have been based on quantitative questionnaires and interviews that have been carried out in the 3 countries of the partners involved in the project. In parallel an ergonomic analysis about adapted games prototype has been carried out in France.

2.1 Quantitative Analysis

Two different questionnaires were send to parents and teachers in France, Sweden and United Kingdom. The main purpose of the questionnaires was to collect information about access to computers in the educational environment as well as at home and how frequently/in what situations the equipment is used. Of special interest for the project is the availability of different types of helping devices for input and output and what

kind of difficulties the young users have met. Finally 78 questionnaires were returned from parents.

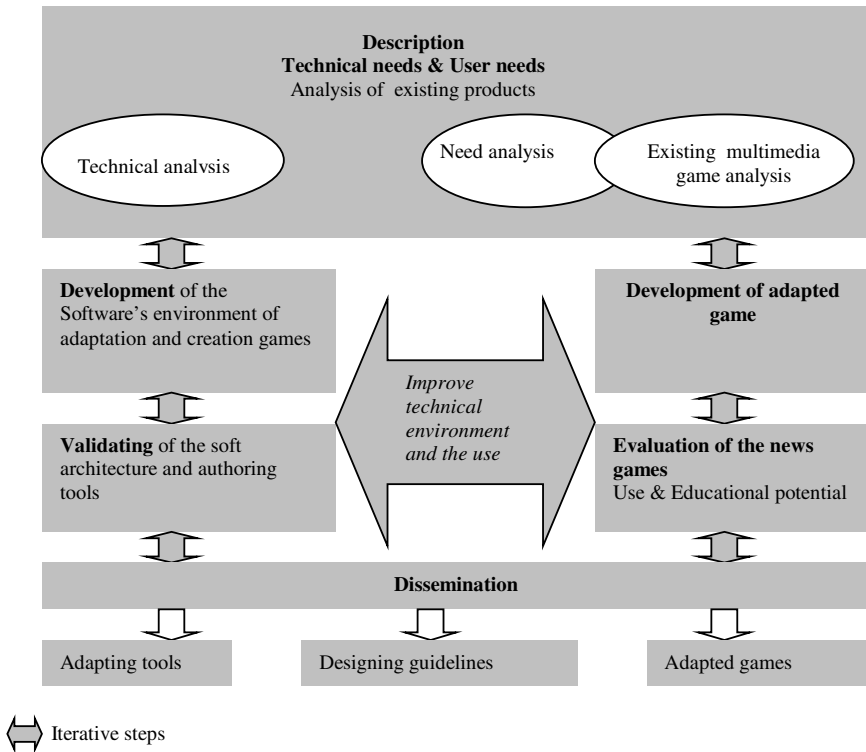


Fig. 1. TiM's methodology

66% of questioned children have access to a computer and 70% use it regularly (week and week end). This type of use is influenced by the child's age. (the older the children are the more they use computers, the youngest they are the more they use it for work school).

One third of the questioned children use computer in an independent way. The age and the degree of visual impairment are important, as expected. Target users are equally less able to use a computer independently than children with a visual acuity better than 0,01. But still there is a for great need help among all children regardless of the degree of visual impairment. The same results have been observed concerning the use of computer games. The existing games do not seem adapted and target user met more difficulties than the other children.

This quantitative analysis does not enable us to define the difficulties actual met by the children during the use of computer games and thus the characteristics of the needs. Therefore, we completed this quantitative analysis by semi-directive interviews, realized in France and Sweden, with a qualitative questionnaire.

2.2 Interviews

From the analysis of the interviews two separate groups of children with different needs have been stressed.

A first group of children is composed of the partially sighted children (acuity better than 0,05), autonomous in the use of video games. They can play with the games on the market using the standard interfaces. Most of the time, the difficulties they meet are due to inappropriate contrast or colours, so that they cannot see the obstacles they have to get across. They prefer to play with a joystick or a "joypad" because the buttons are easy to use.

The second group of children, composed of children with severe visual impairment (from blind to acuity lower than 0,05), cannot access to computer games in a autonomous way. To play, these children need the help of a sighted person because they cannot access to graphical interfaces. In such conditions, many of them do not access all the game. Their direct input on the game are only occasional ones. The children strongly express the wish to have the possibility to play alone, or with others, and to choose by themselves.

These interviews show the importance of researching the means with which the children could be able **to interact to the whole game in an autonomous way.**

Several game scenarios have been described by children and they would like adapted action games, where the main character is living an adventure with obstacles and plots. In this game, the child will be able to access his performances, for instance thanks to a score or a reward.

2.3 Ergonomic Analysis

The observation of children using adapted games allowed to identify **interactional behaviour** and **utilisation difficulties**. Specific recommendations arise from this information about the adapted games which allow to work out "**usage functions**" intended to improve the design of adapted computer games for visually impaired children. The integration of these functions in the conception of adapted games, **has to allow the child to navigate and to find easily a way in computer games**. These functions result from the analysis of observations and bibliographical analysis [2, 3]: Scapin [2] cites the ergonomic principles to respect for the design of an ergonomic interface.

The objective of these first observations is to evaluate the adaptation of two games: "A l'abordage, Pit!" and "Petit Ours Brun".¹ These games have been adapted in an user-friendly way using a tactile interface and modifying the sound interface.

Observations have been made in schools or specialized institutes. The children were between 6 and 20 years old. They were blind or partially-sighted people.

Recommendations for game adaptation have been extracted from this analysis, related to the navigation and the location (by the sound modality) in the Game, and to the layout of information on tactile board .

¹ These games have been adapted from existing French mainstream multimedia games from Bayard Jeune with their free acknowledgement.

2.4 Target Users

From these studies, a specific user group have been decided, addressing children from 3 to 10 years old, blind or having severe visual impairment (acuity below 0,05), with or without additional impairment (from slight to moderate). For these children the information presented on the computer screen in an ordinary way is not accessible and therefore it must be presented in an alternative way.

The specific needs related to the visual handicap when playing must be defined. We should not forget that the visually impaired child is a child. "The adult designer cannot characterize precisely a toy user, he must observe the children's behaviour with the toy to validate his choices" [2]. The author refers to some specialists of child psychology, like Piaget who has thought its research on the universal laws of development, shows that the child goes through by various stages during which he has develops a specific logic and a particular way to see the world around him.

Thus the game's designers must know these various stages to understand the way of reasoning of the users for whom will be make the product. The children's needs, related to level of visual handicap and psychological development, must be taken into account all along these designing process.

3 Existing Multimedia Games Analysis

A multimedia game is composed by an environment and a scenario.

3.1 Game Environment

A game environment is made up by a background and characters who follow the child all along the game. This environment depend on the age of the children.

For children from 3 to 6, game environments are inspired from comics, cartoons, fairy tales, animals and nature. The topic is discovery and the child is guided by an imaginary character. For children from 7 to 10, game environments are inspired from films, cartoons, science fiction. In some games, the objective is related to thought (looking for information, solving enigmas.). The other games allow the child to let off stream.

3.2 Game Scenario

A multimedia game scenario describes, in a operational way, various interactive game scenes.

Let us consider for instance an environment and scenes from "*Lapin Malin, Maternelle I*".² The environment is a magic environment (Fig. 2) with an imaginary character: a mouse. The interactive scenes are symbolised around the main character

² designed by TLC Edusoft.

(elephant, train, flower,...). The child has to click one of the scenes symbols to enter into the corresponding scene (Fig. 3).



Fig. 2. Magic Environment

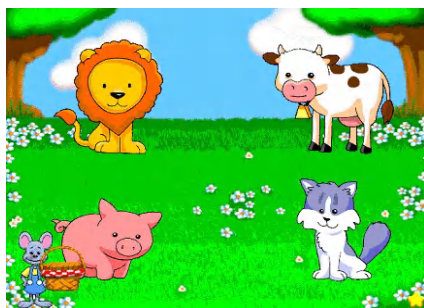


Fig. 3. Scene

In order for the child to have access to the whole of game, the child must be able to:

- navigate and be find his easily in the game’s environment (interface’s game is allowed to get to scenes)
- and the scenes (to achieve the goals of each one of them).

In section 4, we will describe an adaptation of a game on title “A l’abordage, Pit” using a tactile interface.

3.3 Elementary Scenes

By thus breaking up a game, scenes can be isolate in order to adapt them separately. We observed that some elementary situations occurs in many games: the interaction is the same and the various resources involved make different games. It can be for instance the navigation in a maze, a set of questions, a memory game.

The TiM’s approach is to provide generic adaptation schemes, or “templates”, for these “elementary scenes”, that allows access to various specific devices as well as standard devices. Then the adaptation of a given game situation that fit an elementary scene is very easy: the multimedia resources corresponding to this game situations are inserted in the template. Such game will automatically work with any device that was planned in the adaptation scheme.

In section 4, an elementary scene using only sound interface (Bird) will be introduced.

4 Adapted Games

4.1 Game Using Tactile and Sound Interface

We developed an adaptation on mainstream game “A l’abordage, Pit!” (“Let’s Go On Board Pit”) intended to children 6/7 years old. It is an interactive story. Children can read and watch the story by following the words lighting up on the screen. The

original software interface is based on the “book” principle (Fig. 4): the player can navigate in the pages of the book. On each page the child can go to the next page, can try to answer to a question and can access a game.



Fig. 4. Story (environment scene)

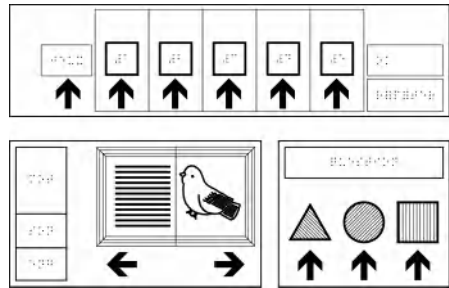


Fig. 5. Tactile sheet

This game was also adapted using the Concept Keyboard. A tactile sheet (Fig. 5) was designed, to give access to the game: the child navigates and plays thanks that tactile sheet. Three large rectangles correspond to the 3 parts of the CD-Rom:

Bottom left rectangle: this part allows to navigate in the pages, to listen to the text of the pages and to the audio illustration of the page (by pressing on the book’s pages).

Bottom right rectangle: this rectangle allows to answer questions.

Top rectangle: the button “games” gives access to 5 different games which are played using the same tactile interface. By pressing several times the button “games”, the titles of the games are given successively. Then a game is selected by pressing the arrow after its title has been given. For example: “*Afrique*” (“Africa”)



Fig. 6. Africa

In the original game, 8 animals are displayed on the screen (Fig. 6) and the player has to select the animals which lives in Africa. In the adaptation 5 animals are attached to the 5 buttons (Fig. 5) and their name is said if the player presses these buttons. The player has to press the arrows corresponding to the animals that live in Africa.

4.2 Elementary Scene Using Surround Sound Interface: “Bird”

The player interacts with a joystick or the four arrows on the keyboard in a surround environment. He/she have to catch a bird which is localised in the surround environment by a sound. The sound intensity increases or decreases as the child gets nearer or further. As the child moves he/she will ear the bird in front, behind, or on

the left or right side. This generic scene is the basis for more complex games using surround environments.

5 Conclusion

The study of the elementary scenes is intended to provide adaptation schemes including an independent access to specific devices. Then these schemes will be easily used to adapt any corresponding game situation. Testing the functionality of games is essential in the process of design. All the adapted game situations are tested in that perspective with the children. These tests must validate if the adapted games fit the needs of the children (autonomy). The description of various elementary scenes with validated adaptation schemes is intended to improve the usability of the adapting tools.

Currently various elementary scenes are studied and the recent release of the first version of the game platform allows to develop game prototypes that implement the corresponding games situations.

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Technical Assistance for Motor- and Multiple Disabled Children – Some Long Term Experiences

Paul Panek¹, Christian Beck¹, Stefan Mina², Gottfried Seisenbacher¹,
and Wolfgang L. Zagler¹

¹ forttec – Research Group on Rehabilitation Technology,
Favoritenstrasse 11/366-1B, A-1040 Vienna, Austria
{panek, chb, gs, zw}@forttec.tuwien.ac.at
<http://www.forttec.tuwien.ac.at/autonom>

² Support Centre Elisabethinum Axams, Mailsweg 2, A-6094 Axams, Austria
s.mina@elisabethinum.at

Abstract. This paper describes the application of a Technical Assistance system developed by the Vienna University of Technology. Main focus has been to provide new means for severely and multiple disabled children in order to support the children's development and to give them more independence and autonomy while exploring their material and social environment. The concept of the system and the experiences collected in practical application of the system in a smart room of an Austrian Support Centre for disabled children are outlined. Based on the encouraging results the system now is also being used in other institutions, in private homes and in higher education in order to enhance independent living of profoundly disabled persons.

1 Introduction and Aim

One of the main reasons for severe motor- and multiple impairments in childhood is cerebral palsy. Here different brain regions can be affected resulting in random combinations of disabilities (motor, cognitive, communication, intellectual etc.). Up from a certain degree of impairment motor- and multiple disabled children rarely are able to use conventional environmental control (ECS) and augmentative and alternative communication (AAC) systems. To attain this ability, in many cases customer tailored user-interfaces plus a long-time training process is necessary. Even learning the relation between reason and effect and experiencing self-effectiveness (being able to make something happen in the environment) is the first big challenge and often an entire new experience. Hence, a technical system capable to meet the needs of these users has to fulfil three criteria: (1) give optimal support to the training-process; (2) support the facilitators with a tool to easily adapt the system to the rapidly changing user needs; (3) be capable to grow from first experiencing self-effectiveness up to a multi-functional multi-purpose technical aid.

The paper discusses an innovative Technical Assistance system developed at the Vienna University of Technology which especially has regard to the needs of motor

and multiple impaired children and to the training-process. After introducing the concept of the Technical Assistance system and pointing out its special features experiences from practical application of the system are described.

2 Methods

For nearly 10 years now our research group has been involved in the development and field-testing of a combined ECS and AAC system we named AUTONOMY [4], [5], [6], [18]. It is based on a PC hardware platform (notebook or a handheld computer) and on the MS-Windows operation system. The input/output hardware can be chosen from a wide range of standard and special devices to meet the specific needs of the disabled user. A set of peripheral hardware components links the system to the physical environment.

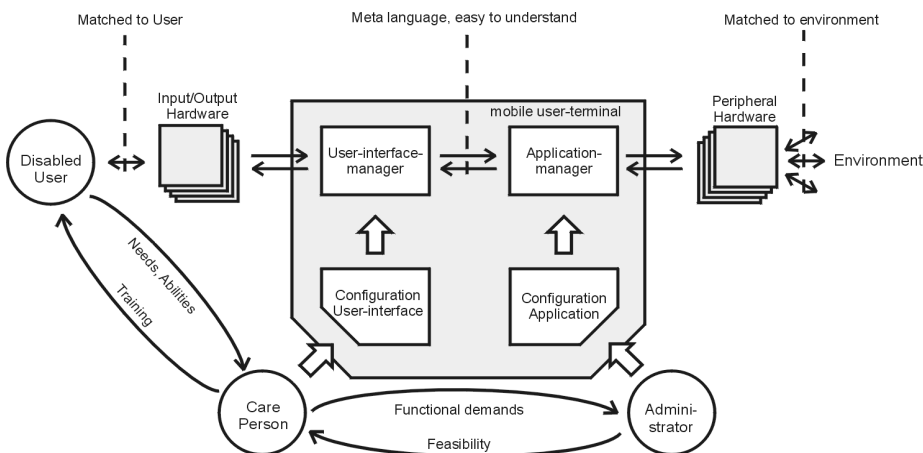


Fig. 1. Block diagram of AUTONOMY system [6], [18] showing interaction between system components and user groups

As a main innovation AUTONOMY offers three different user-interfaces for the three distinctive user groups working with the system (a) The end-user (the person with special needs, who is using the assistance system), (b) the facilitator (e.g. a therapist, pedagogue or family member) responsible for the configuration and adaptation of the user-interface and (c) the integrator carrying out the technical set-up of the system. The cooperation between these three groups of users is essential for optimisation and successful use of the system. The three interfaces/tools (user-interface, configuration tool and set-up/test tool) are tailored to the very specific needs and abilities of the three different user groups according to the specific roles they play in setting up, configuring and operating the entire system.

Fig. 1 shows the interaction between the system components and how the different user groups utilize dedicated user-interfaces. The user-interface-manager and the ap-

plication-manager are internally linked with one another by an easy to understand meta language. This ensures that after the integrator (= system administrator) has set up the application configuration and the peripheral hardware the facilitator (= care person) can refer to non-cryptic (non-technical) terms when configuring the user-interface. The task of the facilitator is to enable the disabled child to discover and exploit new areas of self-determination and independence. He/she will need a versatile and easy-to-use tool which enables him/her to create not only various user interfaces but also creative procedures for working with the communication and environmental control functions in a didactic and therapeutic manner.

Table 1. Numbers of Configurations in relation to size of configurations. Total of 217 configurations in Autonomy Room at Elisabethinum Axams, data collected by December 2001

Amount of Icons (Command Icons and Menu Icons)	Number of Configurations
1-50	189
51-100	8
101-150	6
151-200	1
201-250	4
251-300	2
301-350	5
351-400	1
401-450	1
Total	217

In autumn 1995 AUTONOMY was installed in a Smart Room at a support centre for motor and multiple impaired children in Axams, Tyrol. By using the EIB (European Installation Bus) [8], [14] for the electric wiring and infrared remote control technology, all appliances in the room can be remotely controlled via the system. AUTONOMY usually is placed on a trolley. Thus the user can turn it to face any direction. The Smart Room covers four dedicated areas: living, working (PC with multimedia games, email, WWW, text processor), playing (e.g. electric toy train) and consumer electronic (TV, CD, VCR, ..).

1996 – 1997 several case studies were carried out in order to study the new possibilities provided by the AUTONOMY system [16], [19]. Data were collected by log-books and project diaries in a close cooperation between therapists, teachers, researchers and disabled users. Some of the questions were: (a) What are the main problems for novice end-users and therapists? (b) How can severely disabled children best be trained to handle an environmental control and alternative and augmentative communication (AAC) system? (c) How do the facilitators accept and handle the configuration tool? (d) How can the cooperation between end-user and facilitator be augmented by a Technical Assistance system? (e) Which methods do the facilitators use to introduce and train the disabled children and how can this process best be supported by the system? (f) Is the system able to improve and accelerate the rehabilitation process?

The disabled children observed in the case-studies suffer from high-grade motor and/or cognitive impairments. It could be demonstrated that a Technical Assistance system can be used to improve the rehabilitation-process on a very basic level. Several case studies are reported in [16], [19].

3 Results

After a short time of training a very creative process was initiated by the teachers, therapists and care persons, providing feedback to the engineers to optimise the system and trying and developing new possibilities which a system like this offers. All the professionals found new applications for the AUTONOMY system and tried to adapt the system to match their special requirements. These applications were sometimes very different from the first scope of the system to be an environmental control system. One focus was to use AUTONOMY as communication aid especially with alternative augmentative communication using BLISS, PCS, ALADIN symbols or even photos.

Table 2. Used Input methods of total 217 configurations in Autonomy Room at Elisabethinum Axams, data collected by December 2001

Input Device	Number of Configurations	relative
Single Switch	76	35.02%
Two Switches	79	36.41%
Five Switches / Joystick	61	28.11%
Mouse	0	0.0%
Five Switches combined with Mouse	1	0.46%
Total	217	100.00%

Table 3. Distribution of Scanning Intervals of total 76 configurations in Autonomy Room at Elisabethinum Axams which are using single switch / automatic scanning, data collected by December 2001

Scanning Time	Number of Configurations	relative
0.5 – 3.0	43	56.58%
3.1 – 6.0	22	28.95%
6.1 – 9.0	4	5.26%
9.1 – 12.0	7	9.21%
Total	76	100.00%

The possibility to create very easily and quickly new configurations for a user accelerated this process. Simple configurations can be made by a carer in a few minutes, more complex ones in a few hours. Due to this fact the system was also used for

training, e.g. for novice users to get familiar with the operation of a computer with switches or special input devices and to recognize immediately the principle of action and reaction. When starting with communication via the computer with multiple impaired children the first step is to have only a *yes* and a *no* icon and to provide an acoustical feedback with synthesized or recorded speech. In cases where even that very simple yes/no communication fails the first step is to use environmental control functionality with few devices and acoustic feedback to teach the action reaction principle to the children.

The motivation of the children can be increased e.g. by controlling their favourite toys with the computer. Sometimes the users have already a communication book or something similar (using PCS, BLISS, ALADIN, ...), in this cases an ‘electronic copy’ is built with the AUTONOMY system. An important feature is that almost every kind of picture material, e.g. photos of relatives, can be associated with an icon of a menu. Systems which offer only a restricted set of (often predefined) symbols fail very often if the user has very strong mentally impairments.

Table 4. Used Graphics in Autonomy Room Elisabethinum Axams, total amount of Autonomy configurations = 217, total number of available graphic files = 11,313, totally used graphics = 1,033. Data by December 2001. Used Libraries: *) Picture Communication Symbols, Mayer Johnson Co. US **) Blissymbolics Communication International, Canada ***) Bliss for Windows, Handicom, NL #) PuT – Pädagogik u. Technik GmbH, Germany +) TU Vienna, Austria

Type of Graphic Library	Available Graphics in this Library	Used Graphics	Relative to Graphics in this Library	Used relative to totally Used
PCS color *)	3,043	124	4%	12.00%
PCS b/w *)	2,983	179	6%	17.33%
BLISS **)	2,482	138	6%	13.36%
ISABLISS ***)	186	182	98%	17.62%
Aladin #)	1,321	80	6%	7.74%
Biblio +)	1,066	211	20%	20.43%
Others (individually created)	214	102	48%	9.87%
System Graphics +)	18	17	94%	1.65%
Total	11,313	1,033	9%	100.00%

Certainly one of the most important features of the AUTONOMY system is the very easy and comfortable handling. Out of the first smart training room at the beginning of the project became a system for every day life which is running on different computers in classrooms having a database of more than 250 configurations (ranging from configurations with only two icons and no menu structure up to configurations with more than 100 icons arranged in menus with a depth down to 7 menus) and image and sound file resources of hundreds of megabytes stored on a server.

The concept of AUTONOMY acknowledges and supports the immense importance of the rehabilitation experts (teachers and therapists) for the satisfactory implementation and use of a Technical Assistance system. It could be proven [16] that (a) the

technological concept satisfied all expectations of the users and facilitators and that essential drawbacks of existing systems could be avoided, (b) integrating a Technical Assistance system into the rehabilitation process (mainly in the areas independence, self-determination and development of residual functions) is a factor to speed-up rehabilitation and (c) these results are positively assessed by the disabled users themselves and lead towards an increase in quality of life.

4 Discussion

One of the main goals in developing AUTONOMY was to provide a configuration interface which enables even complete computer illiterate persons to create client tailored user interfaces and application. The concept received perfect acceptance from teachers and therapists and meanwhile several hundred different configurations were set-up at the test site. The extensive use of AUTONOMY at the support centre in Axams also showed that the system offers additional therapeutic benefits beyond pure AAC and ECS. Especially cognitive and motor impaired children encounter severe problems in experiencing the principle of reason and effect. As their possibilities to handle objects by themselves and perceive what will happen ("...will it drop to the floor and crash when I release it?") are restricted they encounter a deficit along these lines. The smart-room can help to teach these basic principles. Properly configured, accessing an icon by hitting a switch can cause to start fireworks of sound and light. It occurred that children needed such experiences to conceive the concept of reason and effect for their first time.

Table 5. Typical amounts of icons and hierarchical levels (menus) per configuration. Applications marked with *) or **) are being used outside Autonomy Room, application marked with **) is used by a non-speaking severely motor disabled student using Autonomy system for writing source code in Modula-2 programming language as part of his studies at Vienna University of Technology [2]

Application	Icons	Levels
starting	2-4	1
ECS	20-50	4-8
AAC (symbols)	40-90	5-13
AAC & ECS	80-150	10-20
AAC (BLISS)	350	17
Independent Living *)	190	24
Independent Living with Access to PC*)	250	16
High Performance Access to PC **)	3.600	115

A next step in therapy can be basic communication training for non-speaking children. The usage of an AAC system is often hard or impossible to explain to severely impaired children. The therapists at Axams, therefore, started to combine AAC with ECS. This has been easy to achieve, as AUTONOMY integrates both function in one platform and under the same user interface. Thus the intensity of feedback from the

environment is significantly increased and the child receives an additional multimodal stimulus.

Currently, (2002) some of the children who started to use AUTONOMY 6 years ago are preparing themselves to leave the support centre and to join a sheltered living community located in Innsbruck, Tyrol. There, Technical Assistance systems also shall provide them with helpful support in order to empower them to live a more independent and self determined life. Based on the successful application at Elisabethinum Axams the system was installed in other institutions, e.g. in 1998 in the Smart Room of a Viennese school, at several private homes for disabled adults, at rehabilitation centres. Since 2001 a disabled student of our Vienna University of Technology is using the system in automatic scanning mode for accessing a PC in order to write source code for his studies of informatics [2]. A commercial version [18] was released in 1999.

In December 2001 a seminar was organised to establish a network of users. Several Austrian institutions and individuals who are using the research prototype of the Technical Assistance system AUTONOMY or who already purchased the commercial version have followed the invitation to present their experiences and to report about their daily usage of the system. About 60 participants joined the seminar, 9 presentations were given to the audience. It is remarkable, that three out of nine contributions were delivered by non-speaking persons with the help of personal assistants or by using speech synthesizers [2]. Besides the dissemination of already collected experiences the seminar also allowed to establish personal contacts among different users and care persons of several institutions. This also can be expected to ease the exchange of ideas and the co-operation in future.

One of the remaining problems is that the system needs a personal computer (even desktop or notebook) this decreased the mobility of the user but there are also first trials to build a robust, mobile AUTONOMY system. The EU funded R&D project DE-4208 RESORT (Remote Service of Rehabilitation Technology) developed a tele-help system [13] dedicated for RT application. The AUTONOMY system served as one of the first demonstrators and is now downloadable as evaluation version with an integrated Tele-Help functionality [18], [20].

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The Design of an Adaptive Web Browser for Young Children with Reading Difficulties

Chi Nung Chu¹, Tien Yu Li², and Ming Chung Chen³

¹Chung Kuo institute of Technology, 56, Sec. 3, Shinglung Rd., Taipei, 116 Taiwan
nung@mail.ckitc.edu.tw

²National Taiwan Normal University, 162, Sec. 1, Hoping East Rd., Taipei, 106 Taiwan
tienyu@ice.ntnu.edu.tw

³National Chiayi University, 300, Shiuefu Rd., Chiayi, 600 Taiwan
ming@chen.twmail.cc

Abstract. It is hard for the children with reading difficulties to manipulate complex traditional browser to surf and read over the Internet. The Adaptive Web Browser in our design, integrating the technologies of HTML interpreter, convenient human interface design, text-to-speech engine and picture communication symbols, facilitate comprehending the contents in the Internet with auxiliary speaking sound or picture communication symbol produced automatically as needed. This new interactive web browser, however, supplies an opportunity for novel children to learning through the Internet.

1 Introduction

Over the past decade the Internet has exponentially increased in users and contents. The web-based learning therefore has become an important channel for the education renovation [4]. It is a basic skill knowing how to use the browser, such as Netscape Navigator or Internet Explorer, for all students to surf the Internet. However, the children with reading difficulties, including the mental retardation and learning disabilities, have difficulties with word decoding and phonological processing. They are unable to learn to read and comprehend the same way that other learners do [3].

To access the Internet, they are facing two challenges in manipulating browser to surf the web and comprehending the contents on the web page. Since the traditional browsers are designed for general use, lots of controls are embedded in their functions. It is very complex and difficult for them to learn operating these functions physically or cognitively. And when surfing the web, the context of contents on the web page are an overload of word cognition for them to perceive. Atkins [2] finds that the peripheral effects of multimedia can seduce students' attentions. Consequently, implementing an approach with pictorial image or audio sound as a cue to alleviate the cognitive overload of word recognition can increase the motivation and understanding of learning [1].

2 Features of the Adaptive Web Browser

The design of AWB is based on the Microsoft Internet Explorer engine running on the Windows platform. It coordinates the Chinese text-to-speech engine of IBM ViaVoice as a voice output producer and a picture communication symbols database as a source of pop-up image to assist children in reading web page. The integrated AWB software is installed at the client. This design not only reduces the overload of server computation and network traffic, but also avoids the redesigning of the existing web sites for the children's special needs. The major features are described below.

1. Simplified Interface. Giving careful consideration to the users' cognition abilities, we modify the toolbar of AWB with a few graphic icons that are used most frequently in IE, including Forward, Backward, Refresh, Stop, Speak Out, and Go Home. Users could learn to interact with the AWB more easily by using these graphic icons instead of the complex toolbar in IE or Netscape. Furthermore, buttons on the toolbar are equipped with voice description, which will function if needed.
2. Adapted Toolbar Arrangement. AWB provides a position option and thus users with range of motion limit can benefit from the position arrangement. The options of position include the topside, bottom, right side, and left side of the AWB
3. Voice assistance. The AWB could read out the word, sentence, or phase highlighted by the users in synthesized voice output. Users could listen to the content of the web page instead of reading.
4. Picture assistance. By connecting to the database with about 3,000 common picture communication symbols, the AWB can automatically pop-up the corresponding picture communication symbol near the target word or phrase as the user moves the mouse over it. This is supposed to enhance their comprehension. In the meantime, the AWB can speak the target word or phrase out by clicking the right button of mouse.

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Can All Young Disabled Children Play at the Computer?

Anita Hildén¹ and Jenny Hammarlund²

¹Swedish Institute for Special Needs Education, Resourcecentre Vision, Box 1313, 17125 Solna, Sweden,

²LEKnyttan Utbildning, 13535 Tyresö, Sweden

Abstract. This poster presentation will give examples of different software, developed in Sweden, used with young disabled children. The result of using this kind of software gives the child an opportunity to play on their own, to be amused and it also gives the child practice in communication and skill training. The response of the software will keep the child motivated and has to be designed differently according to the developmental level of the child and its possibilities to see and hear the response. There are also a number of environmental and ergonomic factors that are of vital importance when working with young disabled children and software. For many of these children correct seating and physical support is crucial, as the position of the input device.

1 “The Toyshop”

Using the software “The Toyshop” designed by Anita Hildén, developed and sold by Swedish Institute for Special Needs Education, you can observe if the child can see an object. The objects are designed in bright colours or black and white. The animations will be different and objects move in different directions. All objects are shown on the screen together with a sound. The teacher will observe which object the child finds most attractive and do a selection of objects in the software. Next step is to let the child understand cause-effect. There are a lot of settings in the software that allows the child to do more and more complicated actions in the software. Input device can be switches; touch window, mouse and keyboard.



Fig.1. Shows the tree parts in the software “The Toy Shop”

2 “Lasten” – “The Truck”

This software is designed by Anita Hildén and Jenny Hammarlund, developed and sold by Swedish Institute for Special Needs Education. The child is playing with a truck filled with animals or objects. The aim is to find out if the child can understand and match pictures to real objects and what size of objects the child can see. Objects and sizes can be changed by the teacher. The vision test is using the same symbols as the vision test developed by doctor Lea Hyvirinen. Input device is concept keyboard with overlays prepared in the software, mouse or keyboard.

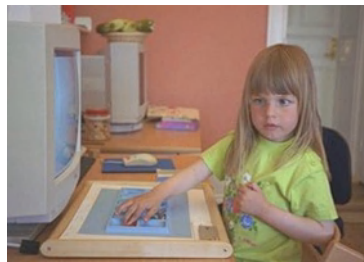


Fig. 2. Shows a girl paying with the software “The Truck” and playing memory with a tactile overlay on the FlexiBoard.

3 FlexiBoard

Using an alternative keyboard, for example FlexiBoard, is a way for children who are severely visually impaired to be able to use the computer. On the board it is possible to put different overlays of tactile material which the child can feel. (1) It is also possible to add various sound illustrations or recorded speech. The board registers pressure in particular places and gives an answer with sound and on the screen immediately. This makes it possible for the child to obtain information via the sense of touch in his/her fingers in combination with audible impressions.

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TL a Language to Create Games for Visually Impaired Children

Antoine Dutot¹, Damien Olivier¹, and Dominique Archambault^{1,2}

¹ Laboratoire d'Informatique du Havre – Université du Havre 25, rue Ph. Lebon, BP 540, 76 058 Le Havre, France {Antoine.Dutot, Damien.Olivier}@univ-lehavre.fr

² INSERM U483 / INOVA – Université Pierre et Marie Curie 9, quai Saint Bernard, 75 252 Paris cedex 05, France Dominique.Archambault@snv.jussieu.fr

Abstract. In this paper, we present TL, a language for creating games for visually impaired and blind children[1]. This language is a part of the TiM¹ project whose overall aim is to offer to young visually impaired children the possibility to play with computer games.

1 Introduction

With the Tim Language (TL) our main goal is to provide developers with a programming language able to help them create games for visually impaired and blind children. Indeed games development languages are usually based on visual representations. In the TiM project, we need scenarios that manipulate abstract object which are linked to multimedia resources in order to be rendered in any modality[2].

So, what kind of approach can be used? The first one is a high-level approach, which uses templates. The second one is a low-level approach based on the traditional vision of a computer language. In this case to create a game we use a specific application programming interface (API). This is more powerful, but also more complex than the first approach. We have chosen for TL to mix the two approaches, as we will see in the next sections, this will allow us to reach the main goal.

2 Goals

To be interesting, TL needs to offer useful advantages in front of other traditional programming languages but it must also keep their fundamental properties. Thus, we must find in this language the usual programming constructs. So first point, TL must be a programming computer language with good properties likes expressiveness, independence from devices, simple and clear syntax, and so on. But second point TL, must be more than that, it must be a specialized language with the possibility to use specific devices like braille terminals, tactile boards... and new devices which will arrive. TL must be expandable. Devices are the first reason, but not the only one. In the TiM project we constantly

¹ Tactile Interactive Multimedia computer games for visually impaired children

improve our understanding of “*what should be a game for visually impaired children*”. Thus we need the ability to add new programming facilities and even new programming constructs.

3 Language Description

In fact a language which is general and specialized is an inconsistent goal. To reach this goal we have defined two levels for TL: an abstract level and a specialized level.

The abstract level only offers generalized programming facilities, that we can find in classical programming languages. It provides the basic building blocks to create a more high level language. The specialized level uses the abstract level and provides specific constructs. In our implementation the specialized level is *game oriented* and we will call it *game level*.

3.1 Abstract Level

We call it AL (abstract language). This is a classical object oriented language whose syntax and basic concepts are inspired from Eiffel and Java, but also from scripting languages like Ruby. Thus a program is always made of at least one class. A class is composed of features (attributes and routines) which define the data and the code. To write the code we use usual programming statements (like loops for iteration, and conditionals for flow control) and classical expressions (arithmetic, assignation, method call, etc.). A class can be used by instantiation or (multiple) inheritance. In TL, all variables are objects, instances of a class.

3.2 Game Level

At this level we don’t want to have, like other multimedia or games languages a concept of screen, mouse or keyboard... For us, an object of the game is rendered but we do not say how. The model we have retained for a game is based on a distributed approach. A game is composed of *entities* which have different levels of autonomy. For instance:

- These entities are characters of the game;
- each character is located inside an environment;
- each character is able to move and act in this environment following rules and cannot infringe these rules;
- each character managed by the computer has a behavior which defines what it must or can do and when. Characters not managed by the computer are under the control of one or more players.

Thus entities of the game are *active objects*[3] that run separately of each other in an environment.

The game level produce programs that must be run on a specific runtime. This runtime is developed at the Pierre et Marie Curie university by members of the TiM project. It provides input and output from and to several peripherals likes braille terminals, sensitive tablets, sound cards, screens, etc.

Entities in the game are abstract. They model the game behaviour, but do not say how it is rendered to the player. One can then attach resources to these entities by mean of resource descriptors that tell how to render an entity an what inputs drive the entity.

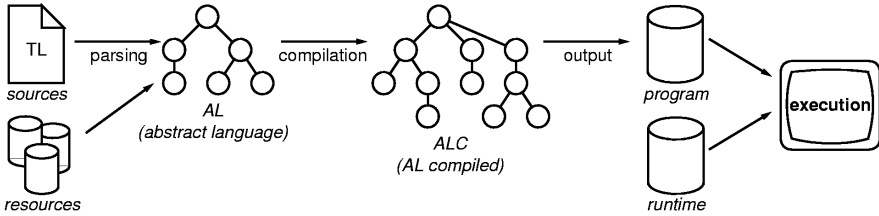


Fig. 1. Compilation process

3.3 Examples

Lets take the example a simple games, and see how our approach allow to implement it: a quizz. How to implement a quizz with active objects? Simply we say that questions are entities in an environment made of a sequence of positions. The player is an entity that jump from a position to another. To each question is associated a resource that allows to ask it, and to respond to it.

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Power Assist System HAL-3 for Gait Disorder Person

Hiroaki Kawamoto¹ and Yoshiyuki Sankai²

¹Sankai Lab, Doctoral Program in Engineering, Univ. of Tsukuba, 1-1-1 Tennodai,
Tsukuba, 305-8573, JAPAN

kawamoto@golem.kz.tsukuba.ac.jp

²Institute of Engineering Mechanics and Systems, Univ. of Tsukuba,
Tsukuba, 1-1-1 Tennodai, Tsukuba, 305-8573, JAPAN

sankai@kz.tsukuba.ac.jp

<http://www.sanlab.kz.tsukuba.ac.jp>

Abstract. We have developed the power assistive suit, HAL (Hybrid Assistive Leg) which provide the self-walking aid for gait disorder persons or aged persons. In this paper, We introduce HAL-3 system, improving HAL-1,2 systems which had developed previously. EMG signal was used as the input information of power assist controller. We propose a calibration method to identify parameters which relates the EMG to joint torque by using HAL-3. We could obtain suitable torque estimated by EMG and realize an apparatus that enables power to be used for walking and standing up according to the intention of the operator.

1 Introduction

At present, people with gait disorder can only move around by wheelchair or by using a wheeled walker. Unfortunately, barriers such as bumps and steps restrict the area that these people have access to. Elderly people who are unable to walk without assistance may lose muscular strength in their legs and become bedridden. Caring for bedridden people entails a large physical burden, and in aging societies such as Japan, this has resulted in a growing perception of this issue as a social problem for the entire community to deal with.

The most effective method ensuring that people do not become bedridden is to provide a way for them to be able to continue walking without assistance from a care-giver. In consideration of this problem, we have developed the *Hybrid Assistive Leg(HAL)* series for such people. The HAL is a walking aid system which capable of allowing the user to problem to movements such as standing up, sitting down, and going up and down stairs[1][2][3][4]. The purposes of this research are to develop HAL-3, to propose a calibration method to identify a constant relating EMG signal to joint torque, and to realize an apparatus that enables power to be used for walking and standing up according to the intention of the operator.

2 HAL-3 System

HAL-3 system has three parts: skeleton and actuator, controller, and sensor. The schema of HAL-3 system is shown as Fig. 1.

The skeletal system of HAL-3 consists of exoskeletal frame. The exoskeletal frame is combined with the outside of the lower of limb, and transmit the assist force generated by the actuator to the lower of limb. The frame has joint at hip, knee, and foot respectively. The each joint has one degree of freedom, and the restriction is given at the joint mobile angle to ensure the safety of the person and to be correspondent to the movement of the human joint angle. The aluminum alloy and steel are used for the material of exoskeletal frame in consideration of lightness. The actuator system of HAL-3 provides the assist force for knee and hip joints. The actuator have DC-motor and harmonic drive to generate the torques of each joint. The actuator using harmonic drive is packed compactly, has large reduction gear ratio, and drives smoothly.

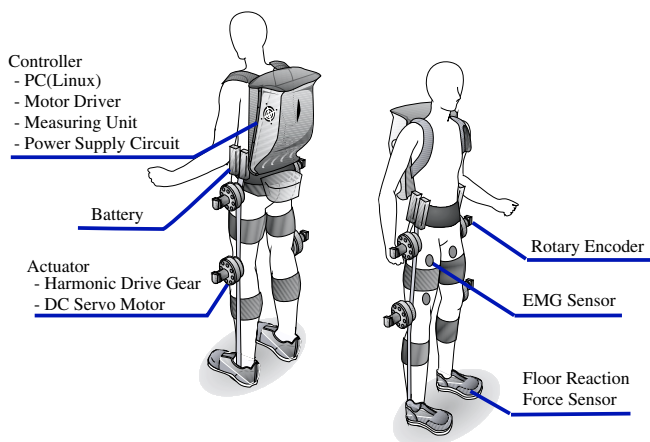


Fig. 1. HAL-3 system configuration. HAL-3 system consists of three parts: skeleton and actuator, controller, and sensor. These parts are developed in pursuit of lightness, compactness and mobility

The control system of HAL-3 is mainly developed by considering mobility because the field of activities of HAL-3 is presumed outdoors like corridors and stairs. So compact type PC as the controller, driver circuits, power supply, and measuring module are packed in the back pack. The real-time processing and the communication using the network are required in the control field. So the operating system of this PC is adapted as Linux which enables the measurement, the control, and the monitoring in real time. Wireless LAN(Local Area Network) card which has 11Mbps transmission speed, A/D(Analog to Digital) converter card which has 64ch(12bit resolution) inputs and D/A(Digital to Analog) which has 8ch outputs(12bit

resolution) are selected respectively.

Sensor Systems of HAL-3 are used to detect HAL and operator's condition and estimate the assist force. The rotary encoder are prepared to measure the each joint angle, force sensors are installed in sole of foot to measure the floor reaction force (FRF), and the myoelectricity sensors are attached on the surface of the skin of leg to estimate the muscle activity and the estimated torques for knee and hip joints.

3 Estimation of Assist Torque

ENG signal of a muscle relates the torque generated by the muscle. It is effective to estimate the assist force from EMG signal. We need to decide the appropriate parameter relating EMG signal to joint torque. So, we propose a parameter calibration method using HAL-3.

3.1 EMG

EMG(Electro Myogram, myoelectricity) signals imply muscle activity, and are used as the estimation of joint torques. EMG is action potential generated in a muscle as the command signal from motion control system of human is transmitted to the muscle through the motor nerves. The muscle contracts, after EMG signal is generated. So EMG signal can predict the beginning of generation of the muscle strength to predict. The relationship between the joint torque and the processing EMG signal in isometric contractions has been reported to be linear[5]. The joint torque can be estimated by the EMG signal. Therefore, the appropriate assist torque can be estimated by using EMG.

The EMG signals are measured through bipolar skin surface electrodes fixed to prepared skin over muscle. EMG signal is amplified by 10^6 times, and filtered by using low pass filter cutting off at 500 Hz and high pass filter cutting off at 33 Hz to remove the effects by motion artifact. The filtered signal is transferred to PC through A/D converter. And imported signals are filtered again by low pass filter cutting off at 3 Hz to obtain the information of muscle force from spike signals[3].

3.2 Method

We find a joint torque from EMG signals which generate in the extensor and flexor respectively. The joint torques for knee and hip joints are estimated by using the following equations.

$$\hat{\tau}_{knee}(t) = K_1 E_1(t) - K_2 E_2(t) \quad (1)$$

$$\hat{\tau}_{hip}(t) = K_3 E_3(t) - K_4 E_4(t) \quad (2)$$

$\hat{\tau}_{knee}$ is estimated the torque for knee joint, $\hat{\tau}_{hip}$ for hip joint. E_1, \dots, E_4 are EMG signals measured from the surface of the muscles shown in Fig. 2 In equation (1) and (2), the term of the positive means extensor and negative means flexor. K_1, \dots, K_4 are

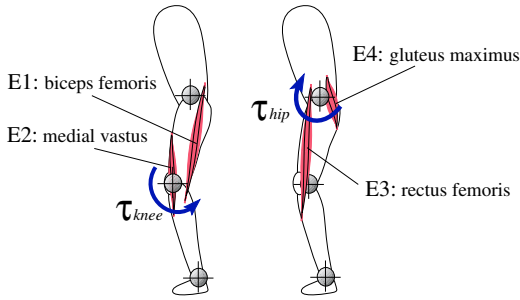


Fig. 2 Represented muscles in EMG measurement. The joint torques are estimated on based of these EMG signals

the parameters relating EMG signals to torques.

3.3 Procedures for Calibration

Previously, the joint torque was measured by strain gauge to identify the parameters relating EMG signals to the joint torques. However, this method is very complex. We propose a parameter calibration method using HAL-3. HAL-3 is used to determine the parameters K_1, \dots, K_4 . We assume that each joint torque is generated by only agonist. For instance, to determine the knee flexor parameter K_1 , the torque $\tau_m(t)$ as the signal for the calibration is generated by HAL-3 knee actuator. The subject generates the knee joint torque $\tau_{fl}(t)$ in order to match with the added $\tau_m(t)$. The knee joint torque $\tau_{fl}(t)$ is equal to $\tau_m(t)$ generated by the knee actuator because the subject outputs $\tau_{fl}(t)$ to keep the knee joint angle constantly.

$$\tau_{fl}(t) = \tau_m(t) \quad (3)$$

And the estimated torque calculated from EMG of the flexor is represented as

$$\hat{\tau}_{fl}(t) = K_1 E_1(t) \quad (4)$$

The error $e(t)$ between the measured torque $\tau_{fl}(t)$ and the estimated torque $\hat{\tau}_{fl}(t)$ is discretely represented as

$$e(k) = \tau_{fl}(k) - \hat{\tau}_{fl}(k) = \tau_m(k) - \hat{\tau}_{fl}(k) \quad (5)$$

The performance function J can be expressed as

$$\begin{aligned} J = e^2(k) &= \sum_{k=0} (\tau_m(k) - \hat{\tau}_{fl}(k))^2 \\ &= \sum_{k=0} (\tau_m(k) - K_1 E_1(k))^2 \end{aligned} \quad (6)$$

The performance function J can be minimized by setting its derivative with respect to K_1 equal to zero. This yields

$$\frac{dJ}{dK_1} = -2 \sum \tau_m(k) E_1(k) + 2K_1 \sum E_1^2(k) = 0 \quad (7)$$

Therefore, K_1 can be expressed as

$$K_1 = \sum \tau_m(k) E_1(k) / \sum E_1^2(k) \quad (8)$$

The other parameters, K_2, \dots, K_4 in Eq(1) and (2) are calculated by the least squares method similarly.

3.4 Protocols for Calibration

To obtain the parameters relating EMG signals to the joint torque, we explain the experimental protocols. The subject is normal 22 years old male. To measure the EMG of knee flexor and extensor, the subject sits with the hip held at near 90° to the upper body. The subject maintains the knee at near 90° against the knee actuator torque $\tau_m(t)$ (See Fig. 3). In the same way, to measure the EMG of the hip flexor and extensor, the subject keep upright standing posture. The subject maintains hip joint at 0° against the hip actuator $\tau_m(t)$. The reference torque $\tau_m(t)$ is made to increase from 8[Nm] to 32[Nm] in every 8[Nm] and is generated as a rectangular wave in the ten second period.

3.5 Evaluation

The parameters calculated for flexor and extensor of each joint is shown in Table 1. For the right leg, the torque estimated using calculated parameters and the reference torque generated by actuator are shown in Fig. 4

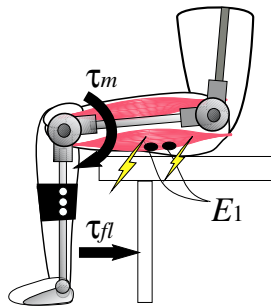


Fig. 3. System configuration of calibration to obtain the parameters by using HAL-3. In case of finding the knee flexor parameter K_1 , the subject generates $\tau_{fl}(t)$ by biceps femoris in order to match with $\tau_m(t)$ derived by the knee actuator of HAL-3. K_1 is calculated from eq.(8) using the measured EMG signal E_1

For the extensor and the flexor of each joint, the EMG would be almost proportional to the torque generated by the actuator. Immediately the torque is generated by the actuator, EMG increases in spike like. The subject relaxes, while the torque is not generated. As the torque $\tau_m(t)$ is formed, the joint angle is slightly moved over the desired angle which is maintained in calibration. The subject needs to generate the relatively large torque to bring back the desired angle. Therefore, the relatively large EMG is produced. After this spike, EMG is maintained at the constant value according to the actuator torque $\tau_m(t)$.

Table 1. The values for each parameters calculated by calibration method using HAL-3

Parameter	K_1	K_2	K_3	K_4
Right leg	3.1133	2.8412	3.6481	4.8901
Left leg	4.5742	2.4446	3.2213	6.9093

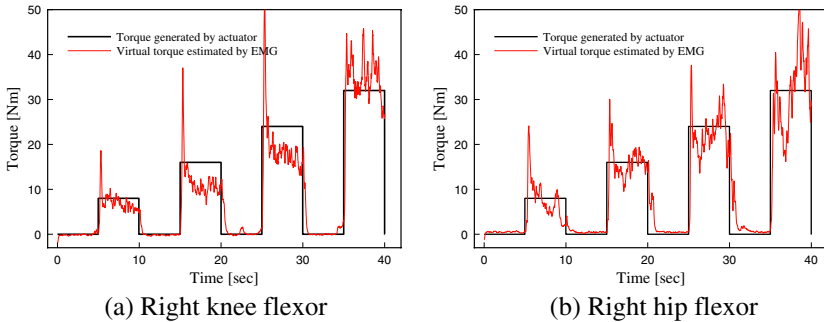


Fig. 4. Torque–EMG relationship resulting from calibration for flexor of the right knee and hip. The reference torque driven by HAL3 corresponds to the amplitude of the EMG of representative muscle

4 Power Assist Control

The experiments in walking and standing up are performed by using HAL-3. The assisted torques are estimated according to EMG signals generated in each motion.

4.1 Method

The subject is normal 22 years old male. To measure the EMG signals, the skin surface electrodes are fixed to prepared skin over of the represented muscles (See Fig. 2), and he wears HAL-3. The each parameters are obtained by the parameter calibration method which is shown in the preceding chapter. In the assistance of

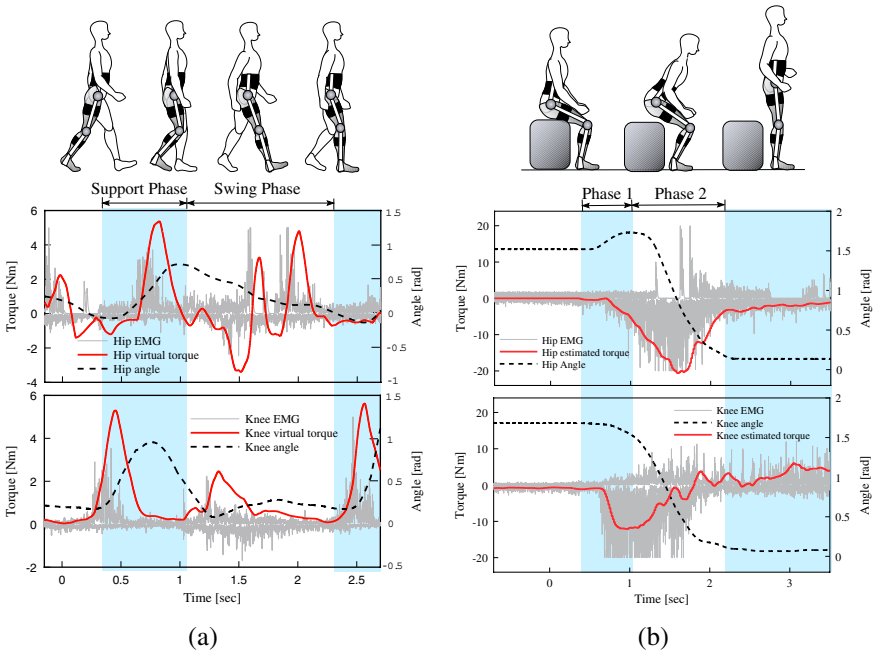


Fig. 5. EMG, the estimated torque and the angle for right hip and knee joints respectively, while power assist of HAL-3 is performed in walking(a) and standing up(b)

walking, the subject begins to walk from the initial condition of the standing posture. In standing up, the subject begins to stand up from the initial condition that the subject sits on the chair which is approximately 40cm high, and maintains the knee and hip joints at near 90°.

4.2 Result and Consideration

Figure 5 shows the estimated torques, the joint angles, and the EMG signals for hip and knee joint in walking and standing up. We divide the motion assisted by HAL-3 into phases corresponding to the particularities of the motion, and evaluate the assistance condition of each phase.

Walking. The motion of walking is mainly divided into two phases, *the support phase* and *the swing phase*. The support phase is the behavior that foot contacts on the ground surface and the body is supported. The swing phase is the behavior that the foot gets from the ground surface, and the leg swings forward.

Figure 5(a) shows that the power assist of HAL-3 is performed in walking. In the support phase, EMG signals are generated at the flexor of hip and the extensor of knee. The walking in the support phase is assisted according to the operator’s

intention by the suitable estimated torque. In the swing phase, the inappropriate estimated torque calculated by EMG signals of hip extensor is generated. It is considered that the hip extensor works to stop the leg swinging forward too much.

Standing Up. The motion of standing up is mainly divided into two phases, *phase 1*, *phase 2*. The phase 1 is the behavior that the center of gravity of the body is moved into the region where the center of gravity is stably maintained at the standing posture. The phase 2 is the behavior that the upper body is lifted by extending knee and hip joint.

Figure 5(b) shows that the power assist of HAL-3 is performed in standing up. In phase 1, EMG signals begin to generate at the extensor of the both hip and knee, and EMG signals of extensor of knee are large. It means that operator moves the center of gravity of his body into the stable region, as the knee joint gets the large torque. In phase 2, the estimated torque of knee decreases. Contrary, the torque of hip increases. So the large hip torque is generated to lift his upper body. Therefore HAL-3 realizes the aid of standing up in correspond the operator's intention.

5 Conclusion

To provide the walking for gait disorder persons, we developed HAL-3 in the consideration of lightness, compactness and mobility. EMG signals were used as a control signal of HAL-3. We proposed the calibration method of the parameters relating EMG signals of the representative muscles to the joint torques for knee and hip joints using HAL-3. The power assist of HAL-3 was realized according to the operator's intention in walking and standing up. The power assist on based EMG by HAL-3 was regarded as essential to aid the basic motion. In the near future we will apply the more sophisticated HAL-3 for gait disorder persons.

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Computer Access Assessment for Persons with Physical Disabilities: A Guide to Assistive Technology Interventions

Ting-Fang Wu^{1,2}, Ling-Fu Meng¹, Hwa-Pey Wang², Wu-Tien Wu², and Tien-Yu Li³

¹Department of Occupational Therapy, Chang Gung University
259 Wen-Hwa 1st Road, Kwei-Shan, Tao-Yuan, Taiwan, R.O.C.
{tfwu, ufx53929}@mail.cgu.edu.tw

²Department of Special Education, National Taiwan Normal University
162 Hoping E. Road. Sec 1, Taipei, Taiwan, R.O.C.
{e14008, t14004}@cc.ntnu.edu.tw

³Department of Information and Computer Education, National Taiwan Normal University
162 Hoping E. Road. Sec 1, Taipei, Taiwan, R.O.C.
tienyu@ice.ntnu.edu.tw

Abstract. An innovative flowchart, called the computer access assessment, is proposed for rehabilitative professionals to perform a comprehensive assessment when determining appropriate assistive technology devices for persons with physical disabilities. According to clients special needs, we reconstruct a new computer access assessment with the following four components: (1) seating and positioning needs, (2) keyboard adaptation needs, (3) potential anatomical control site, and (4) mouse adaptation needs. Advices about special equipment needs will be provided when following this flowchart. Two cases have been studied to illustrate how to utilize computer access assessment to assist therapists in selecting appropriating devices and intervention strategies for a given client.

1 Introduction

Computer technology has developed rapidly and become essential for people's daily lives. However, persons with physical disabilities usually experience obstacles in computer access through conventional input apparatus because of their abnormal postures and movements [1]. In order to solve a challenging task, health and education professionals are engaged in developing an alternative approach to access computer for persons with physical disabilities. Computer adaptation technology, a specific access technology that meet clients' needs to access computers, have been emerged recently. How to choose a proper computer access apparatus to fit special needs for individuals with physical disabilities is a critical issue in computer adaptation technology. However, the number of assistive technology devices available can be overwhelming for a novice. Therapists with little experiences in this field may encounter with difficulties in deciding appropriate devices to be used [2]. In this regard, we develop a systematic evaluation procedure, called computer access assessment (CAA) for therapists to perform holistic assessment and interventions.

Thus, appropriate devices and intervention strategies can be recommended for individuals with physical disabilities to access computers.

In this work, an innovative decision procedure of CAA will be proposed. It was developed through extensive literature review [1–7] and clinical experiences of researchers. Content validity was established through a panel of expertise in this area. Eight faculties from occupational therapy, special education, and computer education, are involved in reviewing assessment items. From therapeutic viewpoint and practical experiences, it seems that the proposed CAA can evaluate appropriate devices effectively.

2 Computer Access Assessment (CAA)

According to clients' special needs, we reconstruct a new procedure with the following four major steps: (1) seating and positioning needs, (2) keyboard adaptation needs, (3) potential anatomical control site allocations, and (4) mouse adaptation needs. Advices about special equipment needs will be provided at the end of the evaluation.

A proper seating or positioning system can facilitate hand function [7]. However, most of existing assessment tools do not consider positioning needs when providing computer access. We emphasize that access positions should be determined before deciding computer input methods and will be considered at the beginning of the evaluation.

Secondly, functional performance of the client's keyboard skills will be evaluated. Keyboard adaptation strategies are decided based on the remaining motor function of the clients. To analyze motor control abilities of clients comprehensively usually may lead to proper strategies of computer adaptation. Most clients can use hands to access the keyboard. Only for person with severely impaired hand function, other body parts appropriate to access computer will be suggested. Therefore, anatomical control sites allocations will be administrated only for persons with limited hand function who cannot access keyboard and mouse through hands.

Finally, we consider the needs for mouse adaptation. Most clients are able to operate a standard or an alternative mouse through hands. For persons with limited hand function, other body parts such as chin or foot will be suggested using the result of previous evaluations of anatomical control sites allocations.

2.1 Step 1: Assessing the Needs for Seating and Positioning

The first step in providing adapted computer access is to decide the access position. Sitting position will be considered as the first priority. Evidences have shown that persons with disabilities demonstrate increased postural control and hand function when seated upright [8]. Fig. 1 illustrates this step in details. Therapists administrate the flowchart via answering 3 yes-no questions. The answer will lead to the subsequent questions or the final solution of positioning and equipment.

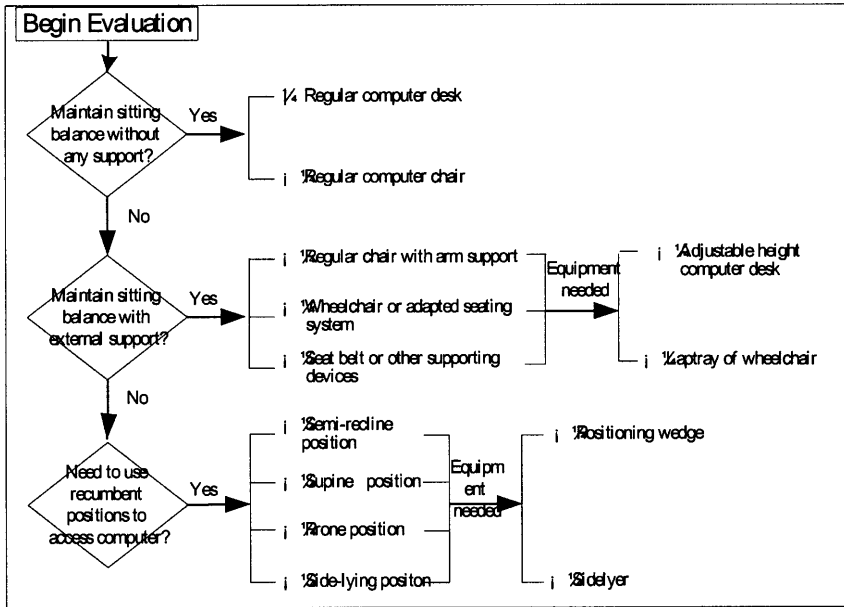


Fig. 1. Step 1: Assessing the Needs for Seating and Positioning.

The first question of this session is “Is the client able to maintain sitting balance without any support?” If the answer is “Yes”, the equipment needed for the client will be listed beside. If the answer is “No”, the therapist needs to go on to the second question “Is the client able to maintain sitting balance with external support?” For clients who cannot maintain sitting balance by themselves, adapted seating systems such as wheelchairs or positioning chairs may be needed. If the client cannot assume a sitting position even with external support, recumbent positions, such as side-lying, supine, and prone, will be recommended. Equipments such as positioning wedge or sidelyer will be recommended.

2.2 Step 2: Assessing the Needs for Keyboard Adaptations

When considering providing computer adaptation for persons with physical disabilities, the therapist will choose as minimal modifications. As shown in Fig. 2, the therapist selects appropriate input methods and devices for clients through sequential yes-no questions. A conventional keyboard will be the first priority. However, most persons with physical disabilities cannot access a conventional keyboard due to insufficient coordination or motion ranges of upper extremities, assistive devices or strategies will be recommended based on client’s residual motor functions.

For clients who use one hand to access keyboards, an alternating keyboard layout will increase the efficiency of computer inputs [3, 6]. A mini-keyboard is suggested for clients with limited motion ranges to reach all keys of a conventional keyboard [2,

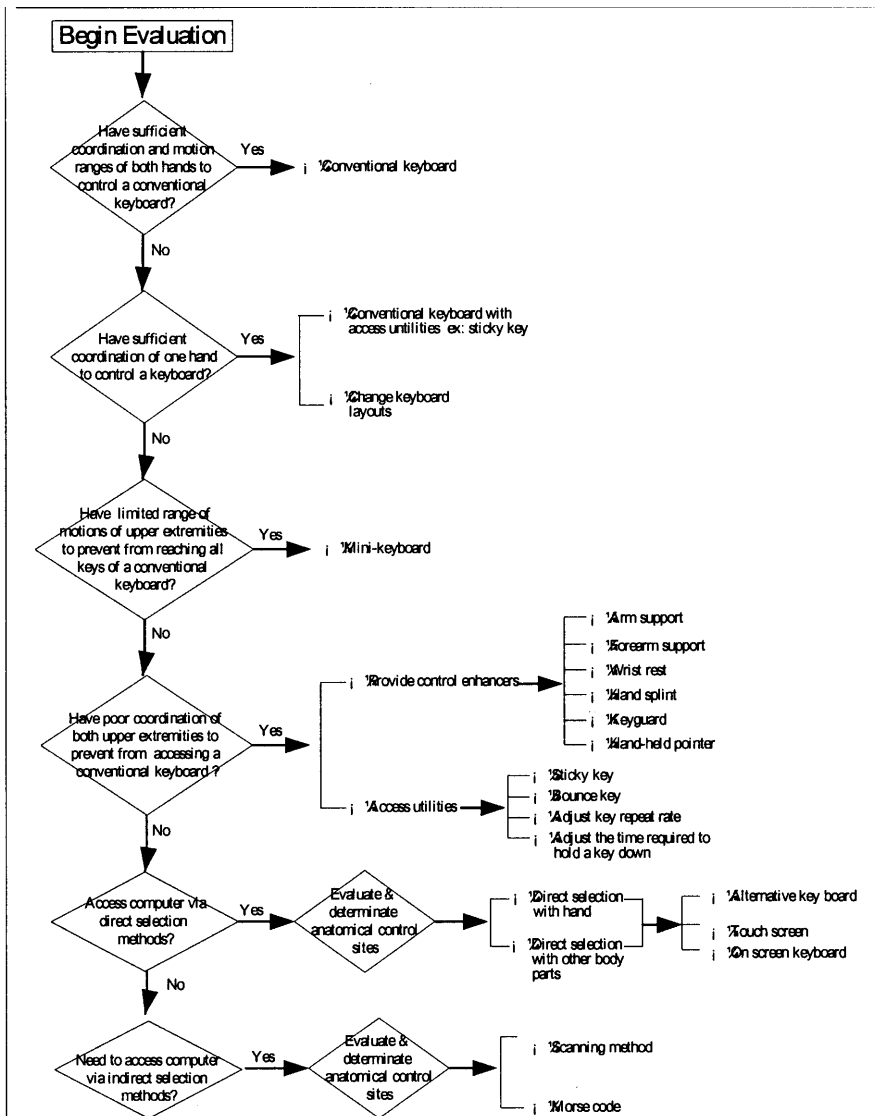


Fig. 2. Step 2: Assessing the Needs for Keyboard Adaptations.

3, 6]. For clients with poor hand coordination, control enhancers (such as keyguards, arm supports, and pointing devices) will be recommended as the first priority [2, 3, 6]. Access utilities will also be provided to increase the efficacy of keyboard inputs.

If the client still can not function well with above adaptations, alternative keyboards and other direct selection methods will be considered next. For clients with very limited hand functions, therapists need to evaluate and determinate other body parts appropriate for access [1]. Hands will be considered as the first priority to access

alternative keyboards and head activation via pointers will be considered as the second priority [1].

Activation via indirect selection methods should be explored only if these direct selection possibilities are not feasible. Scanning involves selection of a desired item for a predetermined configuration. The client presses the switch when selecting the desired item. The entire process is time consuming [1]. However, for clients with severely impaired motor abilities, indirect selection methods are the only possibilities to access computers.

2.3 Step 3: Evaluating Anatomical Control Sites for Access

In the third step, anatomical control sites will be evaluated through testing client's active motion ranges, strength, endurance, and coordination among client's head, arms and legs. Hands and arms will be the first choice. Head will be considered next. Switches can be placed with the following possibilities: (1) under chin, (2) on forehead, (3) at the side of cheek or temple, and (4) back of head [1, 6]. Knee will be considered as the third choice [1].

More than two control sites should be suggested. Indirect selection methods such as scanning with a virtual keyboard will be suggested for the client with limited motor abilities.

2.4 Step 4: Assessing the Needs for Mouse Adaptations

As illustrated in Fig. 3, therapists will evaluate mouse adaptation needs for clients in the fourth step. The conventional mouse is designed for right-handed people. Left-handed persons or the persons with limited motor abilities on their right hand cannot operate the standard mouse efficiently. A mouse specific designed for left-handed persons should be recommended to use left-hand mice. Otherwise, switch left and right buttons of a standard mouse will also improve the performance of the left hand user.

Some people may need to separate the cursor poisoning function from the clicking function [3]. A joystick or a trackball may be used as an alternative input device to simulate cursor movements. A single switch may be used to replace the clicking function of a mouse. Others may use the number pad on the keyboard to move the mouse cursor [3]. Selected strategies depend on residual functions of the clients.

For clients with limited hand functions, multiple switches or alternative keyboards will be recommended to simulate mouse movements. Switches can be operated by chin, by head, or by foot.

Based on results obtained in previous steps, a summary of equipments recommended for positioning and computer access will be recommended. Software adaptation will also be reported.

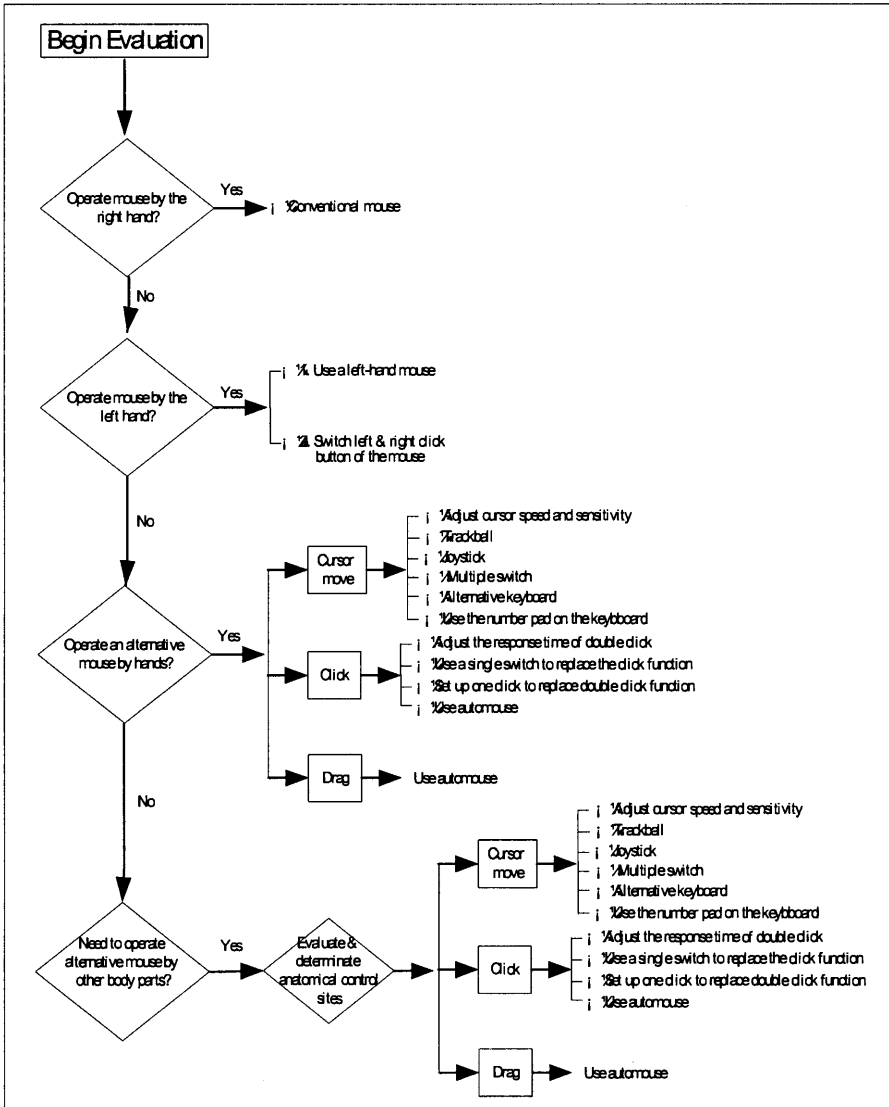


Fig. 3. Step 4: Assessing the Needs for Mouse Adaptations.

3 Clinical Experiments of CAA

The CAA has been successfully used in clinical study for clients with cerebral palsy, muscular dystrophy, spinal cord injury and other physical disabilities. Most clients were recruited from occupational therapy departments of Chang Gung Memorial

Hospital, Chang Gung Children Hospital, and Chang Gung Rehabilitation Center in Taiwan. Significant improvements in speed and efficacy of computer inputs have been observed. The overall content validity is satisfactory. Additionally, the interrater reliability is investigated through case studies of two senior occupational therapists by evaluating clients simultaneously and administering the CAA flowchart independently. Correlation coefficients between two raters also indicate satisfactory results. To explain this CAA flowchart, two case reports will be provided.

3.1 Case 1: Client with Cerebral Palsy

The client is a 7-year-old boy with a diagnosis of cerebral palsy. His involuntary athetoid movements significantly impede his hand function. His handwriting is illegible and his speech is too slurred to understand. Communication is a problem for him. In addition, he is not able to take the notes or complete class assignments by himself. His teacher encourages him to use computers as expressive instruments; however, it has been found he has a great difficulty in accessing computers.

He was referred to occupational therapy department of Chang Gung Children Hospital to find a solution for computer access. The first step we evaluated the needs for seating and positioning. Since he was not able to maintain sitting balance by himself, external supports were provided to achieve an upright position to access computers. An adjustable height school chair with trunk supports was recommended to provide an upright position.

The second step, we looked at the keyboard adaptation needs. Although poor coordination of hands, he still can use his hand to access keyboard with adaptation. A keyguard and a hand-held pointing device were provided to increase accuracy while typing.

The third step was skipped since he was able to access computers via hand. When considering the needs for mouse adaptation, multiple switches were suggested to simulate mouse movement. Four switches simulate right, left, up, and down cursor movement and one switch perform the clicking function of the mouse. Although lots of involuntary movements still exist, he is able to access computers with minimal assistance after several therapeutic sessions.

3.2 Case 2: Client with Spinal Cord Injury

The client is a 22-year-old college student who sustained a C-5 level spinal cord injury 3 month ago. He has excellent head control but limited function of upper extremities. He plans on returning to school to study mechanical engineering and is seeking equipment recommendation for a writing system that will allow him to produce paper work for school.

When considering the positioning needs, a reclined wheelchair with a laptray was recommend for him to achieve an upright sitting position. A trackball with an on screen keyboard were suggested for him to access computer. After adaptation, he still demonstrated difficulty in clicking button of the trackball. A single switch was extended to perform the clicking function of the mouse. He was able to manage typing after all the equipments had been set.

4 Conclusions

We have proposed a new method, computer access assessment, for finding feasible solutions to computer access problems faced by clients with physical disabilities. It is intended to provide therapists a convenient tool to find access solution efficiently. CAA has shown practically useful based on the clinical trails. Two cases have been studied to illustrate how to utilize computer access assessment to assist therapists in selecting appropriating devices and intervention strategies for a given client. As the field of assistive technology develops rapidly, CAA can be refined when new products or adaptations emerge.

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A Proposal of Effective Motion Learning Method Using Sensory Feedback for Walk-Disabled People

Junji Ohyama¹ and Yoshiyuki Sankai²

¹ Sankai Lab, Course of Engineering Systems, Univ. of Tsukuba, 1-1-1 Tennodai, Tsukuba, 305-8573, JAPAN

² Institute of Engineering Mechanics and Systems, Univ. of Tsukuba, Tsukuba, 1-1-1 Tennodai, Tsukuba, 305-8573, JAPAN
{ohyama,sankai}@golem.kz.tsukuba.ac.jp

Abstract. In this paper we propose an effective motion learning method using feedback information from sensory nerves at rehabilitation for the people with movement disorder. We tried to verify the validity of the learning procedures using feedback information from a sensory nerve by constructing the computer modeling combining a motor nerve model and a musculo-skeletal model of walk-disabled people. This research will be a guideline at the development of intelligent power assistive system using FES or actuator for relatively severely handicapped people.

1 Introduction

Movement disorder are often caused by the concurrence of the disorder of central nerves disease such as a defect of pattern generator (PG) of brain by cerebral apoplexy or cerebral thrombosis and the paralysis such as a vertebral injury. Recently rehabilitation becomes popular for slight disabled people. However, the rehabilitation procedures are empirical and different among hospitals or physical therapist. In addition, the rehabilitation needs to continue for a long time and requires great mental powers to the patients. Therefore, it is important to evaluate the most efficient rehabilitation method and to shorten the period of learning the procedures for the patients. In this paper we propose an effective motion learning method using sensory feedback information from sensory nerves to learn the motion at rehabilitation more effectively by the people with movement disorder. One of the example of such a treatment using the feedback information from sensory nerves is that a physical therapist or a helper gives calls or pushes the patient's back with a walk-disabled timely as they are putting their foot forward. We try to verify the validity of the learning procedures using feedback information from a sensory nerve by constructing the computer modeling combining a motor nerve model and a muscle and bone system model of walk-disabled people. We will show an example of a sensory nerve compensation devices using a simple sensor to assist to learn walking by supporting a feedback information from a sensory nerve of walk-disabled people. Especially we evaluate the validity of the learning walking procedure related to the physical conditions supplementing feedback information from a sensory nerve defected by injury of a person who needs rehabilitation for a paralysis of one leg.

2 Method

2.1 Modeling a Human Motor Nerve System

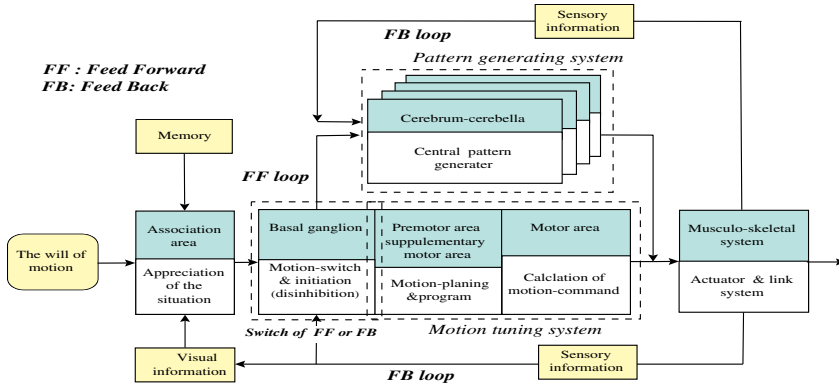


Fig. 1. Human motor nerve system. This model is based on the brain model to analyze human information processing. The outputs of the motion tuning system and the pattern generating system actuate the musculo-skeletal system. And posture informations are feedback to them by sensory nerves

To make a model of the walk-disabled, we construct a motor nerve system model of a physically unimpaired people. A physically unimpaired motor nerve system is shown in Fig. 1[1]. CNS(Central Nervous System)of human nerve system has recursive synaptic connections. Experience is stored by neural activity, reverberating in closed-loop CNS[2]. Human lower CNS generates rhythm patterns like walking patterns. We construct CPG(Central Pattern Generator) by using these characteristics of CNS[3][4]. CPG oscillates by it self, followed by the command input from upper CNS, and by the sensor input from receptor. Considering the characteristics of CPG, we construct an artificial CPG by RNN(Recurrent Neural Network) structure. Human regulates the posture to stand by controlling the upper part of the body based on the feedback information from sensory nerve system to control the posture by the motion tuning system in the motor area of the brain cortex. To control the walking posture, the model needs to control the center of gravity and moment. There is a ZMP(Zero Moment Point) posture control method for the algorithm to regulate the balance and the moment. Therefore, we construct a ZMP controller for a model of motion control system[5].

We constructed a musculo-skeletal model which consists of links and joints. Each joint is connected by a spring and a dumper in the simulator. We used ZMP controller as motion controller, and artificial CPG as feedforward controller. Each controller indicates the model of posture control system and the model of a motion control system of human.

2.2 Modeling a Walk-Disabled People

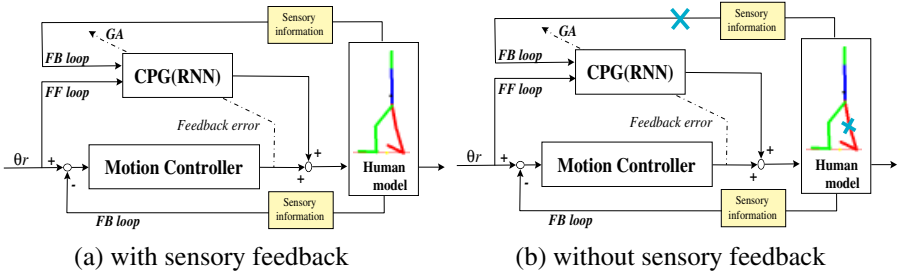


Fig. 2. with/without sensory feedback. In the left normal human model, information from the sensory nerves are fed back to both of the controller. In the right model, CPG has no sensory feedback information from the paralyzed leg of the human link model

If there is no disorder in the motion control system, information from the somato sensory nerve is fed back into CPG. Depending on which part of receptor has disorder, there are several symptoms of spastic paralysis such as loss of a tactile sense or a sense of angle of joint. The model of such handicapped people can be constructed by cutting the feedback loop to CPG based on healthy people. In this research, we evaluated the validity of the learning of walking procedure in relation to the physical conditions by supplementing feedback information from a sensory nerve by injury of a person who has a relatively severely paralysis of a leg. As the model of a leg paralyzed people, we constructed the model of motor nerve system with a little feedback information from the sensory nerves of the paralyzed leg. If the part of the body is paralyzed, information from the paralyzed part in the motion control system is not fed back into CPG.

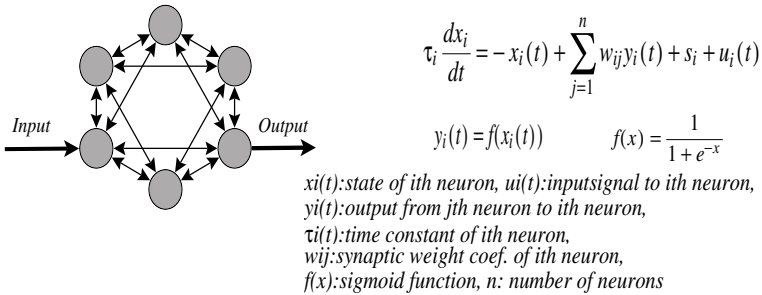


Fig. 3. Recurrent Neural Network[3]. Reference from the human nerve system, we made a neuron model on computer and construct the recurrent network. RNN has the time constant $\tau_i(t)$, so signals are passing through the RNN by the time, like human nerve system

2.3 Artificial CPG

We used artificial CPG to generate rhythm pattern voluntarily into the musculo-skeletal system model as a neural system which controls expansion and contraction of muscles. We adopted RNN and GA(Genetic Algorithm) to construct CPG. RNN is a network system with mutual linkages like a nerve system of human, and it can be used for constructing the effective controller for dynamic systems. RNN can generate dynamical rhythm patterns, and can generate dynamic signals with arbitrary accuracy. RNN has mutual linkages among neurons and can generate complex rhythm patterns. Sensory signals such as tactile signals or visual signals are fed back to this RNN. GA is regard as the system optimizing method. Fitness to the many search points are given at the same time. Regarding these search points as individuals of living thing evolution, GA process is performed by modeling genetic evolution process of living thing. GA's flowchart is shown in Fig. 4. Search points called individuals are calculated and individuals who have the better fitness than the others are alive. This individuals are randomly crossovered and mutated, and become the next community. This way the solution of the better fitness are survive. GA is useful to modify the synaptic connections of RNN. GA has the possibility to generate network connections without teaching signals. And then the model which can evolve with adapting itself into conditions will be constructed.

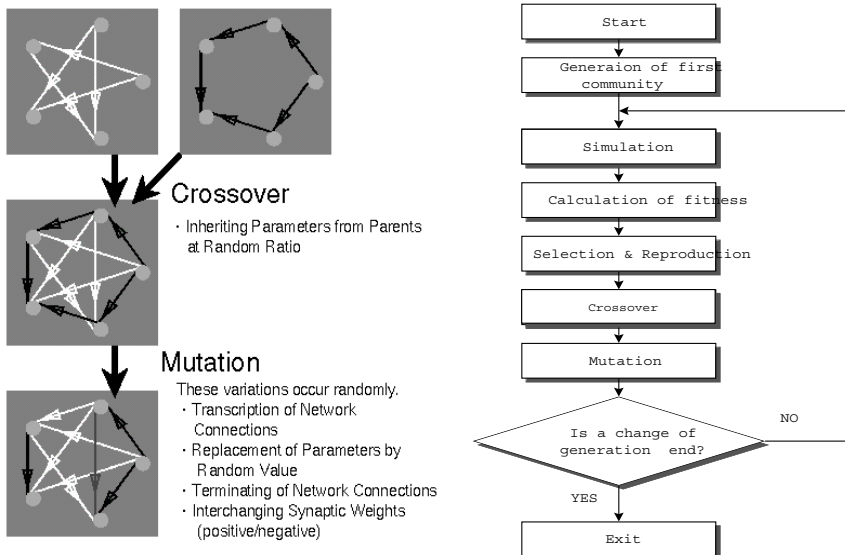


Fig. 4. Genetic Algorithm of this research[4]. Solution of search points called individuals are made randomly, and by the simulation, individuals which have the better fitness are alive. These solutions are randomly crossovered and become next community

2.4 Simulation(A)

By using a walk-disabled person's model in computer simulation, we verified analytically how fast the CPG within a brain could study a motion pattern by using the feedback information from a sensory nerve. Here, we simulated the learning of walking angle pattern, because we were trying to verify about motion learning in brain. We simulated two learning processes by using this model. One was the simulation using the sensory feedback information at rehabilitation, and the other one was the simulation without sensory feedback information which means performed the rehabilitation only to the paralyzed leg. For the former we simulated the walking, with angle feedback information from the knee of paralyzed leg, and the hip of the other leg. For the latter, we simulated two types of walking without any feedback information. Learning motion without using any information input, and using just an unrelated information input, like white noise input. Simulation with a white noise input means to compare the effect of learning, with the input of walking timing and with the input of random timing. This points that the learning effect just show up by the feedback information from the linked part.

2.5 Simulation(B)

Movement of human is caused by the torque output generated by muscles, corresponding to the sensory feedback from the various kind of receptor. So, at simulation(B), we construct the motion system which outputs the torque to realize the suitable angle of the hip suppose from the angle of the knee, by using the already built musculo-skeletal model. Here, we performed the simulation with the angle information feedback from the knee of the paralyzed leg. Then, when output considering torque similar to information as substitution by feedforward, put ϵ for the degree of substitution, we verified about how exact the feedback information required by changing the value ϵ .

3 Results

We could construct the model of walk-disabled people, and performed the learning simulation of walking.

By the simulation(A), we could show that the model could learn faster by using information of sensory feedback from the other parts than no feedback information(Fig. 5).

According to the results of learning(Table 1), when the input information was unrelated to a walk ,for example random input pattern (white noise), the learning effect did not show up. This is because, at the model of those many links human model one part of motion is mutually related to the other parts of the body.

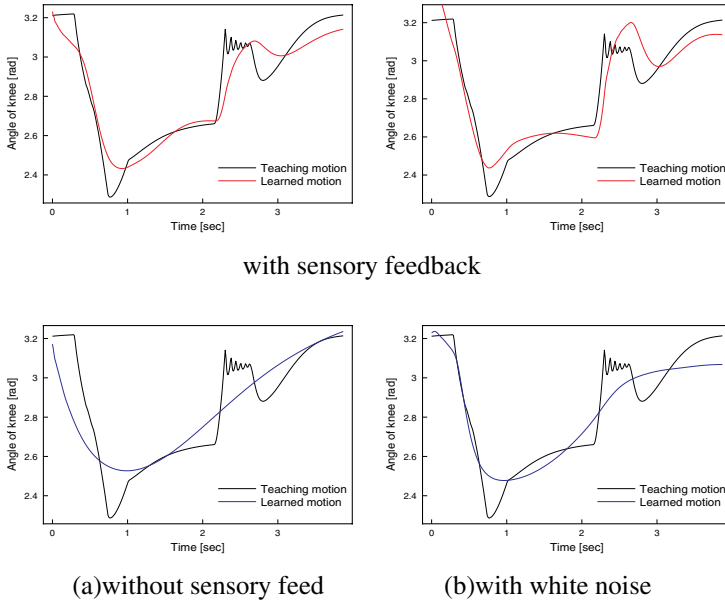


Fig. 5. Simulation(A): Learning the angle pattern of walking

Comparing the learned pattern with sensory feedback to without sensory feedback or with white noise, the effect was just show up when learning the pattern with the feedback information from the paralyzed leg

Table 1. Comparison of learning simulation(A) Fitness was found from the integrated difference between the teaching pattern and the learned pattern

	Input data	Fitness
With sensory FB	right leg	0.428912
	left knee	0.484355
Without sensory FB	nothing	0.242062
	white noise	0.310787

By the simulation(B), walk-disabled people whose sense of the knee was paralyzed, could walk by feedback paralyzed knee information from some compensation devices(Fig. 6 (a)). When the value of ϵ was nearly equal to 1, the human model could walk some steps(Fig. 6 (b)). If the value was more different from the value of simulation(b), the model could not walk well(Fig. 6(c)).

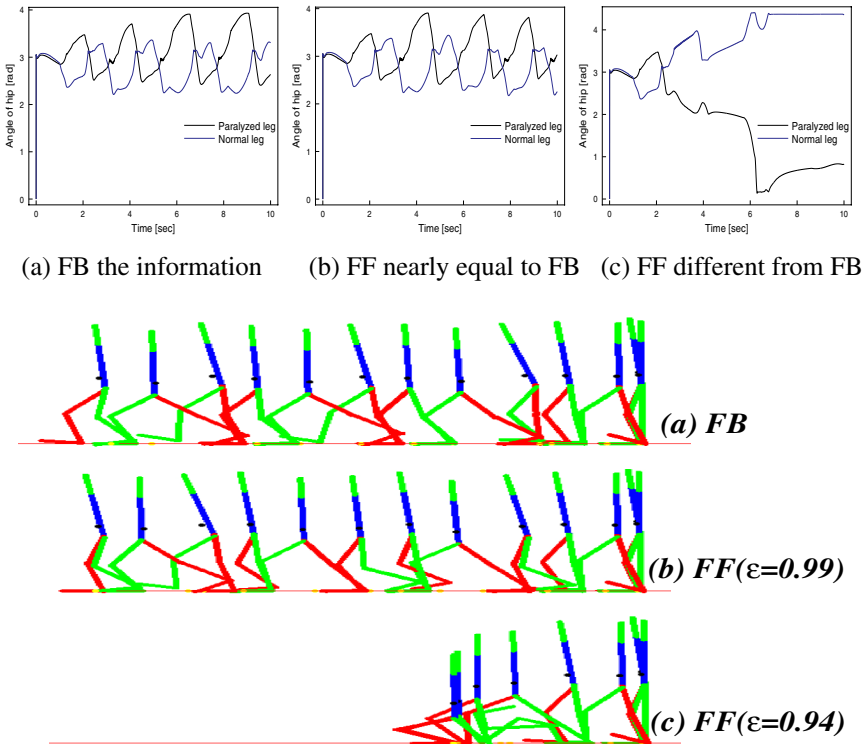


Fig. 6. Simulation(B): Comparison of the torque pattern of walking.

Movement of human is caused by the torque output. So we input the torque pattern using the feedback information of the the knee angle. And we input the torque pattern approximate to the torque pattern with feedback, to see how much correctness of the feedback information is required to the stable walking

4 Discussion

As a results of simulation(A), we could show that the human motor nerve system could learn faster by using information of sensory feedback from the other parts(Fig. 5). From simulation(B), the human model could walk when the feedforward torque pattern was nearly equal to the pattern of feedback walking(Fig. 6 (a)). This means people can walk in open-loop when people already learned a walking pattern. But, it can walk in open-loop because this feedforward torque pattern was referring to the feedback pattern. If the feedforward torque pattern was not similar to the feedback torque pattern, stable walking became difficult(Fig. 6 (c)).

According to the results of simulation(B), it is declared that walk-disabled person can learn walking more quickly by using some compensation devices which feed back information from the handicapped leg instead of the sensory feedback.

One of the example of the sensory information feedback, we suggest to use the simple device shown in Fig. 7. This device has rotary encoder to measure the angle of the paralyzed knee. It also has a speaker to feed back the rotary encoder's angle data to the handicapped person's ear by changing frequency of sound, corresponding to the angle of the knee. So this device can inform paralyzed knee condition of the angle to the handicapped user's brain by the sound. In this research, we have been discussed about motion learning efficiency in slight walk-disabled people's brain at rehabilitation. On the other hand, artificial motor nerve system we made in this research, will be directly usable at the development of intelligent power assistive system using FES (Functional Electro Stimulation)[6] or actuator for relatively severely handicapped people.

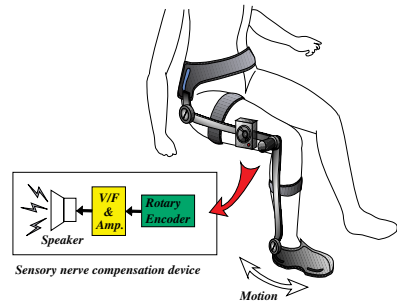


Fig. 7. Compensation device.

The angle is measured by the rotary encoder. This electric value is amplified and outputs the sound from speaker.

5 Conclusion

We constructed the motor nerve system of walk-disabled people, and could develop an effective motion learning method by using sensory feedback by simulation. We could confirm the effectiveness of the proposed method by simulations. In the next step, we will carry out the clinical testing by using the proposed device. We also construct the more exact human model and analyze the mechanism of more complex motion.

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Control Method of Walking Speed and Step Length for Hybrid Assistive Leg

Masako Nozawa¹ and Yoshiyuki Sankai²

¹Sankai Lab, Doctoral Program in Engineering, Univ. of Tsukuba, 1-1-1 Tennodai,
Tsukuba, 305-8573, JAPAN
nozawa@golem.kz.tsukuba.ac.jp

²Institute of Engineering Mechanics and Systems, Univ. of Tsukuba,
Tsukuba, 1-1-1 Tennodai, Tsukuba, 305-8573, JAPAN
sankai@kz.tsukuba.ac.jp
<http://www.sanlab.kz.tsukuba.ac.jp>

Abstract. For the person having functional disorder in their legs, we have developed Hybrid Assistive Leg(HAL). The purpose of this study is to propose the method to control HAL. In this method, according to human walking, the walking task is divided into phases. Keeping COG be controlled through all phases by manipulating ZMP, it would be possible to generate the stable motions without falling down which have several speeds and step lengths. Using computer simulation, we would confirm the effectiveness of this method and the ability for applying this method to the rehabilitation program for handicapped people.

1 Introduction

Due to functional disorder in their legs caused by an accident or their aging, the handicapped and the aged are liable to be tied down in bed, and cannot get around by themselves. In our laboratory, we have developed Hybrid Assistive Leg(HAL) for those persons (Fig. 1). In this paper, we propose the method to control walking speed and step length without falling down, according to HAL operator's request.



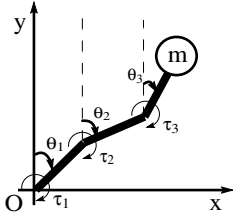
Fig. 1. Hybrid Assistive Leg

2 Method

To make the method to control HAL's walk, we divide a walking period into three phases. In the first phase named "Single support phase", COG(Center Of Gravity) is controlled by manipulating ZMP(Zero Moment Point) and stable posture control is achieved. In the second phase named "Acceleration phase in swing phase", the torque of hip joint is decided using the angle of knee joint. By this torque, the self-excited oscillation occurs, and we can obtain swing movement more efficiently. In the third phase named "Deceleration phase in swing phase and double support phase", the target point of heel contact is regulated without falling. Then, the phase shifts to the double support phase, and COG is kept high. Repeating these phases in order, the periodical walking task is generated. In this paper, the procedure for making the system in 2D is described below.

2.1 Phase 1: Single Support Phase

Since ZMP is defined as the equilibrium point of all forces that affect a mass point, the force from ZMP allows us to control the movement of the mass point. ZMP x_{zmp} is expressed in Eq. (1). Regarding support leg in Fig. 2, motion equations are shown in Eq. (2). From Eq. (1) and Eq. (2), ZMP x_{zmp} is expressed by torque and theta(Eq. (3))



$$x_{zmp} = \frac{x(\ddot{y} + g) + y\ddot{x}}{\ddot{y} + g} \tag{1}$$

$$c_i \ddot{x} - s_i (\ddot{y} + g) = \frac{\tau_i}{m l_i} \quad (i = 1, 2, 3) \tag{2}$$

$$x_{zmp} = \frac{(\tau_1 + \tau_{23})(s_1 c_{23} - c_1 s_{23})l}{(\tau_1 c_{23} - c_1 \tau_{23})} \tag{3}$$

where $s_i = \sin\theta_i$, $c_i = \cos\theta_i$, $s_{23} = s_2 + s_3$, $c_{23} = c_2 + c_3$, $\tau_{23} = \tau_2 + \tau_3$, $s_{123} = s_1 + s_2 + s_3$, $c_{123} = c_1 + c_2 + c_3$, $l_1 = l_2 = l_3 = l$

Fig. 2. 3 links model for support leg

Suppose that we have the target value of ZMP δ corresponded to ZMP x_{zmp} , we see that Eq. (3) becomes Eq. (4) which is arranged about torque.

$$((s_1 c_{23} - c_1 s_{23})l - \delta c_{23})\tau_1 + ((s_1 c_{23} - c_1 s_{23})l + \delta c_1)\tau_{23} = 0 \tag{4}$$

The system's input u, v are determined so that Eq.(3) is satisfied.

$$\tau_1 = \alpha_2 u, \quad \tau_2 = -\alpha_1 u - v, \quad \tau_2 + \tau_3 = -\alpha_1 u \tag{5}$$

where, $\alpha_1 = (s_1 c_{23} - c_1 s_{23})l - \delta c_{23}$, $\alpha_2 = (s_1 c_{23} - c_1 s_{23})l + \delta c_1$

Combining these equations gives the motion equation of the mass point using the input u and target value δ (Eq. (6),(7))

$$\ddot{x} = \frac{1}{ml} \left(\frac{-s_1 \alpha_1 - s_{23} \alpha_2}{s_1 c_{23} - c_1 s_{23}} \right) u = \frac{1}{m} (\delta - l c_{123}) u = \frac{1}{m} (\delta - x) u \tag{6}$$

$$\ddot{y} + g = \frac{1}{ml} \left(\frac{\alpha_1 + \alpha_2}{c_1 s_{23} - s_1 c_{23}} \right) u = \frac{1}{m} (-s_{123} l) u = \frac{1}{m} (-y) u \tag{7}$$

The error of COG position and velocity x, y, \dot{x}, \dot{y} and the angle and angular velocity of the third link $\theta_3, \dot{\theta}_3$ are fed back to the target value δ , the input u and v .

$$\delta = x - \frac{1}{u} \{ k_{px}(x - x_{ref}) + k_{dx}(\dot{x} - \dot{x}_{ref}) \} \tag{8}$$

$$u = \frac{1}{y} (k_{py}(y - y_{ref}) + k_{dy}(\dot{y} - \dot{y}_{ref}) - mgl) \tag{9}$$

$$v = k_{p\theta}(\theta_3 - \theta_{3ref}) + k_{d\theta}(\dot{\theta}_3 - \dot{\theta}_{3ref}) - mgc_3 \tag{10}$$

Using these input, the motion of x coordinate of COG is expressed in Eq. (11).

$$m\ddot{x} = \frac{x - x_{zmp}}{y} (k_{py}(y_{ref} - y) + k_{dy}(\dot{y}_{ref} - \dot{y}) + mg) \tag{11}$$

β is defined as Eq. (12). Then Eq. (11) is changed to simpler equation(Eq. (13)) including x_{zmp} . It shows that COGx is able to control by ZMP when COG y converge to the constant value.

$$\beta = \frac{my}{k_{py}(y_{ref} - y) + k_{dy}(\dot{y}_{ref} - \dot{y}) + mg} \tag{12}$$

$$\beta \ddot{x} - x + x_{zmp} = 0 \tag{13}$$

In the first phase, COG is controlled to the target point \hat{x}_g, \hat{y}_g , which are yield from Eq. (14) and Eq. (15), through manipulating the position of ZMP. The position of forward ankle is set as the target point of x -coordinate of COG \hat{x}_g (Eq. (14)). And the target point of y -coordinate of COG \hat{y}_g is regulated by step length(Eq. (15)).

$$\hat{x}_g = \begin{cases} Link_{support\ ankle} \cdot x : Link_{support\ ankle} \cdot x > Link_{swing\ ankle} \cdot x \\ Link_{swing\ ankle} \cdot x : others \end{cases} \tag{14}$$

$$\hat{y}_g = \sqrt{((Link_{leg} \cdot l_g + Link_{knee} \cdot l_g) \times 2)^2 - STEP^2} + Link_{BODY} \cdot l_g + Link_{HEAD} \cdot l_g \tag{15}$$

2.2 Phase 2: Acceleration Phase in Swing Phase

In human walking, one leg is swung efficiently. So in this phase, swing leg is controlled using inertia for efficient walking. Regarding swing leg as two links pendulum rotating around hip (See Fig. 3), the inertia around hip I_{hip} is expressed by the function consist of joint angle of knee $Joint_{knee} \cdot \theta$ found by difference between the angles of $link_{leg}$ and $link_{knee}$ (Eq. (16)).

Because the self-excited oscillation needs the solution of Eq. (17) to diverge, its

characteristic value must be complex number having positive real part. To decide the input of each joint which gives us the desired characteristic value, the angle of knee joint $Joint_{knee}.\theta$ which is the parameter connected closely with leg's inertia is applied to the hip joint torque τ_{leg} . This feedback signal allows us to change the characteristic value into desired one. At the result of it, self-excited oscillation occurs and the leg swing efficiently without the input of knee joint. Because the step length depends on the hip's torque in swing phase, the feedback gain of hip's input is determined from the value which is the answer of multiplying an constant value K_{θ} by target step length.

$$I_{hip} = link_{leg}.l^2 + \frac{1}{4}link_{knee}.l^2 + link_{leg}.l \times link_{knee}.l \times \sin(Joint_{knee}.\theta) \quad (16)$$

$$= F(Joint_{knee}.\theta)$$

$$M \begin{bmatrix} \ddot{\theta}_{leg} \\ \ddot{\theta}_{knee} \end{bmatrix} + D \begin{bmatrix} \dot{\theta}_{leg} \\ \dot{\theta}_{knee} \end{bmatrix} + K \begin{bmatrix} \theta_{leg} \\ \theta_{knee} \end{bmatrix} = \begin{bmatrix} \tau_{leg} \\ \tau_{knee} \end{bmatrix} + C_0 \quad (17)$$

$$\begin{cases} \tau_{leg} = -K_{\theta} \times STEP \times Joint_{knee}.\theta \\ \tau_{knee} = 0.0 \end{cases} \quad (18)$$

where, M: Inertia Matrix(2x2), D: Viscosity Matrix(2x2), K: Rigidity Matrix(2x2), C0: Gravity term

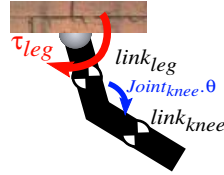
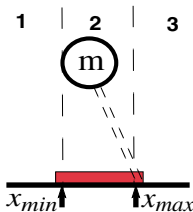


Fig. 3. 2 links model for swing leg

2.3 Phase 3: Deceleration Phase in Swing Phase and Double Support Phase

In this phase, to prevent the operator from falling down, the target point of heel contact x_{ref} is set. Human controls ZMP by pushing the floor through his foot. So the controllable area of ZMP (Fig. 4) is confined by the relational expression between the position and the velocity of COG as follows(Eq. (19)). In this term, we have the discussion focusing on the motion in x axis. Combining Eq. (13) and Eq. (19) gives three area of the motion of COGx(expressed as x in equation) divided by the condition of x_{zmp} .

$$x_{zmp} = \begin{cases} x_{min} : \text{if } x + \beta \{k_d \dot{x} + k_p (x - x_{ref})\} < x_{min} \\ x_{max} : \text{if } x_{max} < x + \beta \{k_d \dot{x} + k_p (x - x_{ref})\} \\ x + \beta \{k_d \dot{x} + k_p (x - x_{ref})\} : \text{else} \end{cases} \quad (19)$$



[Area 1] $\beta \ddot{x} - x + x_{min} = 0 \quad (x_{zmp} < x_{min})$ (20)

[Area 2] $\ddot{x} + k_{dx}(\dot{x} - \dot{x}_{ref}) + k_{px}(x - x_{ref}) = 0 \quad (x_{min} \leq x_{zmp} \leq x_{max})$ (21)

[Area 3] $\beta \ddot{x} - x + x_{max} = 0 \quad (x_{max} < x_{zmp})$ (22)

[Boundary line l_1, l_2]

$$\dot{x} = -\frac{1 + \beta k_{px}}{\beta k_{dx}} x + \frac{k_{px}}{k_{dx}} x_{ref} + \dot{x}_{ref} + \frac{\dot{x}}{\beta k_{dx}}, \quad \text{where } \hat{x} = \begin{cases} x_{min} : l_1 \text{ (Area1 - 2)} \\ x_{max} : l_2 \text{ (Area2 - 3)} \end{cases} \quad (23)$$

Fig. 4. The controllable area of ZMP

In addition we see the behavior of x, \dot{x} in Area1 and Area3 from Eq. (20) and (22). The behavior depends on the characteristic vector of the system matrix which is yielded from the motion equation. It is possible to determine whether x can converge at the target value x_{ref} by comparing the gradient of the characteristic vector, which equals to $\pm 1/\sqrt{\beta}$, to the gradient of boundary line l_1, l_2 , which equals to $-(1 + \beta k_{px})/\beta k_{dx}$. From these value the range of x which is enabled to converge in Area1 and Area3 is calculated by Eq. (24).

$$-\frac{1}{\sqrt{\beta}}(x - x_{min}) < \dot{x} < -\frac{1}{\sqrt{\beta}}(x - x_{max}) \tag{24}$$

Solving this differential equation, we obtain Eq. (25) and be able to see the value of the position and velocity of COG x after t seconds.

$$\begin{aligned} x &= \frac{1}{2} \left(e^{-\frac{1}{\sqrt{\beta}}} + e^{\frac{1}{\sqrt{\beta}}} \right) x_0 + \frac{\sqrt{\beta}}{2} \left(e^{-\frac{1}{\sqrt{\beta}}} + e^{\frac{1}{\sqrt{\beta}}} \right) (\dot{x}_0 - \hat{x}) \\ \dot{x} &= \frac{1}{2\sqrt{\beta}} \left(-e^{-\frac{1}{\sqrt{\beta}}} + e^{\frac{1}{\sqrt{\beta}}} \right) x_0 + \frac{1}{2} \left(e^{-\frac{1}{\sqrt{\beta}}} + e^{\frac{1}{\sqrt{\beta}}} \right) (\dot{x}_0 - \hat{x}) \end{aligned} \tag{25}$$

where, and x_0, \dot{x}_0 are the initial value when the COG is out of Area2.

On the other hand, the swing leg which has already touched the floor must be able to control COG at the time t_s with changing the swing leg into support leg after heel contact. The condition which enable the new support leg to control COG is denoted in Eq. (26) using the center position of the foot at heel contact named x_s .

$$\begin{cases} \dot{x} < -\frac{1 + \beta k_{px}}{\beta k_{dx}} x + \frac{k_{px}}{k_{dx}} x_s + \dot{x}_s + \frac{\hat{x}}{\beta k_{dx}} (\hat{x} = x_{min}) \\ \dot{x} > -\frac{1 + \beta k_{px}}{\beta k_{dx}} x + \frac{k_{px}}{k_{dx}} x_s + \dot{x}_s + \frac{\hat{x}}{\beta k_{dx}} (\hat{x} = x_{max}) \end{cases} \tag{26}$$

To procure the position x_s which is able to control COG after t_s second x, \dot{x} in Eq. (26) are applied to Eq. (26). Eq. (26) is rewritten on the basis of x_s (Eq. (27)).

$$x_s = -\frac{(link_{ankle} \cdot l - \beta K_d \dot{x}_{ref})}{\beta_1} - \frac{\beta_1 - \beta_2}{2\beta_1 Exp} \left(\sqrt{\beta} (\dot{x} - \hat{x}) - x \right) + \frac{Exp}{2\beta_1} (\beta_1 + \beta_2) \left(\sqrt{\beta} (\dot{x} - \hat{x}) + x \right) \tag{27}$$

where, $\beta_1 = 1 + \beta K_p, \beta_2 = \sqrt{\beta} K_d, Exp = e^{\frac{1}{\sqrt{\beta}}}$

Consequently in this phase, PD control is performed so as to adjust the foot position to the target point x_{ref} ($= x_s$). The joint torques of the leg and knee are set as

$$\tau_{leg} = K_{p_{hip}} (x_{ankle} - x_{ref}) - K_{d_{hip}} Joint_{leg} \cdot \theta \tag{28}$$

$$\tau_{knee} = \begin{cases} K_{p_{knee}} (\hat{y} - Distance(link_{BODY} - link_{ankle})) - K_{d_{knee}} (Joint_{knee} \cdot \dot{\theta}): F_{floor} > 0 \\ K_{p_{knee}} \left(\sqrt{(x_{ankle} - x_{ref})^2 + y^2} \right) - K_{d_{knee}} Joint_{knee} \cdot \theta: others \end{cases} \tag{29}$$

3 The Results of the Computer Simulation

Using these method mentioned above, we simulated to generate some patterns of periodical walking on the computer (Fig. 5). For the computer simulation, the 8 links model is readied. Considering an adult male’s value as reference, each parameter of 8 links model, which are lengths and masses in this simulation. When three step lengths had been set as target step length; 0.3[m], 0.4[m], 0.5[m], three step length patterns; 0.25[m], 0.35[m], 0.5[m] could be generated.

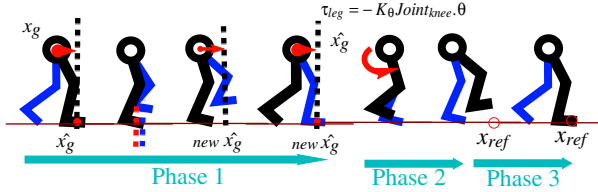


Fig. 5. Shift of phases in the walking control

When each pattern was generated, they could obtain several speed 0.54[m/sec], 0.65[m/sec], 0.73[m/sec] respectively (Fig. 6a). At the same time, when four gains for controlling COGx called Kpx had been set; 400, 600, 800, 1000, four speed patterns of 0.36[m/sec], 0.52[m/sec], 0.65[m/sec], 0.73[m/sec] could be generated. When each pattern was generated, they could have several steps such as 0.38[m], 0.40[m], 0.43[m], 0.5[m] respectively(Fig. 6b).

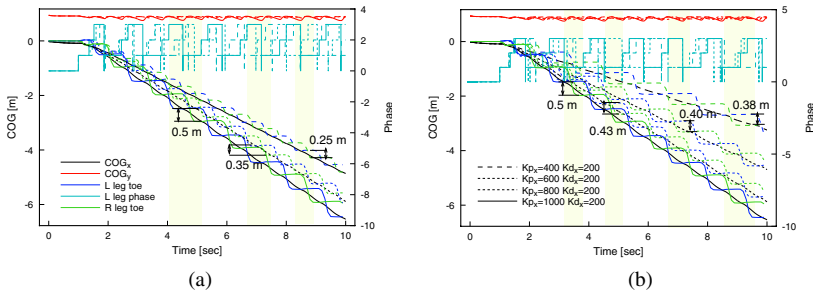


Fig. 6. The trajectory of COG and foot position in the computer simulation

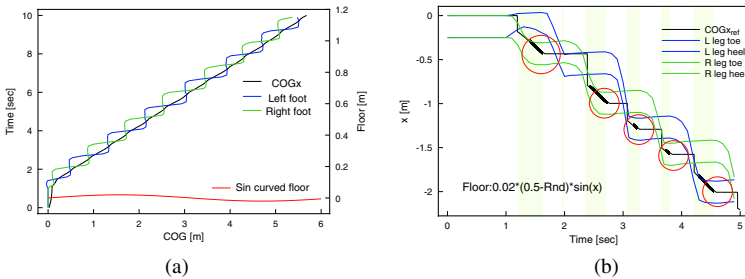


Fig. 7. The target point of foot-touch x_s on unjust ground

In the case of walking on unjust ground, where is set as sin-curved ground with noise, we could also generate periodical patterns stably(Fig. 7a). Figure 7b shows that the target point x_s is always kept in the foot. So, it could be said that COG is controllable after the support leg is switched to the other leg. And Fig. 8 shows the transition of phases and input u of the system walking on unjust ground. The real line indicates the system with no stable controller. The dashed line indicates the system with stable controller. The latter system could generate input u more periodically. It indicates the stable motion is generated by this controller.

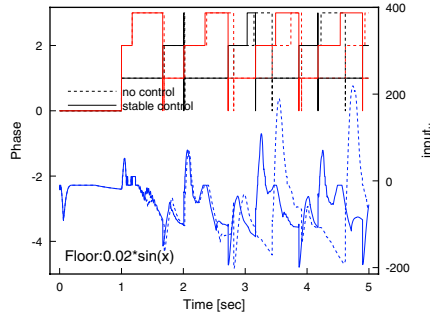


Fig. 8. The comparison of no controller system and stable controller system

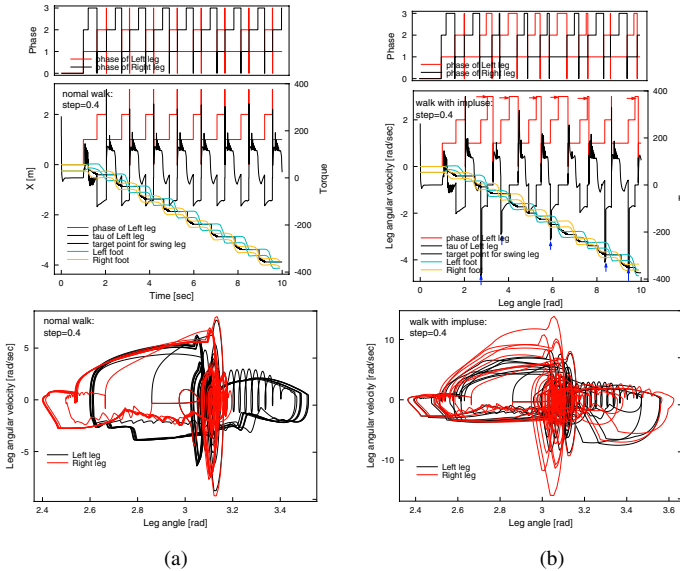


Fig. 9. The trajectory of COG and foot position in the computer simulation. $K_{px}=800$, $K_{py}=500$, $K_{pth}=800$, $K_{dx}=200$, $K_{dy}=100$, $K_{dth}=200$

Figure 9a shows an example of left-right a symmetrical walking which is generated by the system with stable controller under the condition where the target

point of step length was set to 0.4[m]. Fig. 9. has three graphs which are 1) the shift of phases both legs, 2) the shift of left leg's phase, the torque of left leg, trajectory of both foot position and the target value of swing legs, and 3) behavior of hip joint angle in topology plane, in order from a top. From Fig. 9a. it is found that this walking had have left-right asymmetry because the term Phase3 of left leg is shorter than right one, though this is stable and periodical walking. On the other hand, Fig. 9b shows the walking simulation added to external force in 0.05[sec] during Phase2. When the step is smaller than the target step under the same condition of Fig. 9a. The force is proportional to difference between the target step and the step. In Fig. 9b added forces is expressed in blue broad allow. This force bring Phase3 more time and enables the walking to be dissymmetry compared to Fig. 9a.

From these results we confirmed that it would be possible to change the limit cycle, which we have respectively, by adding the external force or by selecting control gain properly. It would have the effectiveness to the rehabilitation program for handicapped people.

4 Conclusions

Using these methods, we could generate several periodical walking patterns which have different speeds and different step lengths stably in the computer simulation. We could confirm the effectiveness of the control method of walking speed and step length which an operator desire without falling down for HAL. We could propose and develop the motion task generation method to control HAL.

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The Development of Gait Training System for Computer-Aided Rehabilitation

Hidetaka Ikeuchi¹, Satoshi Arakane², Kengo Ohnishi¹, Keiji Imado¹, Yukio Saito³, and Hiroomi Miyagawa¹

¹Oita University, 700 Dannoharu, Oita, Oita, 870-1192, Japan
{hikeuchi, ohnishi, imado, miyhiro}@cc.oita-u.ac.jp

²Daihen Technology Institute, 1660-7 Mizoi, Kituki, Oita, 873-0025 Japan
arakane@daihentec.co.jp

³Tokyo Denki University, Ishizaka, Hatoyama, Saitama 350-0311, Japan
saito@n.dendai.ac.jp

Abstract. This paper reports on the development of a gait training system and its experimental results. The outstanding feature of the system is the constant dynamic adjustment of the tension lifting the trainee based on the information from floor reaction force. The load on the trainee's foot on the floor is regularly maintained at a low-burden level; therefore, the load on the foot is similar to the effect of walking in a pool. The system was tested on a handicapped person, and improvements in balancing ability were shown.

1 Introduction

Rehabilitation training is one of the fields where mechatronics systems can provide effective tools for diagnosis of performance. Mechatronics systems can also decrease the physical load in physical therapy treatment, such as gait training. Normally, training for a patient with enfeebled lower limb function uses parallel bars and pools. Parallel-bar training has the disadvantage of causing pain, and it requires strength in the upper limbs. Training in a heated swimming pool is easier on the trainee's body. However, it also has drawbacks, which are the scale and maintenance of the facility, as well as the stress on the therapist resulting from the safety in the pool.

Several gait-training devices with slinging mechanism have been reported [1-3]. A treadmill device is a popular mechanism because of its easy-installation and ease-of-use. Though, this method lacks the sense of dynamic body movement since acceleration of the body in the direction of movement is canceled. Another disadvantage of a static support of the body weight, seen in other systems, is that it limits the rhythm of the movement and cannot reduce the impact force at foot contact. To overcome these problems, our system was developed.

The main feature of the system is constant dynamic adjustment of the tension lifting the trainee based on information from a floor reaction force. The load on the trainee's foot touching the floor is regularly maintained at a low-burden level. The trainee senses the stimulation on the sole and other parts of the body as in a natural walk, since he or she is walking on the force plate, a solid surface. Furthermore, a

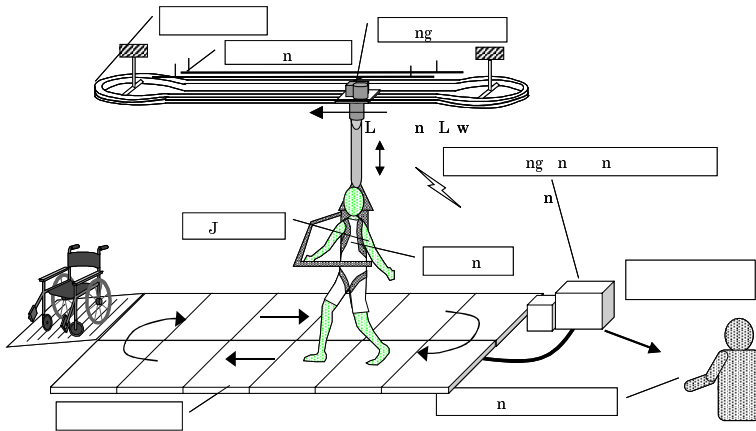


Fig. 1. System diagram of the Conceptual Design

trainee is able to train in various surface environments, for example, a slope, by changing the surface on the force plate.

The technical goal of developing our Gait Training System is to provide a training device that obtains a similar effect as that of buoyancy in a swimming pool. In our system, a slinging device supports the trainee while he walks on force-measuring floor plates. The lifting power of the slinging system is constantly controlled during the training by the information obtained from the force plates. This information is forwarded to the main control unit through a high-speed digital communication system. The control signal computed in the main control unit is then sent to the slinging control unit by wireless. Therefore, this system constantly provides the most tolerable load level to the trainee by adjusting the lifting force according to the trainee's degree of recovery. Moreover, the system provides a tool for evaluating the effect of training by displaying the training records and the force plate data.



Fig. 2. Developed System

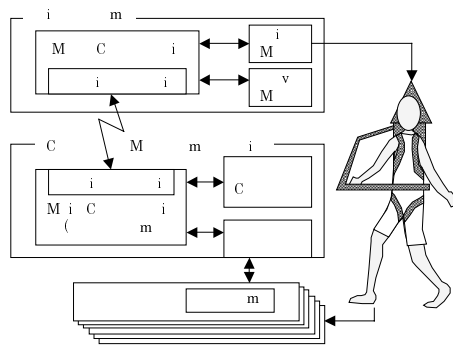


Fig. 3. System Diagram

Moreover, the system provides a tool for evaluating the effect of training by displaying the training records and the force plate data.

2 System Elements

Fig.1 shows the concept design of the system. Fig.2 is the gait training system as developed. Fig.3 is the system diagram of the signal transmission mechanism. The floor area is $7.5 \times 2.9 \text{m}^2$, and is covered with aluminum force plates. These plates have 4 force sensors at the bottom that measure the amount of pressure on them, as applied by the subjects. The walking distance on the device is approximately 12m. Two props support the guide rail that the sling system travels on. The sling system component supports the trainee, and lifts or lowers the person according to the information from the force plates. The information for sling control is sent to the sling system component from the main control unit by Spread Spectrum Wireless Data Communications. Power for the sling system is supplied by a trolley wire; therefore, the trainee can walk without restriction. A touch panel is utilized for system operation. Buttons for setting the load on the foot, walking speed, manual operation of the sling units, and start/stop of training are displayed on the its screen.

2.1 Sling System Component

The sling system manages the load on the trainee's foot by controlling the force on the wire holding the body. The sling system also controls the patient's propulsion and walking speed. This unit is composed of an AC motor for load control, AC motor for traveling, slinging mechanism, traveling mechanism and the computer controller. The computer has 4 functions: data reception, torque computation, traveling speed control, and slinging force control. The wire holding the trainee is connected to a ball screw nut module. Two ball splines and a ball screw shaft drive the nut vertically. The AC motor is connected to the ball screw shaft, and the generative torque is transferred to the wire through the mechanism.

2.2 Supporting Vest

A supporting vest for the harness device was developed. This device holds and supports the weight of the trainee connected to the slinging unit. Therefore, the comfortableness of this device has a significant influence on the success of the system. We tried a number of off-the-shelf products, but none were durable enough. The device still needs improvements in its functional design, and our goal is to improve it so that it is easy-to-wear, painless, and allows more movement during the gait.

The device in Fig 4-(a) and (b) was developed for this purpose. Fig.4-(a) is Type I, which was originally developed in the lab. Denim cloth is mainly used, and the load is sustained mostly between the thighs, while partially supported at the trunk where the jacket is wrapped around the midsection. The jacket provides a sense of security for maintaining body posture. A frame pipe holds a soft stuffed tube for the crotch in a comfortable manner. Also, this pipe works to lower the



Fig. 4. Supporting Vest

mental stress on the trainee by its use as a handle. This type was developed with the chief aim of ease of installation. Several prototypes have been produced through trial and error, and we are continuing to improve on it.

Fig.4-(b) is Type II, which utilizes a harness already on the market, a BIODEX vest, for holding the trunk. This type was developed with the chief aim of lowering the pain caused by the slinging force. Improvements were made on the belt secured to the thigh to hold the lower limb. The same method used in the socket of an artificial leg is applied to support the load. The socket of an artificial leg must support a load without pain and without restricting the walk of the user.

2.3 Force Plate

The size of the force plate is 2400mm * 1400mm. The plate is designed and produced with the aim of lightweightness and low cost. Force measurement using force plates becomes inaccurate as the size of the plate increases, because of the effect of the distortion caused by the empty weight. Therefore, the plate requires more stiffness; however, this increases the weight and requires a force sensor with high accuracy. Furthermore, system cost rises and the device's efficiency decreases. In addition, a solid heavy plate feels cold and uncomfortableness, which causes abnormal gait of the trainee.

We designed a lightweight and stiff force plate by structuring an aluminum honey cam and putting a carbon fiber plate over it. The weight of one plate is 57.2 kgf. This structure also provides sufficient performance with a low-sensitivity force sensor.

2.4 Measuring and Control Unit

The force sensor is arranged in the four corners of each force plate. Output signal is amplified and converted to a digital signal at the amplifier module for all 6 force plates, and is forwarded with a time-sharing process through a single line to the main control unit. Data from up to 12 plates can be forwarded with this system.

The main control unit calculates the sling force from the floor reaction force data measured at the force plates, then transmits the calculated data to the sling system component. Hitachi microprocessor system H8S was used for the CPU of the main control unit.

We use Spread Spectrum Wireless Data Communications for the communication between the main control unit and sling system component. This wireless system is safe for medical appliances since the wireless power output is 45mW, this is 6/100 of a cellular phone. A wireless system eliminates the restriction of movement of the sling system component. We believe wireless control signal transmission is a necessary technology for rehabilitation mechatronics systems, especially for devices that lift and move subjects.

3 Sling Control and the Results of Sling Experiment

3.1 Block Diagram

Fig.5 shows the block diagram of the sling control method. The aim of this method is to maintain a floor reaction force equivalent to the preset target load. The motor torque is computed from the difference of the reaction force and preset load. Threshold is set around the target load to work as a dead zone block and prevent unstable oscillation of the motor caused by minimal errors. A torque signal is computed by adding the offset value; that is, the difference between the subject's weight and the preset load, to the difference between the target and present load. This signal is sent to the sling system component to continually support the trainee. By utilizing this control system, the body is lifted when the subject's weight, through the feet, pushes on the plate, and lowered when leaning or hanging on to the device. This effect produces a buoyancy-like assistance in supporting the body weight.

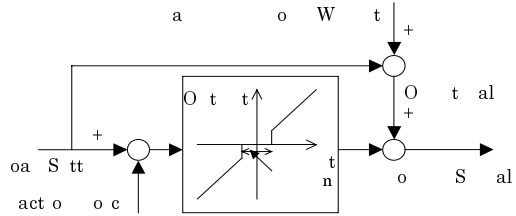


Fig. 5. The Block Diagram of Sling Control

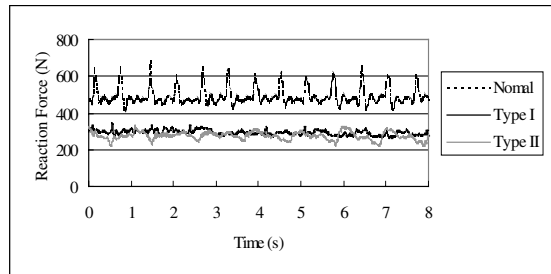


Fig. 6. The Results of Reaction Force

3.2 Results of Experiments

Fig.6 shows the results of the performance test of the control system. The subject of this experiment was a female adult in her early seventies with a natural gait. As seen, the results with sling control provide a gait support that can maintain the load equivalent to the target load, while the result of the gait without the control has an impulsive force at foot contact. The current control system demonstrated the capability of maintaining the lifting force near the target load within 100N error span in our experiments.

4 Field Test on Handicapped Subjects

This system has been tested on several aged and handicapped persons to analyze its function and efficacy. The control and user-friendliness of the system was verified, and improvements are being made based on the feedback.

4.1 Field Test – Sporadic Training on Multiple Subjects

The system was tested on non-handicapped and handicapped subjects with abnormal gait. Feedback was collected on the usability of the system, e.g. fit of the vest, etc. Five subjects were non-handicapped, and 7 subjects had feeble lower limb(s). The 5 handicapped were in their 70's, four female and one male, and two were in their 50's, both male. All of the handicapped were capable of short walks on their own with a cane. Based on the level of disability and subject's condition, the supporting vest, load, and training period were determined. The subjects were questioned before and after the training.

Various experiments highlighted the following positive results:

1. The system has no serious defects when used for gait training by those with feeble lower limbs. Adjustment of the load on the feet was accurately controlled by the system.
2. The type II vest is nearly painless even when the body lifting force is large. One minor drawback is the restriction of lower limb movement caused by the strap on the thigh
3. The characteristics of the subjects' gait patterns were quantifiable by following the graphical representation of the force plate sensor data. The patterns clearly differed based on the subjects' disabilities and their walking patterns. Almost all subjects walked stably with the type I vest
4. Useful feedback on minor modifications was collected from the subjects.

4.2 Field Test –Successive Training on a Handicapped Person

Based on the previous experimental data, successive training was carried out to observe the effect of the system. The subject was a 25-year-old male, who suffered from partial paralysis on his left side caused by a brain tumor. There was also some paralysis on the right. There was no disability in the upper limbs. Therefore, he has used a wheelchair for transportation and has had no gait training in the past 5 years. This patient had enough muscular power to stand and to move both feet forward at the hip. He could extend both knees and other joints fully, but did not have full control of the lower limbs because of the nervous disorder. Hence, the trainee could maintain a standing position for a short time and had difficulty balancing during gait.



Fig. 7. Improved Type I

Table 1. Medical test results before and after training.

Tests		Before training	After Training
Blood Test		Normal	Normal
Biochemical Test		Normal	Abnormal total bilirubin Index
Respiratory function	Lung capacity	2820ml	3170ml
	1 second forced expiratory volume	2600ml	2780ml
Bone density		1485m/s	1500m/s

The subject trained 3 times a week for 10 days. Two 5-minute training sessions were made with a 10-minute break in between. The preset load was set to 150N, which was the maximum load that allowed the subject to walk naturally. Gait speed was set to 7.2 m/min so that the subject could step while confirming his position visually. The distance of the gait was approximately 36 m/set.

To evaluate the effect of the gait training device, CT, bone density, and lung capacity examinations, blood tests and patient feedback were taken before and after the training for comparison. The training period, preset load, and gait speed were increased as the subject requested. Verbal feedback was noted each day.

Settings at the last training session exceeded these figures: preset load 200N, gait speed 9.6 m/min, training period 10 minutes.

Type II vest was initially selected for use to minimize uncomfortableness caused by the high slinging force. However, since the subject was required to keep a catheter attached to his thigh, this vest could not be used. Thus, we prepared an additional part, Fig.7, for the vest in order to support the body at the hipbone.

Table 1 shows the results of the blood, biochemical, lung capacity, and bone density tests. The improvements in respiratory function and bone density need further research to determine their relation to the training, although, similar results were reported by our medical director when training chronic spinal-cord-injury victims in the past. For that reason, we assume that these values are measurements that can be used to monitor the performance of the training. The training was completed in a short period, and no signs of anemia, hemolysis, liver dysfunction, or kidney dysfunction were reported. The abnormal total bilirubin index was not at a level to be questionable

4.3 Results

The trajectories of the point of the floor reaction force in a horizontal plane for the first, fourth, and tenth gait training days are shown in Fig.8. The diagrams are computed from the data collected from one plate arranged at straight-line path of the gait orbit. In the first training, an undescended trajectory is seen when the weight is shifted from the right foot to the left. In contrast, this tendency weakens at the fourth and tenth training trajectories. This matches the awkward character in the early training, but the subject's steps showed signs of discipline as the training went on, for

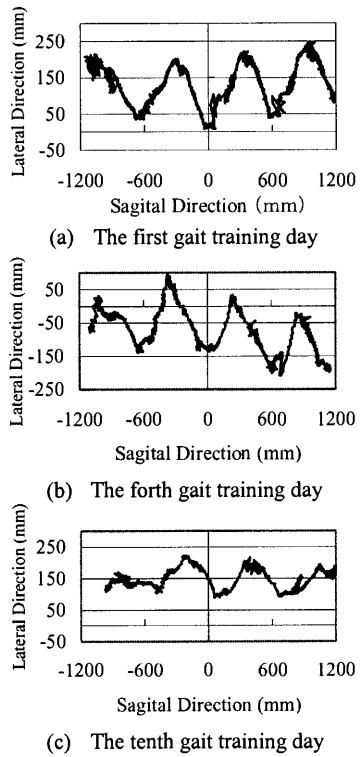


Fig. 8. The point of the reaction force

example, wavering of the left ankle joint disappeared. Subject's comments were as follows:

- Greater satisfaction than using parallel bars, since our system provides a stronger sense of walking on one's own feet.
- Increased ease in getting in and out of the wheelchair because of the improvement in the sense of balance between body and feet.
- Easy control of the ideal level of exertion can be easily controlled by the user, since the computer parameters are easy to set.

To compare the effect of our dynamic support to a static one, gait training without the sling control was performed on a handicapped person. As for this result, the trainee felt heavily fatigued from the second lap, and claimed that the training was difficult to continue for the same amount of time as with the dynamic support.

5 Conclusion

The conclusion of this report is as follows:

A unique gait-training device with a slinging weight support method is presented. The outstanding feature of this system is control of the tension while holding the body to reduce the impact of floor reaction force. Performance tests showed the control system is efficient of changing the floor reaction force around the preset load. The impact at the heel-contact and toe-off was reduced.

Our control system provides a feeling of self-directed walking by working in a way where relaxing and strengthening of the muscles in the legs causes vertical movement of the body. Moreover, the floor reaction data from the system is useful in medical treatment, therapy, and other applications. Therefore, this innovated device, if mass-produced and marketed, could contribute greatly to the rehabilitation of the handicapped people with feeble lower limb.

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Accessing Internet Courses by Eye Movement and Head Movement

James Gips¹, Philip A. DiMattia², Marialice Curran², Debra Lees³, and Maureen Gates²

¹Computer Science Department, CSOM, Boston College,
Chestnut Hill, MA 02467 USA
james.gips@bc.edu
<http://www.cs.bc.edu/~gips>

²Campus School, Lynch School of Education, Boston College,
Chestnut Hill, MA 02467 USA
{dimattia, curranmf}@bc.edu

³Hollybank School, Far Common Road,
Mirfield, West Yorkshire WF14 0DQ UK
debbie.lees@ukonline.co.uk

Abstract. Education of people with very severe physical disabilities – people who cannot speak and are quadriplegic – can be greatly facilitated by the internet and by new computer access technologies. Five students between the ages of 17 and 24 have completed courses over the internet using access technologies that allow them to control the mouse pointer on the computer screen by moving just their eyes or head.

Finding appropriate educational software for people with severe physical disabilities who are in their late teens and early 20's can be difficult. Five students with very severe physical disabilities are taking courses over the internet using access technology that allows them to control the mouse pointer by moving only their eyes or head. These students cannot speak and have no voluntary muscle control from the neck down, yet they now can access academic areas of interest in an autonomous way. These individuals successfully have completed free courses offered over the internet through Barnes and Noble (barnesandnobleuniversity.com). As shown in Table 1, four of the students work from the Campus School at Boston College in the US and one of the students is at the Hollybank School in West Yorkshire, UK.

Table 1. Summary of students

	Gender	Age	Condition	Access	Location
A	Male	17	Cerebral Palsy	EagleEyes	Campus School
B	Male	18	Cerebral Palsy	Camera Mouse	Hollybank
C	Male	20	Cerebral Palsy	EagleEyes	Campus School
D	Female	21	Cerebral Palsy	EagleEyes	Campus School
E	Male	24	Traumatic Brain Injury	EagleEyes	Campus School

The courses were selected by the students and ranged from the serious (“Mapping the Mind,” “Pearl Harbor,” “The Railroad in American History”) to the more entertaining (“The Oscars,” “Holiday Entertaining”).

The students went through the lessons and did assignments and quizzes, some more ardently than others. In addition to learning the material, the students were able to make contact with other people who were taking the courses who do not have physical disabilities. For example, student A had a long-distance correspondence with a woman in Brazil. He posted that he was taking the course using only his eyes. The woman was amazed and wrote him. She asked a lot of questions about him and the access technology he uses and told him that he is an inspiration. Student D had a similar correspondence with her instructor. It is important to these students that these are “university” courses and that no one else, neither the instructor nor the other students, knows that they are disabled unless they tell them.

The students used two technologies developed at Boston College to access the courses.

EagleEyes [1], [2] is a technology that allows people to move the mouse pointer on the computer just by moving their eyes. EagleEyes works through five electrodes placed on the student’s face, around the eyes. EagleEyes measures the EOG (electro-oculographic potential) which is proportionate to the angle of the eyes in the head.

The Camera Mouse [3] allows people to move the mouse pointer by slight movements of the head (or thumb or toe). The Camera Mouse works through a videoconferencing camera that is focused on the student and attached to the computer.

Both technologies serve as general mouse replacement devices for Windows. Clicking is accomplished using “dwell time.” That is, if the student causes the mouse pointer to hover over a location for a settable fraction of a second the driver software issues a standard mouse click. EagleEyes and Camera Mouse work with browsers and other Windows software.

Our goal is to provide the best education we can for our students. Novel access technologies together with computers and the internet provide educational opportunities for students with physical disabilities that were unthinkable a few years ago. We are exploring ways for our students to take advantage of these developments.

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Note: CM Solutions, Inc., of Austin, Texas, has licensed the Camera Mouse technology from Boston College. James Gips has a financial interest in the company.

The Program for Improving the Working Interfaces and Increasing the Work Competencies of People with Severe Physical Disabilities: The Evaluation, Design, and Training of the Adaptive Computer Devices

Tien-yu Li¹, Ling-Fu Meng², Chien-Huey Sophie Chang³, Ming-Chung Chen⁴, Chi-Nung Chu⁵, Arr-Ming Chou⁶, Tony Yang⁶, Chin-Chen Hui⁶, Ai-Chiao Ku⁶, and Yun-Lung Lin⁶

¹National Taiwan Normal University, Department of Information and Computer Education, 162 Ho-Ping E. Rd., 1 Sec., Tai-Pei, Taiwan 106
tienyu@ice.ntnu.edu.tw

²Chang Gung University, Department of Occupational Therapy
ufx53929@mail.cgg.edu.tw

³National Taiwan Normal University, Department of Special Education
Chang641@ms27.hinet.net

⁴National Chiayi University, Department of Special Education
ming@chen.twmail.cc

⁵China Institute of Technology, Department of Information Management
chu@mis.ckitc.edu.tw

⁶Taiwan Assistive Technology Association
amchou@ice.ntnu.edu.tw

Abstract. Computer access is always a concern due to the fact that computer skills are often listed among the basic requirements for job application. In Taiwan, many people with disabilities do not get job offers because regular computer devices are not designed for their special needs. To help these people, the Adaptive Computer Technology Service Team (ACTST) was established to design and provide individualized needs evaluations and computer skill training. This paper aims to report the results of our efforts and discuss future plans.

1 Introduction

Nowadays, computer skills are required for people with disabilities to get a job offering in Taiwan. Many people with physical disabilities are not hired because they cannot use computers or because they use computers slowly. To help them deal with this issue, the following three individualized services are needed. First, a comprehensive evaluation of computer access has to be provided [1]. Second, assistive devices need to be designed to meet individual needs [2]. Third, training in computer skills is needed to be conducted to increase the work competencies and productivity of people with disabilities [3].

The Adaptive Computer Technology Service Team (ACTST) project is proposed by the Taiwan Assistive Technology Association, and funded by the Bureau of Labor

of Taipei City Government. This trans-disciplinary team consists of professional members with master or doctoral degrees in the following fields: occupational therapists, special education, computer engineering, and electronic engineering. This team provides comprehensive, augmentative, and alternative methods and devices to improve the computer access and skills of people with disabilities in Taiwan.

The major goals of this project are as follows:

- a. Adapting computer devices to suit the individual needs of people with physical disabilities;
- b. Establishing tools for evaluating the usability of adapted computerized devices for people with upper limb impairments;
- c. Setting up and conducting individualized training plans (ITPs) for the clients;
- d. Providing training on using adapted computers and devices to increase the working efficiency and job-hunting skills of people with disabilities.

2 The ACTST Project Description

The Adaptive Computer Technology Service Team (ACTST) initially received 32 applicants with physical disabilities after advertising the program through mass media, announcements on Internet, and letters to several associations and organizations of people with disabilities. Sixteen applicants with severer physical disabilities were chosen to participate after the initial screening. In the final stage, ten people out of the sixteen participants who needed individualized adaptive computer devices were chosen as the clients to receive full services from the ACTST. The ten persons are all with normal cognitive ability, and with high school diplomas and above. Either were they unable to operate regular computers or they were having low accuracy rates in doing data entry.

This project was conducted from January 2001 to December 2001. The major achievements were (1) designing evaluation tools for the use of adapted computerized devices for people with upper limb impairments, (2) evaluating each client's needs for adapted computerized devices and the effects of their individualized training plans, and (3) designing and adapting computerized devices.

3 Results and Discussion

3.1 The Results of the Project

After evaluating our clients' needs and providing them with appropriate adaptive devices, we found that their computer access and skill performance have been significantly improved. For example, a modified mouse with specially installed switches was provided for clients who could not freely use a regular mouse or press the buttons. The device solved their problems and increased their typing and Internet searching performances. In addition, a foot operated stick and computer desk were

adapted and adjusted for a female client who preferred doing keyboarding with her feet. These two adaptive devices enhanced her typing accuracy and physical comfort.

3.2 The Effectiveness of the Project

The effectiveness of this project is as follows:

- a. The clients' abilities and skills were improved by using adapted computer devices. These devices thus expand clients' potential for obtaining job offerings.
- b. The established evaluation tools of adapted computerized devices are useful in probing the unique needs of people with upper limb handicaps.
- c. The adapted devices originally designed for our clients, in some cases, could be used by other people with similar limitations.
- d. The individualized training plans and its outcomes can be used as an important reference for other similar cases.
- e. The success that the Adaptive Computer Technology Service Team created can be a model for other projects in the future.

3.3 The Future Plans for ACTST

The success of this project leads to four further plans for the ACTST team in the future.

- a. To conduct on-going evaluation of clients' performances and help those who have progressively deteriorating physical conditions or other special needs.
- b. To promote the evaluation tools of adapted computerized devices, and the training materials used by this project.
- c. To transfer the successful experiences of the ACTST trans-disciplinary model to other local service groups by training professionals from various fields.
- d. To continue to serve people with severe upper limb impairments and expand the services to include persons with other disabilities.

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Matching Typing Persons and Intelligent Interfaces

Introduction to the Special Thematic Session

Wolfgang L. Zagler

fortec – Research Group on Rehabilitation Technology,
Favoritenstrasse 11/366-1B, A-1040 Vienna, Austria
zw@fortec.tuwien.ac.at
<http://www.fortec.tuwien.ac.at>

Abstract. The session will highlight the importance of text production in daily life situations of disabled persons and explain proven and future user interfaces. One of the main goals in present research is the development of highly efficient and effective user interfaces which are perfectly matched to the user needs and abilities. By incorporating intelligent features and know-how from Natural Language Processing a high percentage of redundancy immanent in conventional typing can be avoided thus increasing the speed of text generation.

1 Matchmaking in Assistive Technology

Successful application of Assistive Technology will always call for "Matching Person and Technology" in the best way possible and fitting best into the milieu of the user [1]. As persons are different and environments vary to a high degree, working out this best match is even important for rather common products like a walking aid or an assistive listening device. Much more important it is for high-tech applications in Augmentative and Alternative Communication (AAC) because the ways we communicate and the contents we want to communicate touch the core of our personality. This puts a high demand on the design and assessment of AAC tools.

2 The Importance of Typing

The possibility to produce written texts, to take notes, to write letters and e-mails is a necessity for most people. Among all persons with disabilities three groups face the most severe problems when only standard tools for written communication are available for them: (i) Motor and dexterity impaired persons as they will encounter problems with pencil and paper as well as with conventional keyboards; (ii) Speech impaired persons as they will have to replace talking by typing and always experience that this substitution is much too slow for meeting their communication needs; (iii) Language and learning disabled persons as they will face the problem to put their thoughts into words others can readily understand.

3 Misunderstandings about Predictive Typing

When personal computing became a technological and economic reality and after reaching a sufficient level of computing power it became possible to offer predictive typing programs to private users. During these years a multitude of scientific articles and practical discussions were issued sometimes leaving the impression that such acceleration methods will soon be the technological answer to many communication disorders [2].

However, after this first euphoria about predictive typing, several critical voices could be heard questioning the benefits of predictive text production. Correctly, the authors of these publications pointed out, that Keystroke Saving Rate (KSR) is not the only parameter to be respected when using a predictive typing programme. By watching the prediction list and making selections from this the user is losing time – sometimes to a greater extent than he/she has gained by the prediction itself [3].

This well meant criticism had the effect that many researchers started doubting the general usefulness of predictive typing methods and reduced their efforts. In doing so it is neglected that only the technology–person–milieu match or mismatch will finally decide if a tool is a benefit or not. In fig. 1 it is shown, which KSR at least will be necessary to increase text production speed for a given typing speed k and time t used for making the selection process. This is meant as an encouragement to continue working in predictive technologies as there are sufficient persons who will benefit from that.

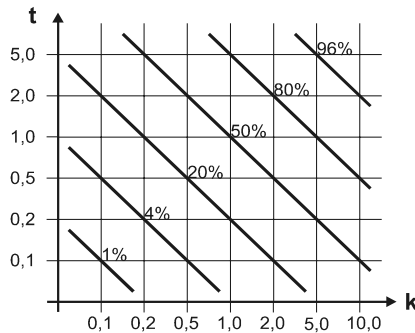


Fig. 1. The relation between the minimum necessary Keystroke Saving Rate [KSR, parameter in %], typing speed k [in characters per sec] and selection time used [t in sec]

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FASTY – A Multi-lingual Approach to Text Prediction

Johannes Matiassek¹, Marco Baroni¹, and Harald Trost²

¹ Austrian Research Institute for Artificial Intelligence,
Schottengasse 3, A-1010 Wien, Austria
{john,marco}@oefai.at

² Department of Medical Cybernetics and Artificial Intelligence,
University of Vienna
harald@ai.univie.ac.at

Abstract. Communication and information exchange is a vital factor in human society. Communication disorders severely influence the quality of life. Whereas experienced typists will produce some 300 keystrokes per minute, persons with motor impairments achieve only much lower rates. Predictive typing systems for English speaking areas have proven useful and efficient, but for all other European languages there exist no predictive typing programs powerful enough to substantially improve the communication rate and the IT access for disabled persons. FASTY aims at offering a communication support system significantly increasing typing speed, adaptable to users with different language and strongly varying needs. In this way the large group of non-English-speaking disabled citizens will be supported in living a more independent and self determined life.

1 Introduction

Whereas experienced typists will produce some 300 keystrokes per minute, persons with motor impairments achieve only much lower rates. One obvious alternative to manual typing is automatic speech recognition. However, diseases affecting the dexterity often also influence the ability to speak and/or the quality of vocal expression. Such persons have to rely completely on typing even for situations usually reserved for oral communication.

Since languages display a high degree of redundancy, low-speed typists can be supported by predictive typing (PT) systems. Such systems attempt to predict subsequent portions of text by analysing the text already entered by the writer. Character-by-character text entry is replaced by making a single selection as soon as the desired word or sequence is offered by the system in the selection list.

1.1 Drawbacks in Existing Predictive Typing Systems

State-of-the-art programs for PT claim Keystroke Saving Rates (KSR) up to 75%. This does, however, not mean, that the Text Generation Rate (TGR) increases by the factor four. Using PT consumes time for reading the selection list

and making a decision. Only substantial KSRs will lead to an increase of communication speed. For every user there exists a (break-even) Keystroke Saving Rate below which the use of a Predictive Typing program will not result in an increase on the Text Generation Rate. For example, to double the TGR of a typical mouth-stick user the program must offer a KSR of about 65%.

For the English language even very simple PT programs yield acceptable Keystroke Saving Rates well above 30%. This success is due to the fact that - almost uniquely among European languages - English is a language with a very limited set of inflectional affixes. For this reason predictive typing became popular in English speaking countries quite early. This popularity kindled the development of more sophisticated PT programs in those countries. Presently, all available PT programs originate from the USA, Canada and the UK. A product search in spring 2000 identified 21 products from the USA, 6 from Canada and 5 from the UK but only one from Germany. When programs of English language origin are transferred to other languages (especially highly inflecting ones) the KSR drops significantly (usually below 30%). Therefore, most motor/speech impaired persons will experience no gain in TGR from existing programs.¹ To offer high KSRs a prediction program must be designed taking into account the properties of the language for which it is used.

1.2 The FASTY Approach

The FASTY system, by augmenting and improving the standard technology, aims at providing impaired speakers of languages other than English with PT systems delivering KSRs currently available for English only. FASTY is being developed for the German, French, Dutch and Swedish language, the concept, however, will be usable for most European languages. FASTY will assist motor, speech, learning and language impaired persons to produce texts faster, with less physical/cognitive load and with better spelling and grammar. FASTY will be configurable for different types of disabilities, different communication settings and different European languages. It will allow easier access to PC based office systems, to modern forms of IT communication and a faster usage of text to speech synthesizers for voice communication. FASTY is an intelligent system by using methods of Natural Language Processing, Artificial Intelligence, self adaptive user interfaces and knowledge bases in order to significantly increase KSR especially for those European languages which are highly inflected.

FASTY follows a generic approach in order to be multilingual by design. The language independent prediction software clearly separates between the predictor, and the language-specific resources. This will result in a system with potential application to many European languages without sacrificing performance.

¹ However, increasing speed is not the only reason for using PT. Some users prefer predictive typing because it is less stressful than character-by-character entry. Dyslexic and learning disabled persons benefit from the selection list, because it supports their efforts in word finding and improves their spelling.

Throughout development a user panel ensures the strong involvement of users (including primary end-users as well as pedagogues, therapists, carers and family members as secondary users) in the project.

The user interface design and the features of the predictor program aim at a wide coverage of end users (various disabilities) and secondary users (various roles in supporting the disabled person). Self adapting parameters and flexible configuring ensure a high degree of usability, user friendliness and accessibility. Innovative and ergonomic user interfaces for various existing input methods (standard keyboard, on-screen-keyboard, scanning) will be developed together with the predictor thus minimising time and effort for selecting the desired word from a selection list presented on the screen.

In this paper we will not go further into details of the user interface design and development but rather focus on the underlying language component.

2 Overall Architecture of the Language Component

The target languages of the FASTY project are highly inflecting ones posing additional challenges to word prediction. Depending on the syntactic context, words take different forms. This makes standard language modelling techniques employing n-gram models of word forms less effective. Thus, additional methods that are able to cope with syntactic constraints are needed. Furthermore, for most of FASTY's target languages (i.e., Dutch, German, Swedish) compounds are written as single orthographic strings, in contrast to English and French, where compound terms are groups of words, still separated by a blank character or at least a hyphen. Since compounding is very productive in all languages, this renders all attempts to have a complete lexical coverage of these languages hopeless.

All the prediction modules are driven by a controller engine that takes care of the input requirements of each module, establishes the required input data from the context, and combines the module's results in a meaningful way, yielding the desired predictions. The operation of the controller is adjustable by language- and user-specific parameters. While the core engine of FASTY is fully implemented the additional components and the controller are currently under development.

2.1 Core Components

N-gram-based Statistical Prediction. Despite the problems with highly inflecting languages discussed above, preliminary experiments with German as well as experiences with a Swedish system [4] have shown that n-gram based methods still offer quite reasonable predictive power. Furthermore, the data sources needed by an n-gram based predictor, i.e., frequency tables of word n-grams, are easily constructed from text corpora irrespective of the target language.

Incorporating Part-of-Speech (PoS) based statistics provides additional precision. Also, user style and preferences can be accounted for by maintaining

n-grams collected from user texts. Thus, the combination of different n-gram statistics constitutes the base of the FASTY predictor providing a baseline performance for all target languages. Other modules interact with these results and improve on them.

Abbreviation Expansion. Abbreviation-expansion is a technique in which a combination of characters, an "abbreviation," is used to represent a word, phrase or command sequence. When an abbreviation is typed, it expands to the assigned word, phrase or command sequence. Abbreviation expansion is smoothly integrated into the ordinary prediction process, i.e. if the user types the beginning of an abbreviation the system is able to predict the abbreviation like an ordinary word (or phrase). In case of predicting the abbreviation code, the user interface can choose to show not only the completed abbreviation code but also the full expansion of the abbreviation in the prediction window.

Morphological Processing and Backup Lexicon. The morphology component is not a prediction component per se, it rather performs auxiliary functions for other components. As a prediction resource it is used in contexts where the other components run out of predictions (e.g., if the correct (in the current context) inflected form of the word to be predicted is not contained in the n-gram tables it can be generated using the morphological lexicon).

Since one of FASTY's goals is to be able to suggest only wordforms appropriate for the current context, it is required that the system is able to perform morphological analysis and synthesis, and to extract the morphosyntactic features needed by the components dealing with checking syntactic appropriateness. Also compound prediction needs the morphosyntactic information of the compound parts to be able to correctly predict the linking elements.

Last but not least, if the frequency based lexica run out of words with a given prefix, the morphological lexicon—provided it is big enough—will serve as a "backup" lexicon and deliver additional solutions.

Morphological processing is implemented via finite state-transducers, which provide very fast, bi-directional processing and allow for a very compact representation of huge lexica.

2.2 Grammar-Based Prediction and Prediction Ranking

The primary purpose of the grammar-based module is to enhance the predictive power of FASTY and improve its precision by syntactic processing. Only predictions that are not in conflict with the grammar will be delivered. The component should also be able to fill in gaps in terms of missing forms in the prediction list delivered by the n-gram based prediction module. It is assumed that syntactically well motivated n-grams provide better predictions than those that are not.

The module is realised as a partial parser employing the UCP (Uppsala Chart Parser) formalism [8], [9]. It uses the same PoS tags as basic categories

as the core module. In contexts where all predictions by the core component are rejected on syntactic grounds (e.g., if the correctly inflected form of the word to be predicted is not contained in the n-gram tables) a prediction can be generated using a back-up morphological lexicon.

The predictive power of a syntactic processor lies in its ability to make predictions in terms of word classes (PoS) and inflectional forms. In doing so, it can handle larger contexts than PoS n-grams and the predictions should be safer. A syntactic processor is not, however, capable of predicting new lexical material. It has to be fed by input from the user or by predictions made by other modules of the system. Typically, the syntactic processor will analyse predictions made by the n-gram module. As a result of the analysis it will primarily categorise them into three categories

- predictions confirmed by the grammar
- predictions outside the scope of the grammar
- predictions turned down by the grammar

A syntactically based ranking of the members of the first and second types is foreseen. It will be based on frequency data on syntactic structures for the different languages. In the first version of the prediction system, the ranking of the members of the first two categories will follow the probabilistic ranking suggested by the n-gram module.

As a rule, the predictions turned down by the grammar will not be delivered to the controller. So, the user will not be annoyed with predictions that are syntactically impossible; further, if impossible forms are left out there will be more space left in the prediction list for other possible continuations and thus convergence to the continuation intended by the user is achieved earlier.

A refuted inflectional form may also indicate the need for filling a gap in the prediction list. In other words, the lemma of the refuted inflected form, may in fact be the one that the user is aiming for. In such a situation first the other predictions are examined if an admissible form of that lemma is already contained. If not, a syntactically appropriate form is searched for in the morphological back-up dictionary.

2.3 Compound Prediction

Nominal compounds (the most frequent type of neologisms) are formed as new words in three of the FASTY languages (i.e., Dutch, German and Swedish). The type frequency of compounds is quite high. Analysis of a German corpus showed that 47% of the wordforms are compounds, suggesting that they constitute a class of words that must be handled for a satisfactory coverage of the patterns of the language.

On the other hand, compounds tend to have a low token frequency, and they are often *hapax legomena*. This suggests that they are formed productively. As a consequence, even with the largest lexicon, many possible compounds will not be in the lexicon. Our corpus analysis also showed that the large majority of

compounds are made of words that independently occur in the corpus (and typically with higher frequency than that of the compounds they form). Therefore, it seems reasonable to conclude that compounds should mostly be predicted by a compound prediction device, rather than be stored in the lexicon. Given that both Dutch [2] and Swedish have also very productive compounding, similar arguments hold for these two languages.

Our data indicate that the large majority of German compounds is composed of two element compounds. Among those, the most common type is the one in which both the first and the second element are nouns (around 80% of the total in terms of both type and token frequency). Thus, our compound prediction module focuses on the prediction of the N+N structure. We will refer to the first/left element of compounds of this sort as the modifier, and to the second/right element as the head. This general structure is also valid for Dutch and Swedish.

The Head Prediction Model. Because of the low token frequency of compounds (vs. the high frequency of their components), compound prediction should be performed very conservatively. In our system, the compound prediction module will only be invoked if the user, after selecting a noun, types the backspace character to delete the space automatically inserted after the noun, providing an explicit signal that she intends to construct a compound.

That means, instead of trying to predict whole compounds, we limit ourselves to trying to predict the head of the compound, after the modifier has been identified. Since in this model the modifier is treated as an independent word, n-gram statistics will be collected counting left elements as independent words. In order to predict compound heads, the module will choose the candidate heads with the highest scores for the weighted sum of the following measures:

- Unigram probability of head
- Bigram probability of head in current context
- Tag-based trigram probability of head in current context
- Likelihood of head to occur in a compound
- Probability of the "compound-bigram" based on semantic classes

The measures proposed are based on very general distributional properties of (right-headed) compounds. They should be completely language independent. A more detailed account can be found in [1].

Treatment of Linking Suffixes. In all three languages, a large portion of the N+N compound lemmas contains a linking suffix attached to the modifier. Our analysis showed that most modifier + linking suffix sequences are identical to inflectional forms of the modifier. The only pattern (in all three languages) that does not always correspond to an independently existing inflected form of the modifier are forms ending in the suffix *-s*.

In the head prediction model, modifier + linking suffix sequences identical to inflected forms of the modifier are handled implicitly, modifiers with the linking

suffix *-s* share a very limited number of endings. A study of the relevant patterns in each language leads to reliable heuristics enabling us to predict the distribution of the *s*-linker in a satisfactory way.

Interaction with Other Modules. Predictions produced by the compound prediction module do not compete with predictions from other modules. Once the user invokes the compound prediction module, the module takes control of the output, and proposes completions for the current substring until the user makes a selection.

2.4 Collocation-Based Prediction

The *n*-gram model predicts words on the sole basis of their immediate context. However, long-distance relationships between a word and other words in the text in which it occurs can also be exploited to improve word prediction. In particular, since texts typically have a topic and are semantically coherent, the appearance in a text of a certain (content) word can be a cue that other, semantically related words, are likely to appear soon.

Trigger Pairs. A straightforward way to exploit this fact is the notion of a trigger pair, i.e. a pair of words A and B that are correlated in such way that the occurrence of the trigger word A earlier in a text will affect the probability of the occurrence of the triggered or target word B in the same text [7]. Of course, A and B can, and will often be, the same word (making the notion of recency promotion as used e.g. in [4] a special case of the more general trigger pair idea).

In order to construct trigger pairs, we need a measure of the "textual association strength" between words. Of course, the task of manually comparing all the words in a corpus and determining, for each pair, how "associated" the two members are, is not feasible, and it is also not clear that our association intuitions would be very reliable. Instead, various statistical association measures that can be automatically extracted from training corpora have been proposed and sometimes compared in the NLP literature (see for example [3], [6] and [7]). Most measures are based on the comparison of the number of times that a pair of words co-occur in the training text to the number of times that the two words would be predicted to occur if they were independent events. Clearly, the larger the deviation from this expected value, the more likely it is that the two words are textually correlated. We will first adopt the average mutual information between two words/events as our association strength measure, other measures (such as the ones listed in [5]) will be taken into account in the future.

Using Trigger Pairs During Word Prediction. Each word in the dictionary is associated with a (possibly empty) list of its targets. With each target, the mutual information score of the relevant trigger pair is also stored. At run-time, for each recognised word the list of its targets (with their mutual information /

association strength score) is added to a table. If a target is already in the table, its score will be increased. During prediction, the collocation-based module will provide (additional) candidates (or promote words already in the prediction list) based on the scores of the words in the target table. An extension to stem-based trigger pairs will also be considered. However, in that case the collocation-based module will have to interact with the morphological component and the syntactic module, to make sure that, for each candidate target stem, only inflectional forms that are morpho-syntactically legal are generated.

3 Summary

We have described the language component of FASTY, a system designed to provide efficient Predictive Typing for European languages other than English. Building on standard technology a number of novel solutions have been developed to deal with problems like inflection and compounding. In particular, morphological processing and partial parsing have been integrated with standard statistical prediction, and a model for split-compound prediction has been introduced. The system is currently under development, first results are promising. A fully integrated prototype is to be expected end of 2003.

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Informing Flexible Abbreviation Expansion for Users with Motor Disabilities

Tim Willis¹, Helen Pain¹, Shari Trewin², and Stephen Clark¹

¹ Division of Informatics, University of Edinburgh, 2, Buccleuch Place, Edinburgh EH8 9LW,
UK +44 6504415

{twillis, helen, stephenc}@cogsci.ed.ac.uk
www.cogsci.ed.ac.uk/~twillis

² IBM TJ Watson Research Center, P.O. Box 218,
Yorktown Heights, N.Y. 10598, U.S.A.
trewin@us.ibm.com

Abstract. In this paper we present results and conclusions of an initial study, intended to inform the design of a system to automatically reconstruct full sentences from abbreviated typed text. Such a system will reduce the number of keystrokes that cognitively-unimpaired users with motor disabilities need to input in order to communicate in full, rich language. A number of techniques for abbreviating messages have been identified, based on empirical studies of users. These include vowel deletion, phonetic replacement, and word truncation. How such techniques might be used to support users with motor disabilities is considered and further empirical work proposed.

1 Introduction

Communication for some people with motor disabilities can be tiring and time-consuming. For users of 'standard' QWERTY keyboards, it may be very useful to reduce the number of letters they must type in order to produce a message. Flexible Abbreviation Expansion is one approach. In order to inform the design of a system to automatically reconstruct full sentences from abbreviated typed text, experiments are being run to investigate the techniques which people use to shorten a message. Analysis of the empirical data, it is hoped, will reveal a number of high-level strategies people use to generate abbreviations, and also provide simple counts for the relative frequencies with which these are applied. These strategies will be implemented in an algorithm which can generate and rank candidate full form sentences.

The target user group is primarily users with adult-onset conditions and disabilities, including Motor Neurone Disease, spinal injury, and Muscular Dystrophy, who are literate, very familiar with typing and would prefer not to learn a symbol system, and who desire or need an alternative to speech recognition.

The next section considers some existing related systems, and the abbreviation strategies people use. Section 3 describes the preliminary experiments designed to

elicit such strategies, and section 4 gives some results and analysis. Section 5 offers some conclusions and describes how we plan to build upon these experiments.

2 Background

There are a number of Augmentative and Alternative Communication (AAC) systems which will expand an input of a few letters or symbols into anything from basic greetings and expressions of need [1], through to fully-formed essays on any topic.

2.1 Word Prediction

‘Word Prediction’ systems allow the user to input a few words or letters, and be offered best guesses as to the intended ‘full form’ of the utterance. At the letter level, *I like fo* might trigger an offer of the noun phrases ‘*food*’, ‘*football*’, ‘*foreign travel*’ etc., ideally based upon a well-informed background knowledge of the user. At the word / morpheme level, *I go town PAST* might generate an offered full form of ‘*I went into the town yesterday*’ [2], [3].

This process is limited by its requirement for constant feedback, and at the start of a sentence there is little information from which to guess what is coming. Strategies include the use of syntactic, semantic, case, and selectional constraints, for instance used in the COMPANSION system [4],[5],[6],[7].

2.2 Abbreviation Expansion

One way of reducing the number of keypresses needed to generate a message is to take an abbreviation and expand it automatically. So an input of *Jn wk scl yr dy* might expand to *John walked to school yesterday*.

‘Flexible’ abbreviation expansion systems do not require the user to memorise a fixed set of abbreviations, and allow them to invent new forms spontaneously, as there is no longer a one-to-one correspondence between an abbreviation and a full form. The system itself interprets them, in the context of a sentence, and may offer alternative interpretations where it cannot resolve the ambiguity.

SMS (Short Message Service) text usage via mobile phones has exploded in the UK in the last two or three years. Some very basic word prediction is available, but the task is still quite laborious on most phones as a primarily numeric keypad means some letters take 3 or 4 repeated presses to obtain. This, combined with a limit of 160 characters per message, has led to a number of abbreviation conventions, many of them originally used on the internet, which has similarly exploded in use in less than a decade. Techniques include standardised abbreviations for words or phrases (e.g. ASAP – “as soon as possible”), omission of words – usually function ones, phonetic replace-

ment (U for ‘you’), and a generally fragmentary nature to utterances. These techniques have also been observed in this study.

2.3 Abbreviation Strategies

We hypothesise that if ambiguity can be sufficiently resolved by automatic means, the physical and cognitive effort required from the user will be less than for both word prediction and fixed abbreviation schemes. A clearer understanding of how people abbreviate may reduce such ambiguity. The following example demonstrates some ways in which an abbreviated string might be expanded.

	<i>I</i>	<i>wt</i>	<i>2</i>	<i>c</i>	<i>th</i>	<i>nw</i>	<i>fm</i>	
=>	[1]	I	want	to	collect	the	new	film
	[2]	I	went	to	see	the	new	film
	[3]	I	want	to	contact	the	new	firm ...

The intention of this research is to identify the techniques which users use to abbreviate, and to reverse-engineer the processes which have produced the input sequence of reduced forms. By obtaining the relative probabilities for each technique, it is hoped that candidate original forms for each abbreviated word might be accurately ranked.

Some of the questions addressed in this study were: Are some letters, or classes of letters, deleted more frequently than others? What are the contexts in which such deletions take place? What are common types of substitutions? What kind of information is used in choosing abbreviations, e.g. phonetic information? Syntactic information? Other types? What role does the initial length of the word play?

3 Experiments

An initial experiment was run on 10 able-bodied, frequent computer users, around 18-25 years old, educated to at least university entrance level. A small number of users with physical disabilities in the target user group were available, but not drawn upon, so as not to over-use them. It was assumed that the target users had at a previous time been very similar to the subjects, in their computer usage.

3.1 Materials

Four texts were created, each of 500 letters. There were no numbers (digits). Two unrelated topics were written about: learning to ski (texts S1 and S2) and Loughborough, a university town in the English Midlands (texts L1 and L2). Subjects were given one text to abbreviate, and another to reconstruct. As far as possible the text to reconstruct was from another subject, and a different topic to the text to be abbreviated, so that they would not become acclimatised to the vocabulary.

For each topic, both a grammatically ‘simple’ (L2 and S2) and ‘complex’ (S1 and L1) form was written, so it could be determined whether syntactic complexity had an effect on how it was abbreviated. The ‘complex’ forms were unrestricted in use of subordinate clauses, co-ordination, and the location of adverbial phrases.

The ‘simple’ texts as far as possible contained only active, declarative, single-clause sentences. All adjuncts occurred after the verb. The intention was to convey the same information in both versions, which necessitated an occasional infinitive clause or gerund.

All four texts were fairly formal, and were written by the first author, who was also the experimenter. No external confirmation of complexity was carried out.

3.2 Procedure

Subjects were randomly allocated one of the four 500-letter texts, and asked to perform four abbreviation tasks on it, followed by a reconstruction task.

The subjects were given the following imaginary scenario: that they needed to send their text down an expensive telegraph line, such that the person at the other end would be able to reconstruct it accurately. Each letter they omit would save money, whilst spaces and punctuation would be free. There would be a heavy charge, equivalent to ten letters’ saving, however, for any words that were either missing, or incorrectly reconstructed at the other end.

Subjects were asked to progressively delete letters, as follows: In their first task, down to 300; in their second, to 260; in the third, to the absolute minimum number of letters, which they thought would be intelligible to another person; and in the fourth to the minimum number of letters which, the subject judged, would allow him- or herself to reconstruct the text at some distant time.

Their final task was to try and recreate either a different text that had been abbreviated by another subject, or their own¹. Either way, the shortened text was from the third task. For each of the first four tasks, the subject could see a full, untouched version of the text for reference. Subjects were given the following rules: They may delete individual letters, and replace one or more letters with others (upper or lower case) or with numbers. Non alpha-numeric characters were not allowed. They could delete an entire word, if they were sure it could be reinserted by a reader, and were asked not just to paraphrase. They were given the example shown in Fig. 1:

Subjects were asked to fill in a ‘notes’ document as they progressed, in which they would outline the techniques they used, and their order, with an indication of the time

¹ It was intended that subjects would reconstruct each other’s texts, and to explore whether subjects had more difficulty with unrelated texts, but this proved difficult to arrange, so that half used their own task three texts, with a delay of at least an hour. Of the three subjects whose Task 5 texts were significantly shorter than the originals (missing over 5% of letters), 2 had worked on unrelated text, and the third had worked on their own abbreviations.

<i>I</i>	<i>will</i>	<i>see</i>	<i>you</i>	<i>later</i>	might become
<i>I</i>	<i>wil</i>	<i>C</i>	<i>U</i>	<i>l8r</i>	
●	<i>losing an 'l' from 'will'</i>				
●	replacing 'see' with 'C', and 'you' with 'U'				
●	replacing the middle three letters of 'later' with an '8' because it sounds similar.				
The number of letters has been reduced from 16 to 9.					

Fig. 1. The example abbreviation given to subjects

taken per task. They were asked for an indication of their use of SMS texting on a scale 1-10.

4 Results and Analysis

Most of the subjects deviated from their instructions to some extent, but useful information could still be extracted. Despite being asked to abbreviate in such a way that it would be possible for another person to reconstruct the text 100% faithfully, several subjects paraphrased whole phrases they felt were comparatively superfluous, which made reconstruction very difficult.

Each original word in the text was considered along with its phonetic form and the forms generated or untouched by that subject in each of the four tasks. Each form was compared with the input to see what letters had been deleted, added and substituted, and the possible intended phonetic representations used in each case were noted. Also any other hypothesis in relation to the particular form was noted (e.g. use of a digit to replace a phoneme). Context information was also noted (e.g. word initial v. word final replacements; vowels v. consonants; word length, function word v. content word).

A set of rules were developed, and where two or more could be said to apply, the one judged to be more specific was noted. Techniques were considered both for each participant across all words, and for each word across all participants. Table 1 gives a number of the rules we elicited from the data.

Non-standard deletions and replacements, which could not easily be assigned to a rule were also recorded as such. Particularly useful examples were highlighted where only one of two possible rules was used, and the other was not, despite being still an option. One such was the word 'shopping', which was treated in a variety of ways, listed in Table 2.

Table 1. Some of the rules elicited

Deletion rule	Context	Example
e → ∅	where it is 'magic 'e''	make → mak
e → ∅	final morpheme, either directly preceding or directly following 'r'	centre → centr
double letter → single	anywhere	tall → tal
g → ∅	after 'in', i.e. a gerund 'ing' becoming 'in'.	skiing → skiin
ing → ∅	deletion of whole gerund morpheme	skiing → ski
final x of y letters → ∅	word final	distance → dist
any letter → ∅	where it is phonetically silent	cupboard → cu-board
vowel → ∅	no other rule already applying	tip → tp
ə] → ∅ (vowel deletion)	unstressed vowel (Phon.)	simile → simle
Substitution rule	Context	Example
ch / qu → k	anywhere it is phonetically a [k]	technique → teknike
er / re → a	word-final	scorcher → scorcha
ce → s	anywhere it is phonetically an [s]	face → fas
ph → f	anywhere it is phonetically [f], i.e. not overlapping syllable boundaries in e.g. 'haphazard'	phone → fone
letters → digit	anywhere phonetically similar	won → 1

Table 2. Abbreviation forms produced by six subjects for the word 'shopping'

Subject	Task 1	Task 2	Task 3	Task 4
D	shpng	shpn	shpn	shpn
E	shoping	shop	shop	shop
P	shop	shp	shp	shp
A	shopping	shop	shppng	[MISSING]
F	shpin	shpn	shpn	spn
M	shop	shop	shop	shop

1. Subject D first used double-to-single-letter, plus deletion of all vowels. This was followed by deletion of 'g' of 'ing', even though the full 'ing' was no longer there.
2. Subject E first used double-to-single-letter, then deleted 'ing'. This can be seen either as end-of-word-deletion, or hypothesised as a more specialised rule whereby the gerund morpheme is deleted. 'ing-deletion' was used by a number of subjects for different words.

3. Subject P used double-to-single-letter, and ing-deletion, followed by vowel-deletion.
4. Subject A left the word intact for task 1, then used double-to-single-letter, and ing-deletion for task 2. In the only instance of reinsertion with this word, the subject added 'png', for task 3. This last form is lacking only the vowels.
5. Subject F used double-to-single-letter, deleted the first vowel, and used ing-to-in. This was followed with deletion of the remaining vowel. In task 4 the 'h' is deleted, which of the four letters is arguably the least important phonetically, though it does modify the 's'.
6. Subject M (the only non-native speaker) used double-to-single-letter, and ing-deletion.

Four of the six subjects kept the same form for tasks 2 to 4. All subjects preserved the letters 'spn' throughout, and 'h' was only dropped once. The most popular early technique was double-to-single-letter (5 out of 6). 4 out of 6 keep some vestige of the 'ing' in task 1, and a similar number the first vowel.

Overall, in Task 3, both versions of the skiing text, and the informal version of the other text (L2) were reduced to an average of 270 characters (55% of the original text). However, the formal text L2 was reduced to an average of about 310 words (62%), which at least somewhat supported the hypothesis that text with more syntactic complexity would prove harder to abbreviate.

5 Conclusions and Further Experiments

We have drawn the following conclusions:

1. Vowels are deleted far more readily than consonants.
2. Letters at the beginning of words are much more keenly preserved than in the middle and end. The first letter is always preserved unless there is a phonetically influential 2nd letter (e.g. 'eNjoy', 'eXist'), when it is very likely to be deleted.
3. People will happily truncate words, reducing a word by up to half whilst preserving the front.
4. Phonetic shorthands are used readily. For instance, 4 out of 6 subjects replaced 'ch' in 'technical' with a k.
5. Users are idiosyncratic and generally consistent in their preferences for rule weightings (what order they are likely to choose rules in) so there is clearly great potential for adapting an expansion system to individuals.

Our pilot study established the presence of several commonly used abbreviation techniques. For a particular word, several of these techniques may apply, and the application of one may affect the applicability of others.

At present, there is only patchy indication (from some participants' notes files) of which letters were easily discarded within the first 40% pass (etc.), and which only reluctantly and in the very last few letters of the chunk. In order to assess whether one word is a more likely expansion than another for a given abbreviation, more detailed information about the priorities given to the observed techniques is needed. Future experiments will investigate the relative importance of the observed 'rules' by requir-

ing participants to make three passes over a set of words. At each pass, the task is to make abbreviations that are:

- 1) Natural: the abbreviation is considered to be obvious
- 2) Short: the abbreviation is a significant reduction in the word size
- 3) Minimal: the shortest possible abbreviation considered comprehensible

Context will play a role in participants' decisions, both at the letter-level, and the word level (syntactic and semantic). The latter will be investigated by presenting the candidate words both with and without a full sentence context.

We hope to obtain relative frequencies of rule applications in the next experiments, which can be used as part of a probabilistic component in an automatic abbreviation expansion system.

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The IPA (International Phonetic Alphabet) font used in this paper was obtained from the following archive at Oxford University:-

<http://info.ox.ac.uk/departments/humanities/chcdown.html>

Cyclic Input of Characters through a Single Button Manipulation

Grigori Evreinov and Roope Raisamo

TAUCHI Computer-Human Interaction Unit
Department of Computer and Information Sciences
FIN-33014 University of Tampere, Finland
+358 3 215 8549
{grse, rr}@cs.uta.fi

Abstract. An alternative text-input method is considered as a model for a menu selection task through manipulation by a single button. A traditional seven-segment display element was used as a layout for symbol input and imaging. Each of the segments was lighted in a temporal sequence and the writer could choose the segment by pressing a button. Instead of the button any switch or similar signal may be used, as well as visual imaging may be substituted by sounds. When all segments have been cycled, the result was interpreted as a character according to a set of rules and depending on the character set used. A physically impaired person to control a computer or other electronic device could use the method. The rationale for the design and the results of a preliminary evaluation are presented.

1 Introduction

User performance in different types of interfaces depends on the speed on which the user can act, i.e. can change the orientation of his body parts or some physiological parameter. These parameters may be detected through an input device, signals of which will lead to changing of the state of information space or data within some imaging field. However, productivity of human-computer interface will depend on not only the resolution of the worse component in the feedback loop, but on the congruence degree of user actions and the way of presenting the feedback cues.

Menu pointing or text-input, could be considered as temporal processes or stimulus-dependent goal-directed behavior of the user (Fig. 1). If we can formalize this process, we can design a simple and efficient model of user behavior and of his interaction with some device. Based on our experience on the amount of modes of watches or radio tuning, the task is not so difficult if the user has no physical barriers and the set of controlled functions of the device is less than 10.

A large amount of switches has been used as input devices designed to be activated by the movement of almost any part of the body [1-3]. A person with only one or two reliably controllable movements is limited not only by the range of single or dual input devices, but by the technique by which he may manipulate the entities of

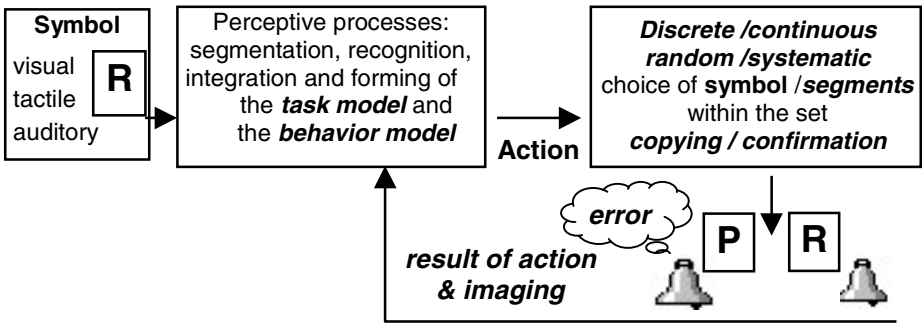


Fig. 1. The forming of behavior model during text-input task

program environment or surroundings. For the pointing tasks within menu as well as text-input the same methods may be applied. Therefore, text-input is universal checking of efficiency of diverse models of user behavior in the control of a large amount of entities. Herewith, a behavior model must take into account both a particular sequence of actions, mental features, physiological reactions and physiological restrictions of the user.

Changing a signal as a result of pressing down the button occurs after presentation of the test symbol or an appearance of some marker on desirable menu item as a rule through 150-250 ms. That is a normal time of simple visual-motor control task in accomplishing with the help of intact muscles of the finger. The time is progressively increased up to 1000 ms and more, if an additional semantic analysis takes place or the subject has physiological restrictions. Assume the user can manipulate only a single button, digital switch or a functionally similar element. What strategy of behavior is optimal depends on the opportunities of the user and in considerable degree from the dialogue structure. For example, digital switch with two or three steady states is used for text-input via Morse code. The main lack of Morse code is that it is exceptionally based on the temporal pattern of the input of characters. To reduce a temporal dependence of each component of the token from operator opportunities, code elements are constructively divided, i.e., one position of the switch corresponds the dot, another the dash. But the character or its segments cannot aright be displayed or interpreted if the sequence of dots and dashes is not completed or interrupted.

There is another approach and its variants: the use of a cyclic temporal sequence of symbols presentation and confirmation by pressing down the button when the right symbol appeared [5]. However, if each symbol has exposition about 500 ms, a cyclic sequence contains 26 symbols and operator has made error, he should wait 13 s for the next appearance of the same symbol. Of course, the subject could control cyclic sequence directly, similar to the tabulation principle and using overlapping time to select a necessary point. Then he should repeat tracking of all positions, as a reverse mode requires an additional action needed to switch a function.

The task model and the behavior model could be essentially simplified if in each moment of the time and actions the user will receive feedback cues, which are relevant to the initial spatial model of test symbol, but not to the temporal pattern. To reduce cognitive loads, the interaction strategy and imaging must be complementary

[4]. Obviously, that the feedback signals must accompany such processes as segmentation and integration not only during recognition of the test symbol but in the mode of its creation.

2 Method Design

A traditional seven-segment display element was used as the layout for symbol input and imaging (Fig. 2). Each of the segments was lighted during a definite time (T_1 - T_7) in a temporal sequence and the writer could choose the segment by pressing a button. Instead of the button any switch or similar signal could be used, as well as visual imaging could be substituted by sounds.

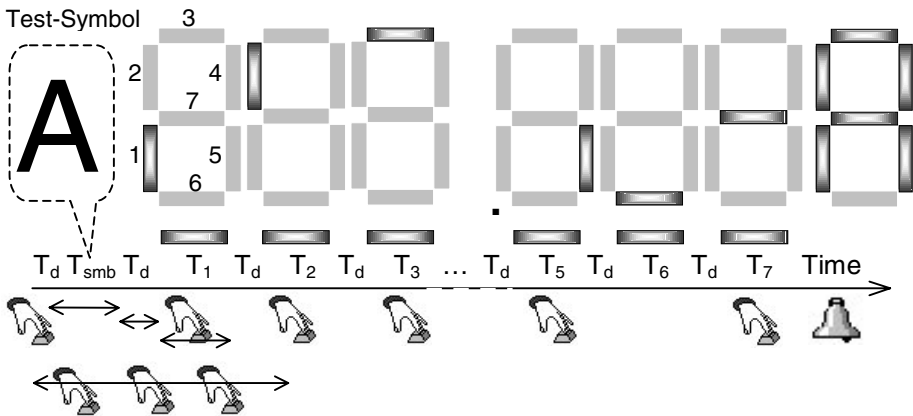


Fig. 2. Algorithm of user behavior during the text-input task through manipulation by a single button

T_d – delay of segment exposition; T_{smb} – test symbol exposition

T_1 - T_7 - segment exposition. Triple-clicks after start is a backspace mode

When all segments have been cycled, the result was interpreted as a character according to a set of rules and depending on the character set used (roman). As shown in Fig. 2, before the input of each character there is a start click and a definite period of exposition delay of each segment (T_d). This time may be constant and depends on individual features of the user.

But this one is necessary, especially in the case in which it is supposed to use sonification of the segment. A small delay of segment exposition decreases the stress or fear of the person: to not see the beginning of the lighting of the next segment in the moment when he presses the button to confirm using of the previous segment.

We designed this method for handicapped persons, but before real application, we tried different modes in a pilot experiment to know more about the situation and the opportunity to make a definite sequence of solutions and actions evoked and synchronized by external source. There are two modes of temporal structure the text-input task through manipulation by a single button. In the first mode a fixed window of the time is used. That is, independently of the moment of the button pressing, the

lighting or sonification of each segment occurs during a definite time, for example 500 ms. Thus, duration of the cycle is constant, 3500 ms, while this approach allows selecting any symbol of alphabet without any tension. The second mode provided stopping of segment exposition after the button was pressed down and the lighting or sonification of the next segment after a small delay.

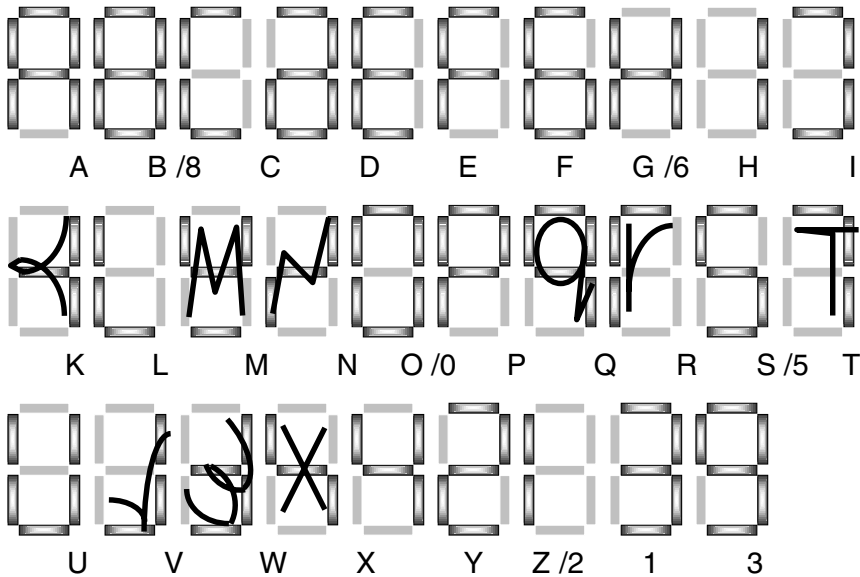


Fig. 3. Cyclic synthesis of alphabet tokens and numerals

The duration of the cycle in this case depends on the speed on which the user can act, i.e., to predict pressing down the button in the next moment. In any case, before the start-click, the user must imagine a layout of desired character and accomplish a sequence of pressings in own rhythm or in a definite speed.

What to do if the user has made a wrong action? There are two kinds of errors: a combination of confirmed segments has not a corresponding character in a basic set, or the character is not desirable. In the first case the segment combination may be ignored. The second case requires of an opportunity to delete undesirable characters or words. To provide a backspace we used the next algorithm, which may work both with a fixed duration of segments lighting and in accelerated mode with stopping of segments lighting after pressing down the button. Each time after the first click we launch a special temporal window, duration of which is about $\frac{3}{4}$ of segment exposition. If during this period the user generated three clicks a backspace will be activated. This duration as well as segment exposition depends on individual features of the user and is stored at tuning of interface.

The seven-segment display element allows imaging 128 diverse combinations of lighted and dark segments. But only 16 uppercase characters and 10 numerals coincide with conventional imaging, herewith, most of numerals have the same graphics as alphabet tokens. We tried to synthesize some characters by using simple

graphic analogies of handwriting and lowercase characters imaging. Thus, we received 29 test symbols presented in Fig. 3.

3 Test Design and Results of Pilot Evaluation

To evaluate the features of the proposed cyclic input a special test program was written in Microsoft Visual Basic 6.0. Snapshot of the program with opened frame of the tools is shown in Fig. 4. This frame was hidden during testing. The space key of a conventional keyboard was used as the digital button (Fig. 2).

The visual-motor control task consists of an exposition during 500 ms of test symbol, which appears after the first pressing down of the button near the layout of the seven-segment indicator, and recording of the input time of the seven-segment equivalent. A backspace mode was not used and incorrect symbols were substituted by special sign “#”.

The cyclic input of the characters was evaluated with the help of able-bodied subjects (of students and employees). Each of them implemented 21 trials during a week. In each trial 29 test symbols were presented. As learning for novices we used a fixed duration of segment lighting. At testing, the mode with breaking of segments lighting was used only. During exposition of the test symbol signals of keyboard were blocked. Because delay duration was constant (100 ms before each segment), we recorded only the time from the moment of segment lighting up to the first signal of the button. The time of exposition of each segment was set as 500 ms. The results were recorded into a table and stored together with comments.

Besides visual imaging of the test symbol, we used a simple way of sonification of characters using previously recorded wave files formed via FlexVoice 2 text-to-speech engine [7]. Meantime, we tried sonification of segments with the help of MIDI synthesizer to provide a method of the input of characters for the blind. This method requires special testing and we suppose to investigate it later.

Fig. 5 shows average values and dispersion of reaction times of three subjects in 21 sessions. As you can see, while dispersion value is within duration of simple visual-motor reaction, the average time varies significantly in dependence on test symbol. Naturally, it was supposed that the time would be defined by an amount of segments, which are necessary to form the character. However, the maximal amount of segments (7) requires a minimal time and vice versa, two segments of “1” and “I” symbols require practically the full time of a cycle.

We analysed the process of input for each symbol and found out that making decision brings an essential component into the duration of user manipulation. In Fig. 5 test symbols are grouped according to the amount of using segments. Besides that, the sequence of each group is begun from more easily typed characters up to the more difficult ones. The main difficulty is that the typing process should be continuously supervised. During the complete cycle the user is waiting for the activation of segments, comparing imaging with a prospective model and is restraining or launching an action. The balance of excitation-inhibition is a very difficult process that may later restrict applications of this method. We also noted that rhythmic groups

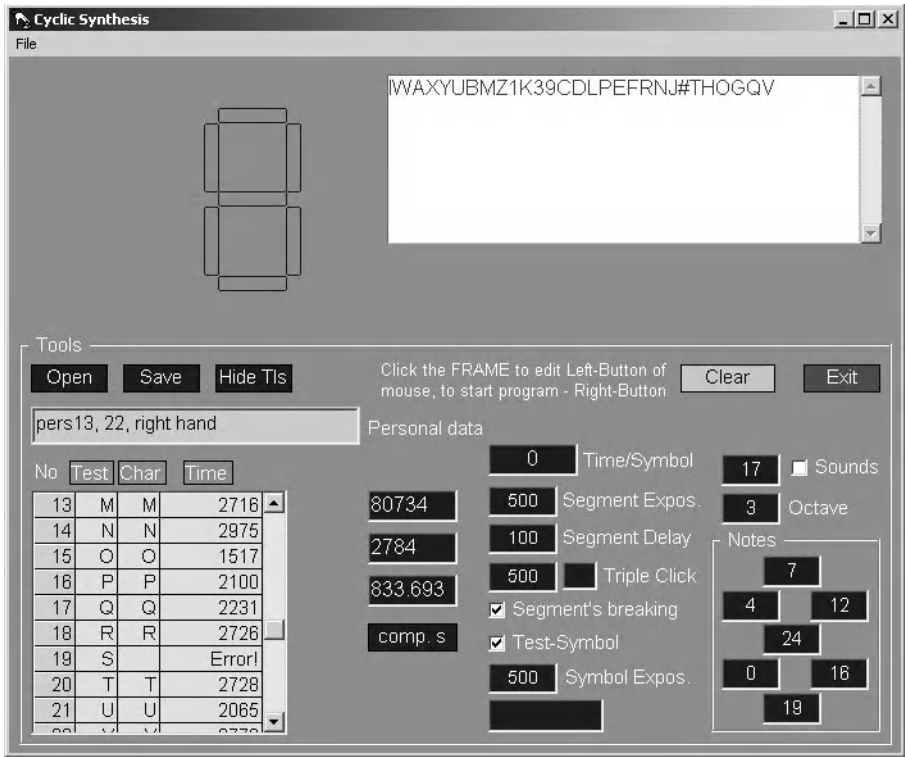


Fig. 4. Snapshot of the program with opened frame of the tools

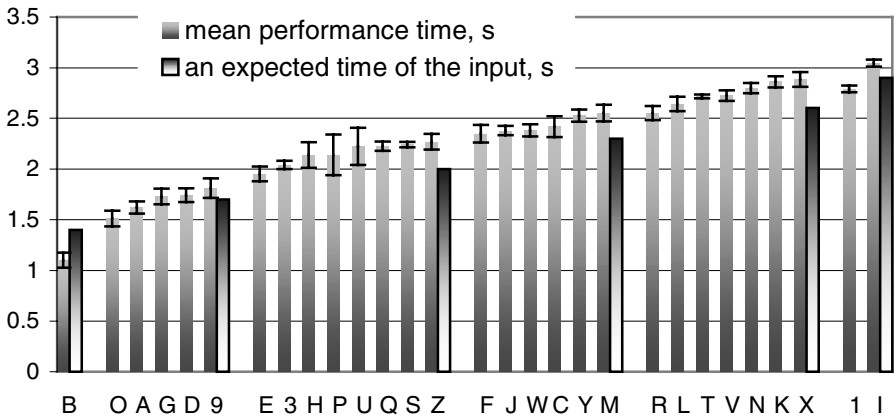


Fig. 5. The typing difficulty in dependence on an amount and position of symbol's segments; three subjects in 21 sessions

including 2 or 3 segments (Fig. 3) facilitate the input of characters. If sequential pressing down the button is carried out from some segment up to the end of the input, i.e., it is not necessary stop and to miss a segment, typing occurs more easily and quickly (symbols B, D, 9, 3). Finally, the first segment is the most difficult, at least, during the test. Even if the user had experience he could not predict what next symbol will be presented. Therefore during the 500 ms presentation of the test symbol he should imagine, what segments are needed, and obviously the cognitive model does not always coincide with the proposed one, at least in a sequence of playback.

In general, changing of a sequence of playback is possible, if we could to predict what the next symbol the user is going to type. But during this test all symbols are launched from the first segment. The average typing performance, with able-bodied subjects, was within a range 1100-3046 ms plus 100×7 ms – delays before each segment, and dispersion was 148-73 ms accordingly, herewith an average percent of error was 12.83%.

4 Future Investigation

In the case of single button manipulation we have a temporal sequence of clicks. Components of the temporal pattern may be equal or not. To manipulate through a temporal pattern it is necessary not only a high accuracy and repeatability of manipulations, but a good perception of the rhythm. For many disabled people this task is very difficult. Therefore, a simple spatial layout could decode the state of a process or simplify perception, facilitating navigation through sequence of actions [4]. Another application of graphic layout is to present a sequential input through a tactile array for blind people.

The proposed alternative text input method is easy to learn. In further usability tests it is necessary to evaluate the sonification method and to optimize the individual sound layouts (sound chords and different harmonic sequences). Instead of the button we could also try using voluntary activation of with a facial muscle, like the muscle that knits and lowers the brows [6], as well as eye blinks.

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Developing of Predictive Communication System for the Physically Disabled People

Vidas Lauruska¹ and Tomas Musteikis²

¹Siauliai University, Faculty of Technology, 141 Vilniaus Str., LT-5400, Siauliai, Lithuania,
vidas.lauruska@tf.su.lt

²Kaunas University of Technology, Faculty of Telecommunications and Electronics,
50 Studentu Str., LT- 3028, Kaunas, Lithuania
t.musteikis@tf.su.lt

Abstract. People with impaired mobility, the blind, who have speech difficulties, or who find difficulty in hearing, can become isolated because obtaining information for them from surroundings sometimes is narrow or impossible. It's possible to improve communication possibilities by providing person with appropriate technological help. We have created predictive communication system for physically disabled persons with speech and language impairments. A very important feature of this communication system is that the program is controlled by one on/off switch. Instead of this switch other alternative input devices, such as head pointer, eye blink registrar, person's capacity registrar, suck-blow tube, etc, can be used. Also we are working on computer system, the idea of which is to connect all the house equipment into common control communication network.

1 Introduction

One of the most important things in our life is the ability to communicate with each other. We communicate through media, body movement, speech, written and typed letters, an of course through computers, electronic mail and computer processed data. The speech is most important but, if person lacks the ability to speak or move, help is available with some forms of devices, which allow, for example, to write messages, letters etc. Many people who lack speech, however, also lack the necessary body control to operate such devices efficiently. Whatever the misfortune is the effect of communication disability is similar: the person becomes isolated and unable to express his thoughts, emotions, and needs.

Electronics and information technology can greatly improve the quality of life for people with disabilities and play major role in the field of augmentative and alternative communication. There is only one way to solve the problem - create equipment that would let them to communicate and control environment.

Computer access for severely physically impaired people usually is related with degree of motor capabilities and it is important to choose the suitable input device and related selection method to fit residual abilities of any user. A person who may have only one or two reliably controlled physical movements can choose from a wide range of single input devices [1].

Computer communication system must accomplish two main user's requirements: the system should be simple to operate and entirely controllable through one single switch; it should support simple communication and control mode.

In spite of extremely fast development of the technology in Lithuania the offer addressed to persons with severe motor disability who cannot use the standard computer equipment is still very limited. We need both: special hardware as well as computer programs enabling to change the options so that quick access to the computer recourses would let to individualize the users taking into account intellectual and motor possibilities of the disabled. The software that meets requirements of non-speaking persons with severe motor disability has not been accessible on the Lithuanian market so far.

2 Methods

The system consists of three major parts (Fig. 1): a PC with a networking adapter (either a modem or a LAN card), a switch-type interface adapter and special software. The system does not require a powerful computer, so even relatively old models can be used. The networking adapter is required for the computer's connection to the Internet. The software is based on element scanning and switch-type input [2]. This means, that elements on the screen (such as virtual keyboard buttons, as well as function buttons) are selected in turn, then waiting for the action of the user for the predefined time period. For the input a switch-type device is used, which is most suitable for the particular disability. The software allows three communication means: text files, email messages and SMS messages. Thus users can create and edit text files, read and write email messages and SMS messages to mobile phones. The software allows easy adaptation to different languages and different levels of disability.

The switch-type interface adapter is a box that is connected to the PC's parallel port. It allows any kind of switch to be connected (e.g. eye blink registrar, blow switch).

3 Results

We have created predictive computer communication system for physically disabled people in Lithuania [2]. The program was created on MS/DOS platform and in initial stage have 128 Lithuanian words prediction database.

Special feature of communication system is that the disabled person can control program by one on/off switch. This system was used with such alternative input devices: simple switch, mouse switch, head pointer, function key "ENTER" from standard PC keyboard, eye blink registrar and person's capacity registrar. So the individuals with disabilities can choose a necessary input device.

Now we are developing software and a word prediction system, which will help the disabled in an easy way to write sentences. We modify the communication program

for Windows 9X/ME/XP platforms and try to construct databases containing Lithuanian language elements. Also we are working on implementation and adaptation of software components for the analysis of the database text body. In initial stage the created 128 words database is too small for individuals with poor language skills. Database must be minimum 1000 words for people with poor language skills and about 5000 words with rich language skills [3]. So we are trying to develop language element databases co-operating with Lithuanian language specialists and therapists.

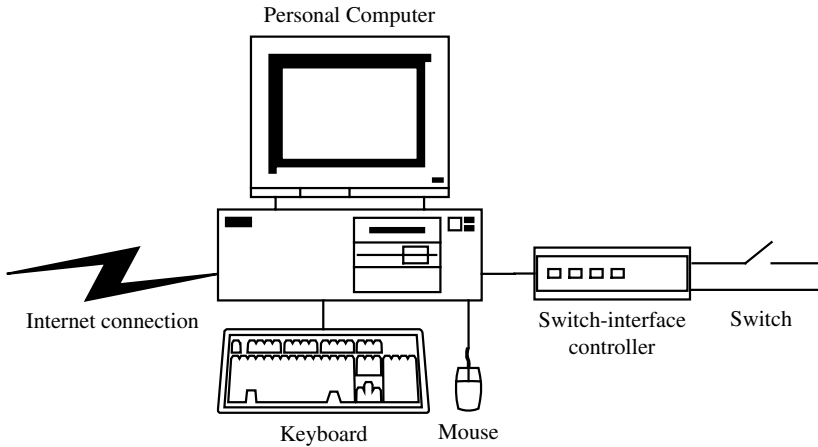


Fig. 1. The block diagram of system



Fig. 2. Patient T.S. is working with system

Nowadays computers have possibilities to integrate control over a range of functions, including communication, environmental control and mobility, within one system. So we are also working on the combination of communication and control modes in one system [3].

4 Conclusion

It is possible to reduce communication impairment by providing a person with appropriate technological help.

During text entry a predictive system is one of the function which facilitates key savings. So the created software with enlarged database can increase the speed of text writing for individuals with disabilities in Lithuania.

Software of this type can support the educational process in the field of the general development, also can build and improve the ability to communicate with other people and it can be aid in learning to read and write.

Earlier it was necessary to have different devices and different switches or other inputs for each activity. Nowadays computers are universal systems for individuals with physical and sensory disabilities that need aids to help them communicate and control external devices more effectively.

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Teaching Adolescents with Disabilities to Learn Chinese Keyboarding by Using Multimedia Computer Assisted Input Method Learning System

Ming-Chung Chen¹, Hwa-Pey Wang², and Tien-Yu Li²

¹ Department of Special Education, National Chiayi University, 300, Shiuefu Rd., Chiayi, 600 Taiwan, R. O. C.
ming@chen.twmail.cc

² National Taiwan Normal University, 162, Heping East Rd., Sec. 1, 106 Taipei, R.O.C.
hpwang@icon.ntnu.edu.tw
tienyu@ice.ntnu.edu.tw

Abstract. The purposes of this study were to design a multimedia computer assisted input method learning system (McAIML system) and to explore its effectiveness. The McAIML system included three parts; they were roots learning system, assisted learning keyboard, and roots assembling learning system. Three adolescents with physical or cognitive disabilities participated the instruction experiment that designed based on multiple probe single subject design. All these three participants could learn the basic assembling rules of the Da-Yi keyboarding method after the instruction.

1 Introduction

Although it is very important for the peoples with disabilities to learn more effectively by means of computer information technology in the information age, in fact, they could not operate the computer input system due to their physical or cognitive impairment. As we know that there are so many kinds of alternative keyboard available for them in the Western. But the peoples could not type a Chinese character by providing them the alternative keyboard only, due to the Chinese input method adopts phonic of pattern assembling system instead of the spelling keyboarding system using in Western.

In the previous project, the researchers have designed an alternative keyboard for peoples with physical or cognitive impairment; and the alternative keyboard worked more effectively than the QWERTY keyboard in the usability evaluation [1]. In order to teach these peoples to learn a specific keyboarding method, researchers adopted multimedia approach to design a multimedia computer assisted input method learning system (McAIML system) and examined its effectiveness.

Since there are so many input methods used in traditional Chinese computer keyboarding system, researchers chose Da-Yi input method that used most usually in Taiwan to develop the McAIML system.

2 Description of the McAIML System

Researchers developed the McAIML System to help the peoples with disabilities who could not use QWERTY keyboard to learn a specific keyboarding method. The system included three parts, they are Chinese Da-Yi roots learning system that was used to teach the learner to be familiar with the important roots; Di-yi roots assembling learning system, including 120 typical Chinese characters which were selected depended on the result of Chinese structure analysis from 1000 common words, that was used to train the learners to learn the principles of Da-Yi roots assembling; and an assisted learning keyboard that was accommodated from the alternative keyboard designed by the researchers [1] by added the other important roots sorted in roots learning system on each key.

3 Methodology of Experiment

Since the group of target users was small and various, researchers adopted multiple probe single subject design to exam the effectiveness of the McAIML system instead of group design. Three adolescents with disabilities, one is with cerebral palsy (subject A), one is with moderate mental retardation(subject B), and the other is with cerebral palsy combined mental retardation(subject C), participated in the study. All this three adolescents studied in the special education schools in Taiwan. They used assisted learning keyboard as interface to learn the basic Da-Yi roots at first, and then they learned the rules of Da-Yi input method by the assembling learning system.

4 Result

Three subjects learned the principles of roots assembling step by step under the McAIML system's guide. All of them could disassemble the roots of the 120 typical words correctly and maintain the performance after the instruction period. In the generalization test, the percentage of accuracy was from 82% to 92%. On the other hand, the speed of keyboarding himproved too. Subject B and subject C could not type a word before, and they could type 7.7 and 6.7 Chinese characters per minute after experiment. For subject A, she could type 10.2 Chinese characters per minute instead of 2 characters by QWERTY keyboard before.

Based on the result indicated above, we believe that the McAIML system could assist the people with disabilities to learn a specific Chinese keyboarding method.

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Accelerating Assessment with Self-Optimizing Devices

Shari Trewin¹, Patti Slobogin², and M.G. Power²

¹ IBM T.J.Watson Research Center, P.O. Box 704, Yorktown, NY 10598, USA
trewin@us.ibm.com

² Lower Hudson Valley Regional Technology Center, Westchester Institute for Human Development, 443 Cedarwood Hall, Valhalla, NY 10595

Abstract. Self-optimizing devices are able to adapt themselves to meet their user's needs. This paper presents the Keyboard Optimizer, a self-optimizer for keyboards, and examines its potential within the professional assessment process. The Keyboard Optimizer allows individuals who have difficulty keyboarding to demonstrate their typing, and then offers appropriate operating system configuration settings that could improve keyboarding accuracy. Initial trials in a professional assessment setting suggest that The Keyboard Optimizer could play a useful role in assessment by accelerating the process of evaluating the match between a user and a keyboard. Users themselves liked having adjustments chosen automatically, and found the interface easy to use.

1 Introduction

Evaluating the match between a user and a computer input device requires analysis and adjustment of many interrelated variables, including the position and orientation of the device, the need for physical control enhancers such as mouth sticks, and the available configuration options of the device itself ([2], [4]). Clearly, the time available for configuration of each device is limited. Yet device configuration can have a significant effect on the speed and accuracy with which a device can be used ([1], [5], [7]).

Configuring control devices can be difficult and time consuming. One approach is to present users with an initial questionnaire about interaction needs and preferences, as exemplified by the Microsoft Accessibility Wizard, and the AVANTI project ([6]). However, question-based approaches assume that users already know what configuration options they require and can choose values for those options. This information may not be known until a user has tried the device and the configuration options it offers.

In an assessment session, an individual may be trying several devices, each in a number of different positions, with different control enhancers. The configuration may need to be adjusted for each change. One promising way to achieve this without a significant investment of time and effort is to have the devices optimize themselves.

2 Self-Optimizing Keyboards

An *optimizer* is a software program capable of inferring and implementing an appropriate configuration for a computer input device, based on a sample of a user's actions with that device. A device together with an appropriate optimizer constitutes a *self-optimizing device*. The Keyboard Optimizer is a program that turns a keyboard into a self-optimizing device.

The Keyboard Optimizer is intended to support individuals who wish to use a keyboard but who have mild to moderate physical disabilities that negatively impact on the accuracy of their keyboarding. This might include individuals who have tremors or have difficulty releasing keys, resulting in unwanted repetitions of keystrokes; individuals who have fine motor coordination difficulties and end up hitting adjacent keys in error; or individuals who cannot easily depress two keys simultaneously. Typical typing difficulties for such individuals are discussed in detail elsewhere ([8]).

The program controls the keyboard accessibility filters available in modern operating systems ([3]). For example, it might slow down the key repeat rate or introduce a key acceptance delay. It is applicable to any kind of keyboard that provides keystrokes to the operating system in a conventional way. Appropriate settings for these options can reduce or eliminate many kinds of typing error ([1], [5], [7]).

The Keyboard Optimizer operates by recording the characters pressed and combining this information with knowledge of the keyboard layout, statistics describing the probability of particular character combinations in English, general knowledge about typing, and specific knowledge about keystroke patterns that indicate relevant typing difficulties. The result is an assessment of which of the available configuration options are relevant to this user, and what the settings for those options should be for maximum typing accuracy. This assessment is continually updated as the user types. The Keyboard Optimizer begins making recommendations after the first key press, and a single sentence is sufficient for detection of moderately severe accuracy problems.

The goal of an optimizer is to hide complex configuration details from users while still giving them control over the configuration of their device. The Keyboard Optimizer's adjustments are made under explicit user/clinician control, but decisions are made at a high level. Suggested modifications are described in non-technical terms, and users have the opportunity to try them directly. Technical details are available for the clinician to view if necessary. The user/clinician then decides whether to accept or reject the proposed new settings. Optimizers do not require users to answer queries about their configuration requirements. The Keyboard Optimizer forms its conclusions by observing the user typing English text. Users can type into any application, allowing clinicians to use existing assessment protocols that involve text entry.

3 User Trials

The Keyboard Optimizer was used in keyboard assessments in a clinical setting with 8 individuals, average age 60.6. All had disabilities which affected their keyboarding, including tremors (2), full use of only one arm or hand (2), multiple sclerosis (1), loss of fine motor control (1), nerve damage (1) and back and shoulder impairment (1).

These individuals used the Keyboard Optimizer for an average of 7.4 minutes, entering an average of 163 keystrokes. The Keyboard Optimizer offered 21 configuration modifications, 20 of which were judged by the clinicians to be appropriate. The average number of keystrokes entered before each suggestion was made was 26. Clinicians suggested a further 9 potential modifications that were not offered. Participants liked the interface and found it easy to use. They liked the idea of having adjustments made automatically, based on their actual typing. One would have preferred to be presented with technical details.

4 Conclusions

Preliminary analysis of the Keyboard Optimizer's performance suggests that it could play a useful role in assessment. It allows users and clinicians to quickly get a sense of the achievable typing accuracy for a particular keyboard. Detailed analysis and refinement of the model's sensitivity and stability are ongoing.

The use of self-adjusting devices in assessment can eliminate the trial and error process normally employed in choosing specific device configuration settings. This enables a greater focus on variables such as device positioning, or user seating, or trying alternative devices.

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A Proposal of an Evaluation Framework for Writing Assistance Systems: Application to VITIPI

Philippe Boissière and Daniel Dours

IRIT – UPS – CNRS, 118 Route de Narbonne, 31 062 TOULOUSE Cedex France
{boissier, dours}@irit.fr

Abstract. We propose an evaluation framework for writing assistance systems. This framework is used to evaluate VITIPI and provide the first results.

1 Introduction

Writing is very important for anyone in everyday life. For some disabled, it may be the only way of communication. Unfortunately, it takes them a long time to write. Thanks to Information and Communication Technology, we can find a lot of writing assistance systems, using abbreviated, selected or predicted words. But it is difficult to make unbiased evaluation systems, and users have no objective criteria to select one of them. In the first part of the talk, we are going to list all main features of existing systems. Going further, we shall explain our frame evaluation. Finally, we will give VITIPI as an instance for the framework evaluation.

2 Evaluation Framework

In order to help the user to choose a writing assistance system, according to his or her intellectual and/or physical abilities, we propose objective criteria for comparisons. We are to notice that it is difficult to compare two systems in regards to their variability. First of all, several systems are still mainly laboratory prototypes and their characteristics are not known. Then, evaluation results are often not published or based on tries with non-identical corpora.

Rigorously, an evaluation is made up of five ergonomic criteria: utility, usability, efficiency, no dangerousness and user's satisfaction [1]. In the field of writing assistance some of these criteria are trivial. We just want to focus on the efficiency criteria which is the most important according to user's point of view. The evaluation framework is divided in two parts: The first one deals with "*system features*" The second one provides "*system performances*".

"*System features*" represents the features characterizing the assistance writing system (type of coding, interactivity, domain and lexicon size, language, etc.).

"*System performances*" is made up with various parameters. We have avoided qualitative results based on users' or therapists' judgments because they are too personalized.

2.1 System Features

- *Coding principles* : The user has to write a text shorter and easier than he should have written without assistance system. Two kinds of coding can be distinguished. *Static and explicit coding methods* : User knows a list of abbreviated words and rewriting rules, *Dynamic and implicit coding methods* : User doesn't know coding rules. When he types one letter, system displays others letters, it is an *interactive coding*. Depending on the interaction mode, two sorts of systems can be found: *Displaying list of words* or *System displays a part of word*.
- *Running*: Systems dealt with *isolated words* only. Nowadays, systems try to take into account *previous word* by introducing grammatical rules or others patterns (Markov models, N-grams, ...).
- *Typing adaptability* : User can type *new entities* i.e. new words or sentences that do not belong to the initial database, or misspelled words (typing or orthographic mistakes). System can accept it.
- *Database update*: When new entities are detected by the system, they could be: *Integrated on line* during the session, (enjoying typing adaptability) or *Integrated off line* after the session, requiring intervention of target (sometimes with specialized knowledge).
- *Automatic database building*: User can build (him/her) self its database, with its own parameters, without standard lexicon, only for *one language* or for *every languages*, without knowing grammatical rules.
- *Separated editor*: Window text editor could be an ordinary word processor.

2.2 System Performances

The main value evaluated is the ratio time saving with the evaluation of the following parameter: The ratio of input keys typed by the user compared to the ratio of output characters provided by the system output. To evaluate it, we have to compute the number of keys typed by the user with system assistance :

$$Input_symbols + key_functions \quad (1)$$

With:

- *Input_symbols*: Number of letters typed by user. It includes also digits or numbers contained in the text and spacing (just one for each word)
- *key_functions*: Number of keys functions typed to select word in list or to correct word prediction.

Without system assistance, user should have to type all the entire text .

$$Input_symbols + Output_symbols \quad (2)$$

With :

- *Output_symbols*: Number of symbols automatically provided by the system.
- Finely, the ratio time saving (*R.T.S*) is obtained by the following formula (3) which is similar to Zagler keystroke saving [2].

$$R.T.S = \left(1 - \frac{(1)}{(2)} \right) \quad (3)$$

3 VITIPI Evaluation

VITIPI is a writing assistance system. We are not going to explain its running yet exposed in various publications [3], [4], we just want to project it through the Frame Work evaluation, as an instance of assistant system.

System Features: VITIPI is a *dynamic and implicit coding method* that doesn't display list of words. It runs with *previous words* with a very huge *typing adaptability*. Database is automatically *updated online* and could be built in *every language*. VITIPI can be used with a *separate window editor*.

System Performances: Various simulation tests were done with several corpora. Using a weather forecasting French corpus (439 sentences, 7,830 words 985 vocabulary size) it has been found that with unknown sentences corpus and 3 previous words, R.T.S. is 45 % when a standard lexicon (5,930 French words) is used, 47 % without French lexicon. When all sentences belong to corpus, R.T.S. climbs up to 78.9 % without French lexicon and 10 previous words. Another testing has been made with e-mail exchanges concerning a workshop organization (159 sentences, 2,539 words 912 vocabulary size). It has been shown that with unknown sentences corpus and 3 previous words, R.T.S is 30 % with lexicon versus 43% without. When all sentences belong to corpus R.T.S. reaches 82.7 % with 10 previous words without lexicon.

4 Conclusion

We point out some features to evaluate a writing assistance system. Thanks to this framework we hope we reach for two objectives: The first one is to help users by providing unbiased criteria to help them select their system. The second one is to help designers by optimizing parameters in order to near the maximum efficiency. This frame is available to evaluate several writing assistance systems.

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Individually Assisted Text Entry with Situational and Contextual Prediction

Dirk Clemens¹, Helmut Heck¹, Michael Kühn², Olaf Perlick¹, and Frank Reins¹

¹ Forschungsinstitut Technologie-Behindertenhilfe (FTB) der Evangelischen Stiftung Volmarstein, Grundschötteler Str. 40, D-58300 Wetter/Ruhr, Germany
sekr@FTB-Volmarstein.de — <http://www.ftb-net.de/>

² Forschungsgruppe Computerlinguistik, Fachbereich Informatik, Universität Koblenz-Landau, Postfach 201 602, 56016 Koblenz
kuehn@uni-koblenz.de — <http://www.uni-koblenz.de/~kuehn/>

Abstract. The EMBASSI project aims at developing Electronical Multi-Medial Operating and Service Assistance for applications of electronic devices in private, automotive and public environments. — In order to assist “slow typers” in typing free texts and to speed up text entries in public terminal systems, a text prediction system is being developed that predicts text while the user is slowly writing. The system takes into account application dependent vocabulary, user dependent preferences in writing, and the user specific features of impairment-dependent Personal Mobile Control Devices (EMMA) with individual user interface layouts.

1 Introduction

Within the German focus project EMBASSI (Electronical Multi-Medial Operating and Service Assistance [1]) a system architecture has been defined that gives active assistance to the users in operating a variety of electronic devices in private environments (e.g. TV, video, home system, PC), automotive environments (e.g. car navigation system, MP3 player, phone) and public terminal environments.

Since people with disabilities often have severe difficulties in operating public terminal systems, a scenario is being built up where persons with various disabilities (blind — motor-impaired — severely motor and speech impaired) operate various terminal systems, e.g. bank terminals, ticket machines or shopping terminals, using customised impairment-dependent Personal Mobile Control Devices (EMMA) with individual user interface layouts. The terminals transmit wirelessly the application-dependent information (content) to the users’ personal EMMAs while the EMMAs (visually, tactile or audibly) display the content and enable user feedback via keyboards, speech, or buttons — according to the users’ personal profiles.

In order to assist severe motor-impaired people who are not able to use speech input during writing, a predictive text entry system is developed that predicts user input based on situational and textual context.

2 Situational Context from Application and User

Due to the users' physical characteristics and preferences, there are quite different versions of EMMA necessary: a user might have a full keyboard but he is rather slow in pressing keys; another user may be unable to use a physical keyboard at all, but he may operate an on-screen keyboard with a single switch; another user may prefer to apply a "reduced keyboard" with only few keys (like a keyboard on mobile phones used for SMS text entry). — On the other hand, the various terminal applications (banking, shopping etc.) require different categories of text entries, even within the same application: specific words and numbers in on-screen forms, individual user specific information like names and addresses, and free text.

The use of situative context information can be used to enhance the quality of word prediction. In our approach, unique identifiers for the text categories within an application are used to select an algorithm that is expected to work best for the respective category. The selection of the prediction knowledge is managed in a two stage way. If available, a unique identifier of the current user serves to select a user-specific context for the current control. Alternatively, a general user-independent context is provided as a fallback strategy by the device.

In the case of public terminals, unique text category identifiers are required for the synchronisation between the remotely operated EMMA and the terminal. A unique user ID is required for the offering of personalised services. In this scenario, the user-dependent knowledge (personal preferences in writing) is stored on the portable device EMMA, whereas the user-independent, but application-specific knowledge is stored in the terminal system.

3 Interface for Different Prediction Algorithms

According to the different user input modi, the different categories of text entries, the different application contexts, and the application-specific versus user-specific vocabulary, there are different strategies and algorithms for text prediction necessary. Our text entry module provides a generic programming interface that supports a set of prediction algorithms by providing basic function calls: (a) to initialize the statistical text model; (b) to set the immediate context to be considered; (c) to compute the next prediction list; and (d) to access the predictions one by one. Several prediction algorithms have been implemented: the reactive keyboard algorithm; word completion based on word frequencies; word prediction in combination with a "reduced keyboard". At the moment we are experimenting with word prediction based on word-sequence (n-gram) frequencies.

Word completion tries to predict the next word or to complete a partially typed word on the base of a statistical text model, e.g. a word list ordered by frequency and recency [2]. Due to the many possible suffixes a German word can have, a naive application of word completion in the German language faces the problem that often many similar word forms belonging to one stem will be

proposed after typing the beginning of a word [3]. Therefore we plan a simple morphological treatment where in a first step the word stems are predicted and the inflections are predicted in a second step.

The reactive keyboard algorithm [4] uses a statistical, variable-length model of character sequences to predict the most probable sequence of following characters. In contrast to word completion, the predictions are made across word and sentence boundaries.

Kushler [5] proposes the use of a “reduced keyboard” for text entry situations where a standard keyboard cannot be operated. Each key is assigned several characters. (Phone keys are used this way for the so called vanity phone numbers: Every phone digit key from 2 to 9 is additionally labeled with at least three letters.) The prediction task now is not to complete a typed word based on the beginning letters but to disambiguate a sequence of non-unique key codes with respect to a dictionary of known words.

4 Conclusion

We expect that the efficiency of text entry by “slow typers” in various applications will improve considerably by exploiting (1) contextual and situational information, (2) user specific preferences in vocabulary, and (3) customised user interfaces. This assistance function for public terminal systems will be evaluated by blind, physically disabled, and not disabled users in fall 2002. In case of positive results, the predictive text entry methods will be transferred to other (home) applications.

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Accessible Digital Media

Introduction to the Special Thematic Session

Deborah I. Fels

Ryerson University
350 Victoria St., Toronto, CANADA M5B 2K3
dfels@ryerson.ca
<http://www.ryerson.ca/clt>

Digital media including audio, video, animation and graphics have an ever-increasing prominence and use in education, on web-sites and even on television.

The television industry is undergoing the most significant revolution since the origin of the NTSC and PAL standards in the 1940's. Television is without exception the last partner in the communications industry to embrace digital delivery of its transmission signal. The United States (US) and Canada have only recently begun the process of converting to digital transmission while European Union (EU) countries have been working on standards and services for digital and interactive television since 1999.

The possibilities of combining the flexibility, power and interactivity of digital computing technologies with the quality, ubiquity and production resources of television represent the next new frontier of innovation.

The education industry is also undergoing a significant evolution that is being driven by the availability and ever-growing capacity and distribution of digital technology and network bandwidth. Educators are exploring new way of creating and delivering content so that students can learn at any time and in any place.

Researchers and practitioners in the fields of assistive and adaptive technologies have an unprecedented opportunity to drive, influence and design some of the innovations and solutions in using these new technologies as well as to participate in developing new standards; industry practices and interfaces. In addition, we have the opportunity to explore ways of solving some of the access difficulties and issues that were present in the analogue systems without repeating some of the mistakes. For example, there are many issues to be resolved with closed-captioning and analogue television. Sound effects, music and emotion are rarely expressed in Line21 captions or teletext in a way that conveys the total affect of that particular sound. Digital technologies can allow researchers, designers, practitioners to explore way of conveying these sounds.

There are three main accessibility solutions for media (analogue and digital), captioning (close, open or subtitling), described audio, and input technologies. Low literacy versions of these three solutions are also included within these solutions.

Captioning and the EU equivalent, subtitling, is the verbatim transcription of words along with other short descriptors (speaker identification, background, music and other non-speech descriptions) said in video based content (e.g., characters, narrators, and interviewees). Subtitling for language translation involves an interpreted version

of the speech-based content and should not be confused with teletext subtitling. Captioning and subtitling are useful for people who are deaf and hard of hearing assuming that the language level of the film is at an appropriate reading level and speed. Some of the issues that have not been addressed with the analogue version of captioning include inadequate or non-existent descriptions for other sounds such as music and sound effects, unavailability of preference settings and interactivity. There is limited bandwidth for the analogues systems (NTSC 608 captioning have a maximum bandwidth of 960 baud.) and therefore limited capacity for graphics and other multimedia techniques to use in expressing the missing information.

Described audio provides the verbal description of scenes in a video where there is no sound. This type of technology provides access for people who are blind or low vision. Described audio must fit into the time between sounds and as a result can be limited and even incomplete. In addition, the quite or silent times in dramas are usually intentional and intended to provide dramatic effect. However, in educational media, and documentaries, silences are not often used for dramatic effect but rather for demonstration or vivid visuals. In these cases, described audio is important and useful during the silences but longer descriptions from what is permitted during the actual silences may be required.

Input devices for access to analogue media systems are particularly limited. For example, the input device for television is typically a remote control system to change parameters such as channels, and volume. This type of control system has limited potential for access solutions and interactivity, although there are some existing technologies that can replace a remote control. There has been considerable development of alternative input systems, such as head pointers, and alternative keyboards for interactive computing systems and we have an opportunity to investigate the use and development of these systems for general use.

Testing and evaluation methods for accessible media are very limited especially for real-time analysis of user interest, enjoyment, engagement and learning. We need to devise evaluation methods that can assess user reaction as these occur rather than in summary form following a viewing of a particular piece of media.

The move to digital media allows opportunities to resolve some of the issues with analogue media used in television, film and education, and create new and innovative . As this move to digital media is relatively new an untested, there is an unprecedented opportunity to integrate access solutions at the beginning of this new paradigm rather than retrofit systems once they have been adopted and standardized. Rather than requiring legislation to include accessibility in technology, we have an opportunity to drive it. Standards regarding digital media are still being devised and internationalized and much research and development work remains.

The four papers presented in this session provide innovative solutions to some of the issues surrounding accessible digital media. We need to accelerate our discussions, research and development, and especially community and user demands for increased presence in digital media development and standards. Finally, the work presented in this session represents excellent examples of electronic curbcuts where there are many benefits to the public at large, not just for the target population studied.

Methods for Inclusion: Employing Think Aloud Protocol with Individuals Who Are Deaf

Vera Roberts¹ and Deborah Fels²

¹ ATRC, University of Toronto, 130 St. George Street, Toronto, Ontario, Canada, M5S 1A5
vera.roberts@utoronto.ca

² Ryerson University, 350 Victoria Street, Toronto, Ontario, Canada M5B 2K3
dfels@acs.ryerson.ca

Abstract. Courseware accommodations for individuals who are deaf are examined including translated and hearing video viewing preferences. Within a computer interface, two forms of translated educational video were provided: standard and acted. Think aloud protocol is carried out as part of a usability study of the courseware and its effectiveness as a method for ASL users is considered. There was no influence of translation type on participants' performance on a comprehension test. Trends in the data suggest that individuals find the accommodations worthy of extra cost and are willing to shoulder some of this cost. Preliminary analysis of the verbal reports suggest that sufficient and rich data may be collected from ASL users in a TAP methodology.

1 Introduction

With increasing use of the Internet for delivery of education and the right to equal access to education regardless of disability, the onus is on developers of courseware to enable accessible content. Advances in technology such as high speed or broadband Internet, greater computer memory and storage capacity and increased processor speeds provide opportunities for enhancements that just years ago would have rendered online courses too cumbersome for use. For individuals who communicate with American Sign Language (ASL), the opportunity for improved access to online education as a result of these technological advances is significant and worth pursuing.

The most common accommodation to video material for individuals who are deaf is the provision of text and closed or open captioning. However, this accommodation is not optimal or appropriate for native ASL speakers because English (or other spoken language) is commonly a second language and often ASL users are much less fluent in their second language than in ASL. For this community, where ASL is the language of daily life and the first language for many, provision of materials with ASL translation is a more equitable accommodation. Some would argue that ASL translations are inadequate and that original ASL material would be most equitable. However, with the vast archive of video educational material available, it is sensible to consider methods

to offer this material in an inclusive manner without having to re-produce the original video as an ASL video.

Technological advances provide the opportunity to explore new ways and formats of providing inclusive content leaving researchers to answer the question of what new accommodations in educational software and online delivery are optimal in supporting student attainment of learning outcomes and student comfort. One common methodology used to study software and/or product usability is talk aloud or think aloud protocol (TAP). This protocol requires the product user to speak aloud his or her thoughts while manipulating the product in prescribed ways. The qualitative data gained from this protocol influence the ongoing development of the product. Think aloud protocol is a common technique used by researchers to give insight into the mental processes and thoughts of an individual while performing a task. This methodology has not been widely applied with individuals who are users of ASL yet inclusive mandates for education and applications of technology require that research methodologies appropriate for this group be developed and tested. A “thought-sign” protocol that uses similar procedures to TAP may prove to be an important methodology in assessing the usability and quality of online educational materials for ASL users.

1.1 Usability

Usability testing is a standard part of software development. This step is essential to the development process because “Designers know too much about their product to be objective judges: the features they have come to love and prefer may not be understood or preferred by the future customers” [8, p. ix]. A usability study involves anticipating or observing how users interact with the product. A number of usability evaluation methods (UEMs) have been developed over the past twenty years in the field of human computer interaction (HCI) as electronic devices and the software to power them have gained increasing prominence in our world [9,7,2,6].

Usability studies gather important information for developers. They provide information about how the user interacted with the product, where users had difficulties or positive experiences with the product, and recommendations for ways that the product may be made more user-friendly. While there are a number of design guidelines and standards such as Web Accessibility Initiative (WAI) [14] that are helping to set standards for inclusive web design, there remains a dearth of UEMs to use for assessing the usability of interfaces by people with disabilities, particularly those who do not communicate using traditional oral means. This project is aimed toward filling this gap in software development by considering not only the user needs of individuals who are deaf but also the efficacy of the think aloud method for usability testing with this group.

1.2 Think Aloud Protocol

Think Aloud protocol (TAP) is a common UEM that is based on a method developed by Ericsson and Simon [3] to understand cognitive processes during tasks. Think aloud protocol enables examination of how people manipulate and interact with a computer

interface in real-time because it allows a more free interaction and provides opportunity for the investigator to learn the user's rationale for the chosen approach [5]. This method is routinely used in human computer interface (HCI) studies as an effective and informative UEM. Further discussion of TAP as well as its advantages and disadvantages is available in [5, 4,12,1].

While it is clear that TAP may be an effective method to evaluate the usability of computer interfaces, it is not clear if this process will be successful with individuals who communicate using visual/gestural languages such as ASL rather than aural/oral languages (spoken languages). TAP method has been used successfully to study the cognitive processes of ASL speakers in at least one study of reading [11]. Our study builds on this earlier success and attempts TAP with ASL speakers who view an educational video delivered via a computer interface. This work is particularly important because there is a need to develop inclusive methods for usability studies or risk excluding groups of individuals from the very technology that could enable them to participate in the world more freely and independently.

2 Method

2.1 Materials

A software video player interface was developed and tested for this study. The interface allowed users to view an educational video about traffic court as well as an ASL translation of the video. The original education video was produced as a standard NTSC video with traditional verbatim closed captions, was provided by Canadian Learning Television and is part of a full social studies curriculum. The ASL translation was provided in two formats, an acted ASL version where actors in costume played the parts of the original actors, and a standard ASL version using a single translator for all of the parts.

Video controls in the interface allowed the user to play, pause, move forward or rewind the video. Viewing preferences could also be set by the user and included adjustment of video and translation window positions, proximity of the windows, relative size of the windows and use of borders around the windows.

A short training video was provided to enable users to become familiar with the preference and video controls. The two viewings of the educational test video were separated by six multiple choice and one short answer comprehension questions.

2.2 Apparatus

The subjects were provided with a PC that met the following minimum requirements: processor speed at or near 450 MHz, 128 - 256 Mbytes of RAM, video card with 8-16 Mbytes, 350 Mbytes of storage. The PC included keyboard, mouse, speakers and 17-inch colour monitor. Each PC was further equipped with key-stroke logging software. Two video cameras were used to record the signs made by the participant and by the investigator so that they could be translated at the close of the study.

2.3 Subjects

Participants were 17 individuals who are deaf and fluent in ASL and ranged in education level from high school to college/university. The Canadian Learning Television video on traffic court was aimed at the age and education level of the participants. The participants were recruited using recruitment posters at the Canadian Hearing Society offices in Toronto and Sudbury, Ontario. Participants were compensated travel costs to and from the test site as well as \$8/hour.

2.4 Design

The study is a within subjects design. There is one independent variable with two levels: 1) standard ASL translation, 2) acted ASL translation. The dependent variables include time on video controls, viewing preference selections, comprehension test scores and counts from the verbal protocol.

2.5 Method

The Task. Training & Practice provided an opportunity for the participant to become familiar with the video interface as well as with the “think-aloud” method used to gather responses to the interface. During this step the participants practiced using the video interface while signing out their thoughts at the same time. The participants had opportunity to select their viewing preferences for first video.

Following training, individuals were asked to watch a 10-minute segment of the traffic court educational video. After the video, participants completed a short multiple-choice test for content comprehension. Following the comprehension test, participants were again provided opportunity to set viewing preferences for the educational video. Next, participants viewed the same educational video segment but with a different ASL translation format from the first viewing. Following viewing both iterations, participants were asked to complete a post-study questionnaire. Subjects were involved in the training and experiment for approximately one hour

Participants were asked to sign their thoughts about the task as they were performing it. After short periods of silence (about ten seconds) the investigator would remind the participant to sign these thoughts

3 Results and Discussion

3.1 Video and Translation Ratings

Participants' ranking of quality and comprehensibility of the two translation types did not vary with treatment order. Furthermore, chi square analysis showed that participants significantly liked the educational video (content $\chi^2=10.71$, characters $\chi^2=7.12$, plot $\chi^2=7.88$; $p<.05$ for each category) and the quality of the ASL interpretations

($\chi^2=10.71$; $p<0.05$). These results suggest that the participants were not at a disadvantage for the comprehension test due to translation order or video content issues.

3.2 Comprehension Test

Indeed, the results of the comprehension test were evenly split between the two treatments such that of the 8 participants who scored at least 4 correct out of 7 questions (57%), 4 completed the test after watching the acted interpretation and 4 after watching the standard ASL interpretation. The failure rate on the comprehension test was high but may relate to the task demands placed on the participants. In this case, participants were conscious of reporting usability issues to the investigator while at the same time working with and learning from the novel interface and video. It would be interesting to compare test results to participants who are hearing and who are asked to carry out the same procedures with the original video. . Also, since the multiple choice test was presented in written English (although ASL interpretation of the questions was always available) it may have been useful to include the closed caption track of the video script. In this way, participants would have opportunity to see the information in the same language in which the test was presented. Comprehension results would likely increase if the educational component and test were part of an actual course in which the participants would have a vested interest in studying and reviewing the material.

3.3 Preferences & Features

While online delivery of courses is now quite common, it is not common to provide hearing video with concurrent ASL video translation as an accommodation to students who are deaf. Furthermore, flexibility over the way these videos are viewed (preference settings for size, position, proximity and borders enabled) is an additional feature of the interface in this study. We asked participants if they would be willing to pay for these features and if the features were worthy of the related rise in production costs.

Worthiness of Added Production Costs. As is shown in Figure 1, 14 of the 17 participants suggested that the acted video was worthy of extra production costs and that having the flexibility to control how the video is viewed as less desirable than having acted video (only 9 of the 17 participants rated viewing preferences as more worthy or very worthy). However, when asked about willingness to pay these extra costs, the affirmative trend, although still there, was less distinct with a more even distribution. The cost data shows a trend towards willingness of participants to pay for either a standard or acted interpretation of the video as well as for provision of viewing preferences control.

Preference Settings. As might be expected, viewing preferences varied considerably from participant to participant. One clearly popular setting was to have the ASL window large with all but one participant stating that it was their preferred setting. Also, 12 of the respondents preferred to have the ASL window below the original video window. Other choices such as borders and proximity seemed discretionary.

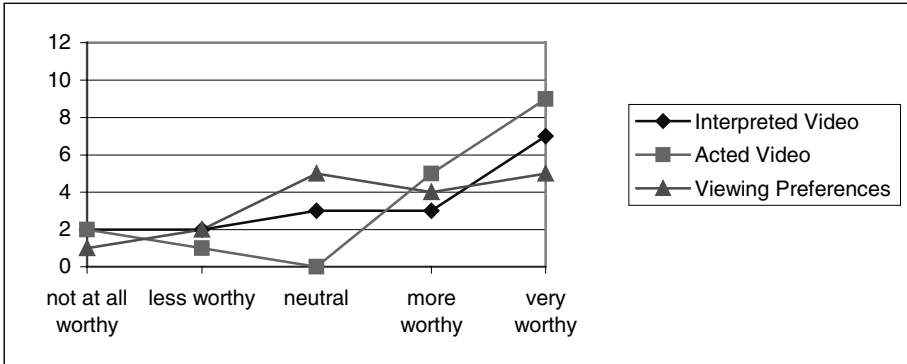


Fig. 1. Worthiness of Added Production Costs. The added features are generally seen as worthy of the associated rise in production cost

This information is particularly valuable in cases where viewing preferences are static. Developers of such an interface would be able to base decisions on known preference data and have at least a greater chance of meeting the preferences of a greater proportion of the deaf population. More research on viewing preferences and their potential effect on the learning process should be investigated so that accommodation standards may be determined for the courseware industry.

3.4 Think Aloud Protocol

While the research assistants who carried out the investigation were fluent in ASL the principal investigators were not. The challenge of different languages was overcome in the study through video recording of both the participant and the investigator. These recordings were then viewed by certified or college-trained interpreters who translated and transcribed the signed utterances. In order to capture facial grammar and other nuances of the language that could not be made easily through translation alone, the interpreters would provide additional comments and contextual information to ensure that the full meaning of the utterance was captured in the translated transcription. Shirmer [10] and Steward et al. [13] provide a thorough discussion of ASL, its interpretation, communication and culture.

In order to assess the transcriptions, a protocol was developed that was based on the usability and format questions we wished to answer in the study. The protocol had nine categories as seen in Table 1. The first seven categories could have either a positive or negative selection while the final two categories were simple counts.

In order to determine whether the inter-rater reliability of the transcription assessment protocol and the operational definitions, two operators were instructed how to use the software and trained in the meaning of the operationally defined events. Each operator then independently analyzed four complete video transcription records. Results from each operator were totaled across category and were entered into SPSS for

Windows (version 9.0). The Intraclass coefficient (ICC) was 0.88 indicative of excellent inter-rater reliability. All subsequent analyses can be carried out by only one rater.

Each ten-minute session (2 each per participant = 4 sessions) elicited on average 13 coded comments with each session having at least 11 coded comments. These results support the notion that use of TAP with individuals who are deaf will enable collection of sufficient and relevant comments. Table 1 summarizes the positive and negative comments from all categories in the rated sessions..

Table 1. Count of Ranking of Comments for Four Video Sessions

Category		+ve	-ve
Quality of interpreter/actors presence and expression		2	1
Interpretation quality (speed, novel signs)		3	7
Ease of using video interface (video control buttons)		0	0
Viewing preferences (position, border, size, proximity)		1	3
Technical issues with video (synchronicity, visibility)		1	5
Content of video		2	7
Acted vs interpreted ASL content (comparison, busyness)	Acted	2	5
	Standard	6	2
Closed Captioning Requested		2	
Recommendations		2	

As is illustrated in Table 2, the general trend was for more comments to be elicited for the standard interpretation. Interpretation quality was criticized by only one of the participants for both of the translations. Further coding of other sessions will be necessary to determine if the quality was frequently cited as an issue. Not surprisingly, the greatest number of comments was in the category for comparative comments between the two ASL translations. These comments naturally occurred during the second video session. The discussed trends may not bear out once all of the sessions have been coded and analyzed.

Table 2. Count of Comments by Video Type and Order

Viewing Order	Acted Interpretation	Standard Interpretation
First	4+, 7-	4+, 10-, 2 neutral
Second	3+, 6-, 2 neutral	6+, 7-

A more efficient way to collect verbal data with ASL users, especially when the investigators are not fluent in ASL may be to have an interpreter simultaneously translate the signs as they are made so that the audio translation is on the video tape. It would also be useful to have a split screen video that shows the events on the computer monitor as well as the participant (and translation audio). This method may prove less cumbersome than the translation/transcription method employed in this study. Other considerations include the physical requirements for gestural communication. Frequent use of the hands was not needed during this study, however, care must be taken in similar work to ensure that individuals who use gestures to commu-

nicate are not impeded by the requirements of the usability study (e.g., data entry tasks, large amount of mouse movement).

4 Summary

The analysis of the data thus far supports the use of TAP in usability studies with individuals who are deaf. Furthermore, accommodations for students who are deaf must be built into courseware or else we run the risk of excluding a large segment of the population from the technology that has the power to enable them to interact with the world freely and independently. This study takes the first steps towards determining appropriate and useful accommodations for the deaf population as well as developing effective methodologies for usability studies with this group.

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Emotive Captioning in a Digital World

Charles Silverman and Deborah I. Fels

Centre for Learning Technologies
Ryerson University
csilverm@acs.ryerson.ca
<http://www.ryerson.ca/clt>

Abstract. Traditional closed captioning provides limited bandwidth for verbatim text and sparse background information to reach the viewer. However, the information and richness contained in paralanguage, music, and background sounds is lost to the deaf viewer. The Emotive We are exploring the ways to fill these gaps with the increased bandwidth offered by the newdigital media.

1 Background

Closed captioning has been available to North American TV audiences since 1980 to Deaf and Hard of Hearing viewer who purchased special set top boxes that attached to their TV sets. Since 1993, due to the U.S. Television Decoder Circuitry Act, Closed Captioning has achieved universal availability in North America (Robson, 2002).

The current closed caption system uses simple text-based format, with a modified character set built into the decoder chip. While several modifications have taken place over the past twenty-two years, the basic system is unchanged. The current system provides a single, mono-spaced font, a single font size, a short set of text colors, and a black background., captioning gains are appear insignificant. Initially only uppercase letters were available, along with white as the only text color. The system has since gained mixed case letters, a small set of text colors, along with a few special characters. The original absence of mixed case and a single text color has habituated users to being more comfortable with uppercase captioning than mixed captioning, and conventions such as using lowercase text for “whispering.” Only in the last two years have caption writers begun to replace uppercase text with mixed text.

After some twenty-two years, the advent of digital television is providing a vehicle for change and a new, more flexible caption standard, called EIA 708, is emerging. The new standard will offer variable-spaced fonts, a variety of font sizes, and multiple colors The new standard represents a great advancement for closed captioning. However, the captions remain text-based, new features that have been taken for granted by computer users for years.

2 Text Is Not Enough

Do the Deaf and Hard of Hearing viewers have the same experiences when viewing a show? Studies and anecdotal reporting suggest that deaf and hard of hearing viewers

feel they are missing things. Early on, caption viewers demanded verbatim captioning and the industry has mostly complied. Hawkins (1995) reports that caption viewers feel they don't have enough information. They want description to be explicit rather than implied. They want to know when strong emotions are expressed; an explanation for puns, clear identification of speakers; and greater description of background information.

In the course of our work, we have interviewed over 15 deaf, hard of hearing and hearing viewers about their likes and dislikes. Most expressed frustration with the current state of captioning. One of our interviewees summed it up when he reported, "I want to feel the characters... I feel like I'm missing something."

There are two problems with text-based captioning. The first has to do with human speech. Words are just part of the picture. Paralanguage, or the non-word part of speech, is a large part of the communication process. Mahrabian (1968) notes that the semantic breakdown of language is just 7% words, 38% paralanguage, and 55% body language. Paralanguage is five times the weight of words. Although body language is the most weighted in Mahrabian's triad, what if the caption viewer can't see the actor? The second problem has to do with the role of music and sound as deliberate dramatic elements.

3 Graphics and Haptics

Simply adding additional text to provide a full range of information is not a viable solution. We do not want to increase the number of words per minute making captions difficult to follow, nor distract the viewer away from the primary viewing experience. As an alternative to text, graphics and haptics are promising approaches. DTV and other digital platforms offer the kind of significant bandwidth required to accommodate these approaches.

To explore these issues, we used the Quicktime Pro video environment due to its capacity to work with multiple media objects and offer multiple tracks for media storage. Prototypes were created using a multimedia authoring tool called "Revolution" which has built-in Quicktime support.

Using the video short "Il Menu," an amusing spoof on opera that contains both dialog and music, we created graphic captions using a comic art approach. We focused on a basic set of emotions, Happy, Sad, Anger, and Fear with intensity as a modifier in selecting appropriate speech bubble shapes and text styles. We used speech bubbles and icons with descriptions to depict background sounds and transitions. Communication with the video's creators enabled us to determine the director's intentions in regard to his characters, choice of sound, and overall mood.

As part of an ongoing study, eleven deaf and hard of hearing viewers, all of whom are seasoned closed caption users, viewed the resulting enhanced captioned video. Ten viewers felt that the approach increased their understanding of the content, although several viewers reported that they had difficulty with the use of comic conventions as they associated these conventions with children's content. Several viewers expressed appreciation for their heightened sense of themes, depth, and feeling that the graphics helped to convey.

We have also begun to explore using a tactile system in conjunction with video as a way to relay information in a way similar to music and sounds (Fels, 2001).

Currently, we are using a foot-pedal based vibro-tactile unit to match selected transitions in the II Menu video. We have made an analogy between this unit and percussions. Percussion instruments offer speed and energy; they communicate with an emotional intensity. The vibro-tactile unit offers frequency and amplitude control, which is equivalent to speed and force, two key pieces in percussions. In one instance, we selected a scene in II Menu where the viewer is surprised by the sound of a liquid splashing into a character's face. The sound of the "splash" or "splat" is quite pronounced and plays a role in the viewer's involvement the video. We matched the "splat" sound to a high intensity burst at full power for 400 milliseconds, timed to the moment of the sound's appearance. A pre-test subject reported that the tactile experience blended with the video viewing, enhancing the sense of surprise, much the way that the audio would.

4 Conclusion

Initial responses indicate that the deaf and hard of hearing populations both need and desire a better system. We will be continuing our usability studies. In addition, we are building a graphics and haptics caption editor module to explore the potential applications of these approaches.

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Spoken Subtitles: Making Subtitled TV Programmes Accessible

Maarten Verboom¹, David Crombie¹, Evelien Dijk¹, and Mildred Theunisz²

¹ FNB, Dutch Federation of Libraries for the Blind,
Molenpad 2, 1016GM, Amsterdam, Netherlands
projects@fnb.nl
<http://projects.fnb.nl>

² FSB, Dutch Federation of Organisations for Visually Impaired People
Utrecht, Netherlands
mtz@sb-belang.nl

Abstract. FSB (Federation of Organisations for Visually Impaired People), together with NOS (the public broadcasting-company) and FNB (the Federation of Dutch Libraries for the Blind) have joined forces to improve access to subtitled television programmes. In the Netherlands, many television programmes from foreign countries are available, and these are commonly provided with Dutch subtitles. The *Spoken Subtitles* initiative makes these subtitle-translated programmes accessible to the visually impaired by creating a service which automatically produces talking subtitles using synthetic speech. The paper describes the conceptual background of the Spoken Subtitle initiative, and outlines the results and the first experiences of the current service.

1 Introduction

Most blind and partially sighted users of TV are aged over 60 and some also suffer cognitive impairment. Visually impaired people watch television and videotapes on a frequency similar to the general population and, based on the findings of a recent American study [1], they have similar programming tastes and preferences.

Thirty per cent of the programmes on Dutch television are foreign programmes. These programmes are provided with subtitles. As a result, these programmes are inaccessible for visually impaired people. Therefore FNB (the Federation of Dutch Libraries for the Blind), together with NOS (the Public Broadcasting Company) and FSB (Dutch Federation of Organisations for Visually Impaired People) have joined forces to enhance access to television through the use of spoken subtitles. By bringing together broadcasters, service-providers and end-users, a unique service which automatically produces a talking version of subtitles, in real time, has been created. The technologies involved in bringing spoken subtitles to the homes of the visually impaired involve the integration of speech-synthesis and broadcasting. To encourage the uptake of this new approach, a relatively cheap and easy-to-use assistive device has been developed and piloted. This research has been developed over a 2-year

period and the results have led to the decision to implement a permanent service. These results provide interesting pointers to all those concerned with improving access to information for the visually impaired.

2 Background and Context of Research

Television plays an important role in everyday life for people with a visual impairment. People with visual impairments can often understand the contents of a program by listening to the sound and more particularly to the spoken texts. However, the perception of the visual information in television programs poses many problems for the visually impaired.

Research on the accessibility of television programs has shown that television is very important for people who are visually impaired. The Packer-Kirchner (*op cit*) study noted the similarity in viewing habits between the visually impaired population and the general population

Similarly, a Nielsen Media Research survey for the American specialty channel, Narrative Television Network [2], noted that 94% of visually impaired people watched TV at least once a day.

The process of watching TV for a visually impaired person involves the use of auditory information and critical thinking skills to build the same knowledge about plot and action that a sighted person would gain. Although the skills a visually impaired person uses to watch television are adequate to allow an understanding of the general plot, some scenes may be confusing or totally inaccessible. Indeed there are often visual aspects of a program which communicate additional elements or change the meaning of a scene in a way that a blind person cannot know if no reference to the visual information is made [3].

In a 1998 response to the U.K. Green Paper on the convergence of telecommunications, media and IT sectors [4], the RNIB noted the importance of the broadcast media in the lives of visually impaired people. In addition to the more obvious use of radio, television is equally, if not more important. RNIB's Needs Survey showed that 94% of visually impaired people use the television and that watching television and listening to the radio are in their top three leisure pursuits. Television is important not only because of the dominant role it plays in society, but for visually impaired people it can be their main source of information and entertainment. It can also provide company, particularly for those people who are housebound. Public service broadcasting is of particular importance to blind and partially sighted people, as it is often the most accessible source of information, and should be subject to some form of regulatory protection.

2.1 General Solutions and Audio Description

A number of different approaches have been adopted and some of these are outlined below by way of illustration. In a number of countries a proportion of television programs and movies on video-tape are made more accessible by audio-description, a technique in which the visual information on the screen is described in spoken text. Together with the original sound (text) in the program, access to information for

people with a visual impairment is maximised. Thus verbal commentary describing the action taking place during silent intervals of a television program is already available, for example, to blind people in the United States and Japan.

The possibility of providing audio description on television in Europe was considered by the TIDE project AUDETEL (TP169), which set out to provide television (TV) access to blind and visually impaired people by using added audio description [5]. It was suggested that commentaries could also help sighted elderly people with cognitive impairments to follow what was going on. Providing technical features to satisfy both sets of users is extremely complex. An indication of the complexity involved is clear from the style guides which are being written for broadcasters [6].

In Germany, the Deutscher Verband für Blinde und Sehbehinderte in Studium und Beruf (DVBS) started the „Project Audio Description Film" in April 1998 [7]. In the same year more than 20 feature films and 13 television series were produced and broadcasted with an audio description.

Although Audio Description is one way of making television programs more accessible, it is a very expensive approach. It is not financially feasible for most broadcasting companies to make a significant portion of their programs accessible.

3 Situation in the Netherlands

In the Netherlands, considerable focus is now placed on achieving equality of access to information, with particular emphasis on providing equal access to the internet, although many initiatives are undertaken on a voluntary rather than legislative basis [8]. Thus far, a voluntary approach has also been adopted in the broadcasting media sector.

In many smaller countries like the Netherlands, foreign programs (and texts) cause extra problems for visually impaired people. These countries often do not use speech-synchronisation for a translation, but use subtitles in the native language. Because of this, these programs are almost inaccessible for people with a visual impairment. About 30% of all television-programs in the Netherlands are foreign, and as a consequence not suitable for visually impaired people who are not familiar with the foreign languages. The translated subtitled text is of no value to this group.

In a number of countries television programs from foreign countries are provided with dubbing, a voice-over or spoken translation. Aside from the fact that these techniques are very expensive, they have also proved to be unpopular. For these reasons, in the Netherlands foreign programs are provided with subtitles.

However, standard subtitles also present problems. Research undertaken at the University of Eindhoven [9] has shown that about 180,000 people in the Netherlands experience difficulties with the size of the letters and the contrast between the letters and the background. Between 40 and 60% of elderly respondents declared that they don't have enough time to read the subtitles. *In recent study* [10] an inventory was made of all the aspects of television accessibility. One of the recommendations was to implement spoken subtitles. Because of the high costs anticipated for Audio Description, a feasibility study was suggested. In 1999 at a conference about the accessibility of television programs [11], the initiative for an implementation project for spoken subtitles was born.

4 Key Objectives

The primary goal of the project was to make television programs from foreign countries more accessible for people who are visually impaired. In addition, this service might also be useful for the elderly and people with language impairments (for example aphasia or dyslexia) or cognitive impairment (for example mental retardation or decreased concentration).

4.1 Target Audience

For many people, a reduction in visual capability comes with age. In the Netherlands most visual impairments are a result of ageing or age-related diseases.

Although it is not possible to give an exact indication of the extent of the primary group, research of the Verwey-Jonker Institute [12] has shown that about 1,2% of the Dutch population is visually impaired. This means that there are around 200.000 visually impaired persons living in the Netherlands. On average a Dutch person watches television for more than 2,5 hours per day and elderly people watch for considerably longer periods. As most of the visually impaired population are elderly, this group are deprived of information and entertainment on television because they are unable to read the subtitles.

In order to ensure that the products and services developed by the Spoken Subtitles initiative meet the requirements of the end-users, it was important to involve existing user organisations and advocacy groups to disseminate information on the Spoken Subtitles initiative. Indeed, the main organisation for representing the interests of visually impaired people in the Netherlands, FSB, has been a key stakeholder in the project.

5 Proposed Technological Solution

The technologies involved in bringing spoken subtitles to the homes of the visually impaired are chiefly speech-synthesis and broadcasting. On the end-users side a practical decoding device has been developed and piloted.

5.1 The Process from Text to Speech

The spoken subtitles are produced by an advanced text-to speech system which is situated at the NOS broadcasting company. An industrial computer which is fitted with speech-synthesis software converts the text into speech. This output is then converted into a signal.

At this stage, the signal is compressed (G 729 compression). With the help of data-broadcasting with a transmission rate of 14.4 Kb/sec it is possible to send the signal together with the television program to the consumer without disturbing the program in any way.

In order to ensure that a person can hear the subtitles that are shown on the screen, the speech synthesizer is used to create an artificial voice which reads the text out loud at exactly the same time when the program is broadcasted.

5.2 Selection of Speech Synthesizer

Before selecting an appropriate speech synthesiser, a survey of five Dutch speech synthesizers was undertaken [13]. Five speech synthesizers were compared in this evaluation

Acceptability was tested by asking 119 visually impaired respondents subjective judgements of 5 qualitative aspects of the synthesizers on a 5-point scale. Intelligibility was measured by asking listeners correctly to reproduce semantically unpredictable sentences. Fluent Dutch (Fluency Speech Technology version 1.4) was found to be the best Dutch speech synthesizer in this study, closely followed by Infovox (Telia Promotor version 2.0) and Eurovocs Soft (Technologie en Integratie version 1.2). Experience with a speech synthesizer has an effect on intelligibility scores and on judgements of qualitative aspects of speech synthesizers.

Shortly after this study was completed, a new Dutch synthesizer, namely RealSpeak, developed by Lernout & Hauspie and taken over by ScanSoft [14]. RealSpeak Text-to-Speech solution reads and converts computer text into natural sounding and intelligible voice. The technology is based on concatenation algorithms, where actual human voice segments are stored and used to convert text into speech. The basic units of the RealSpeak engine are not limited to diphones. The system uses a range of speech segments such as diphones, syllables, and also larger phoneme sequences. This mixture of voice segments and in-depth linguistic knowledge provides intelligent and human sounding pronunciation of variable text input. This software was then introduced to the user group and was found to be by far the preferred choice.

5.3 Spoken Subtitles Decoder

In order to unpack and decompress the signal, and to hear the subtitles, the end-user needs a decoder. For this project a special decoder has been developed based on criteria from the point of view of elderly or handicapped end-users [15]. (*see Figures 1*). This device, the Komfox [16] decoder by Komfa is easy to use and relatively cheap (220). The decoder can be used with either a headphone or a speaker.

6 Evaluation

As Spoken Subtitles is a new service, the NOS and the FSB decided to evaluate the value of the service to end-users. 100 visually impaired people have been given the decoder to use for a period of one year. During this year FNB has interviewed these



Fig. 1. Spoken Subtitles Decoder

people in order to gain feedback on the service and the device. The chief focus of the evaluation was to establish whether or not the service makes television programs from foreign countries more accessible in a manner which meets the needs of the end-user.

A series of questionnaires were developed to gather both qualitative and quantitative data, and the initial results were processed. The testing and evaluation phase began on the 1st February 2001 and ran until December 31 2001.

6.1 Results

The interviews were undertaken shortly after the start of the service and in the fall of 2001. The results show that most of the people who participated in the evaluation were very enthusiastic about this initiative [17].

The first evaluation found that, in general, people complained about the quality of the sound of the spoken subtitles. Users often experienced the voice as monotonous, dull and without emotion. For this reason users found it difficult to maintain a balance between the sound of the television programme and the sound of the spoken subtitles. In consequence, listening to the Spoken Subtitles required considerable effort.

As a step to overcoming some of the hurdles identified, an expert group was established. Their first task was to listen to different variations of sound qualities and to decide which sound quality was easy to listen to and to note how the intonation could be improved. After improvements in the quality of the sound were following consultation with this expert group during a second evaluation, respondents reported higher comprehension of the Spoken Subtitles.

At this moment there is only one voice that reads the subtitles. In addition, there is no break between the different sentences, with, for example, dialogue running together (eg *“Do you like a cup of tea yes please...”*). These factors make it difficult to distinguish who is saying what. It was however easier to listen to the spoken subtitles when there was a clear break between the sentences.

It was found that movies are particularly difficult to watch because there are different people talking over a short period of time. Conversely, it was easy to lose track of the context of the story where there was no-one talking for a long period.

A significant finding in the evaluation was that users want access to news and current affairs programmes with spoken subtitles. This is perhaps understandable as unpublished figures indicate that these programmes account for about 50% of the viewing content for the general 65 plus age group.

6.2 Service

The positive results led to the decision that Spoken Subtitles would be continued as a regular service of NOS. On the 14th of December 2001 the service was officially opened by Dutch Secretary of State R. van der Ploeg and the President of the Board of NOS, G.J. Wolffensperger.

In the first four months of the service approximately 1500 decoders were sold. Feed-back from users makes it clear that they prefer the simplest model. Although the number of complaints seems limited, people are dissatisfied with the fact that not all the programmes with subtitles contain Spoken Subtitles. This depends on whether subtitles are added to the images (Spoken Subtitles possible) or if the subtitles are a part of the image (Spoken Subtitles not possible). Until now only the programmes of the public broadcasting companies have Spoken Subtitling. The success of the service could be improved if the commercial broadcasting companies also added Spoken Subtitles to their programmes.

Any further improvements in the service are dependent on developments in different fields, such as text-to-speech technology and the general implementation of digital television broadcasting.

7 Conclusion

This paper has described the evolution of the Spoken Subtitles initiative and explains why it is sometimes important for television programs from foreign countries to become more easily accessible for visually impaired people.

Thirty per cent of the programmes on Dutch television are foreign programs. Since the techniques of dubbing or voice-over are too expensive and unpopular with end-users, the initiative to create Spoken Subtitles has provided a unique opportunity for a wholly new service for visually impaired end users. The inclusion of end user representatives and the public broadcasting organisation has been an important factor in raising awareness of this problem.

The Spoken Subtitles initiative automatically produces a talking version of subtitles in real time. The technologies involved in bringing spoken subtitles to the homes of the visually impaired are chiefly speech-synthesis and broadcasting. A relatively cheap and easy decoding device has been developed and piloted for end-users.

The positive results of the evaluation led NOS to the decision to continue the service of spoken subtitling on a regular basis. Initial feedback suggests the service is popular with greater accessibility, there is still room for improvement.

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Accessible Digital Media

Deborah I. Fels

Ryerson University
350 Victoria St., Toronto, CANADA M5B 2K3
dfels@ryerson.ca
<http://www.ryerson.ca/clt>

1 Introduction

The television industry is undergoing the most significant revolution since the origin of the NTSC standard in 1941. Television is without exception the last partner in the communications industry to embrace digital delivery of its transmission signal. The United States (US) and Canada have only recently begun the process of converting to digital transmission while European Union (EU) countries have been working on standards and services for digital and interactive television since 1999.

The education industry is also undergoing significant evolution that has been. The EU has released the Digital Video Broadcast (DVB) standards and implementation specifications and more recently has embraced the Multimedia Home Platform (MHP) as its iTV authoring environment [1]. The United States is implementing a separate and different standard, ATSC [2] from the DVB platform adopted in Europe and by many cable and satellite enterprises throughout the world. These different standards may spell important interoperability challenges for access solutions that already exist for the analogue systems (e.g., difference between NTSC and PAL video formats).

Direct to Home satellite services embraced digital in the mid-1990's, with cable and multi-channel, multi-point distribution service (MMDS) operators, such as Sprint and MCI WorldCom, have already begun changing over to digital and a complete change is expected within the next two years. These services have been using the DVB standard as its transmission standard. In the US, the FCC has imposed a deadline of 2004 for commercial television stations to transition from analogue to digital for over-the-air broadcasting services [3].

With all of this change in the television industry, many of the limitations of existing access solutions for television can be addressed and new solutions can be developed. However, we must proceed quickly to devise improvements in technologies, procedures, standards and interoperability or risk having access solutions become a retrofitting exercise with limited opportunities to explore new and creative ideas that take advantage, integrate with and perhaps even direct some of the new technologies rather than just comply with them.

In this paper we will present some of the issues for access surrounding the change from analogue to digital television and highlight some of the international efforts being made to address some of these issues. Efforts such as using multimedia techniques

to create enhanced access to digital video content. Enhancements include graphical objects (shapes, colours and symbols), animation (text and graphical objects) and tactile equivalents of the sound information (e.g., sound effects, music, and paralanguage) that is currently missing from text-based closed or open captions.

2 Captioning for Analogue Television

Current analog television closed captioning in North America relies upon an industry-agreed standard, EIA 608. This standard is designed to be carried in the vertical ancillary blanking interval (VBI line 21) of the analog television signal. The bandwidth offered by VBI line 21 is restrictive hence EIA-608 can only sustain a maximum data throughput of 960 bits per second. This throughput can only support limited text captions and perhaps changes in colour and font. However, it cannot support animated, graphical or other displays for captioning.

In Europe, Teletext was developed in the 1970s to provide television viewers with selectable access to additional information services such as news, weather, and sports. It is designed around a text-based page model where pages can be subtitles (UK equivalent to closed-captions), news, weather, sports pages or pages on other subjects [4]. Viewers pay for and choose the types of pages that they want to access. However, subtitling is provided as a public service and there are no charges to use it. Teletext allows for use of colour, and graphics to represent information although the predominant medium is text along with provision for different fonts, sizes and mixed-case [5].

3 Captioning and Digital Television

Since the mid-1990's, the broadcast industry worldwide has agreed to adopt a digital transport stream for digital television based on MPEG-2. Video carried by MPEG-2 is substantially more efficient than analog NTSC/PAL multiplexing for television signal carriage and as a result more bandwidth is available within the broadcast channel for future data services. A new captioning standard for digital television in North America, EIA-708, was designed with to take advantage of this expanded bandwidth.

EIA-708 supports a data rate of up to 9600 bits per second of captioning data. This extra throughput will allow many of the restrictions of EIA-608 to be lifted such as limitations on fonts, colours, caption borders and caption positioning. EIA-708 does indeed have provisions for using alternative fonts, colours, caption positioning and other options related to text-based enhancements [6]. Robson and Hutchins [7] provide a detailed account of some of the technical issues that arise with EIA-708. However, there have been few research initiatives investigating ways of incorporating enhancements such as colour, and font. There are also few available captioned examples that demonstrate even simple enhancements for broadcast content.

Digital subtitling in the UK uses the existing teletext model, inserting the bit-mapped imaged of the closed-captions into the VBI of the MPEG-2 digital video sig-

nal [8]. Colour, speed specifications (supports up to 192 kbps) and insertion techniques are different from the analogue version but the subtitling process remains essentially the same. There is no provision or implementation guidelines that take advantage of the multimedia capabilities offered by the digital environment to enhance the subtitles.

4 Issues to Address

Advances in digital television technologies require important exploration of issues around providing complete access to broadcast-based entertainment and information. We have a rare window of opportunity to examine the strengths and weaknesses of existing practices for providing accessible broadcast content, and explore ways to improve the quality and quantity of access options.

There are three main issues that we must consider in the context of closed-captioning/subtitling and digital television: 1) interoperability of international DTV access standards; 2) expansion of capabilities beyond text to better suit needs of individuals who are deaf or hard of hearing and/or overcome the limitations of existing systems; 3) explore the need for new or updated standards to reflect the integrative nature of computing, the Internet and television.

4.1 Expansion of Capabilities

With closed-captioning models, the deaf or hard of hearing caption viewer must rely on visual-only cues such as body language and gesture combined with the words and short text descriptors of other information to understand a television program. Mehra-bian [9] suggests that human-to-human communication consists of seven percent words, thirty-eight percent non-verbal linguistic modifiers (paralanguage), and fifty-five percent visual cues or gestures. While television viewers are not active participants in the human conversation of a television program, they are the intended receivers of this communication. It is through the interaction between humans on-screen, background sounds and music that much of a television program's semantics are conveyed. Without continual access to conversation modifiers and access to the paralinguistic components of human conversation, people who are deaf and hard of hearing may misinterpret or misunderstand the semantics of television, be unable to discuss the program with hearing viewing partners, and come away with an unsatisfactory experience.

Limitations in viewer reading speed [10] and vocabulary levels [11] also contribute to the limitations in the quantity and speed of text presentation. There is often only enough time and space to provide the verbatim translation of what is being said. We must therefore consider using alternative display strategies such as with graphical, animated and tactile displays to convey the additional non-verbal information such as paralanguage, music and sound effects. Fels et al [12] have begun to investigate the use of alternative displays for expressing emotion, music and sound effects for digital

television. Their initial results are very positive and viewers who are deaf and hard of hearing seem to have a different and more satisfactory experience of the captioned video content.

4.2 Efforts in New Standard Setting and Internationalization Activities

A task force of the W3C, the timed text task force [13] has been struck to examine some of the issues of creating accessible text for time-based media such as video and audio. The scope of the activities of the task force includes text associated with video such as captions (closed or open), and moving credits, animated text (Flash or Swish), and hyperlinks. The intention of this task force is to establish an operational standard that would allow digital media producers. The current proposal call for use of SMIL 2.0 as the common authoring language creating XML expressions. SVG, MathML and other standard markup languages are recommended for using for enhancements to text (e.g., graphics and equations). The proposal also suggests incorporating the timed-text standard into authoring environments such as QuickTime, and RealMedia and Windows Media so that developers can produce and play text in this standardized format rather than in the proprietary format currently used in these authoring environments. However, these authoring environments are designed to produce compressed web-based video and audio, and not video and audio for television or film. In television and film, text is often inserted with specialized editors such as captioning and subtitling systems, or digital video editing software such as Adobe Premiere, Final Cut Pro and high-end professional editors. We need to better understand the impact of a web-oriented timed-text standard on the different international television and film standards and practices.

Some of the issues that remain to be considered are: how to incorporate animated text, how text authored using this standard will integrate with DVB and EIA-708 digital television protocols, and captioning or subtitling software and industry practice, and the impact on the production industries. In addition, considerable research is required to determine whether current industry conventions are still suitable or even desirable by the deaf and hard of hearing viewers/users, and the impact of enhanced text on the viewing population.

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Electronic and Virtual Libraries: Access for Print Disabled People

Introduction to the Special Thematic Session

Jan Engelen¹ and Dominique Burger²

¹Katholieke Universiteit Leuven, Belgium
Research Group on Document Architectures
jan.engelen@docarch.be

²INSERM U483, Université Pierre et Marie Curie,
75252 Paris Cedex 05, France
dominique.burger@snv.jussieu.fr

Abstract. The group of print disabled persons consists of those who cannot use the standard printed material for their information needs because of a visual handicap (low vision, blindness), because of dyslexia or because of a severe motor handicap that makes it impossible to handle books or magazines. Also persons with a severe auditive handicap often prefer sign language information above character-and-word based information. Although more and more persons get used to access electronic documents it is absolutely vital for print disabled persons that the information is made available electronically. We will briefly describe the current status in this field and produce a framework in which the ICCHP2002 contributions can be located.

"All of us have had fantasies from time to time of enjoying full access to the publicly available collections of printed materials that our sighted neighbours take for granted" (Eric Duff)

1 Electronic Libraries

An enormous amount of libraries and library support systems are currently accessible via the web, but we will try to distinguish the different types:

1. classical (paper-) libraries with electronic catalogues providing also some electronic texts for part of their collection.

Examples are the Library of Congress, Bibliothèque Nationale de France and many others. The *ALO-books2u* initiative will be discussed in this session by M. Köttstorfer¹

¹ Marco Köttstorfer, Klaus Miesenberger, "Virtual Libraries Initiatives with usable results for Print Disabled People: ALO, books2u!, Metae", ICCHP2002

2. uniquely electronic/web based libraries providing search systems and full texts. Examples are the Gutenberg collection, BrailleNet², etc.
3. specialised libraries (Braille, talking books, sign language) with electronic catalogues and, sometimes, downloadable documents. Examples are the National Library Service for the Blind and Physically Handicapped (NLS) at the Library of Congress and the many European and American organisations for the Blind providing not only the adapted material for which they provide a bibliographical service but also different types of electronic documents.
4. webportals. Webportals are systems that permit to access a large number of services through one access point. An example of this type of service is the Dutch webportal "anderslezen.nl" which will be discussed in this thematic session³.

Setting up an electronic library is not a trivial task. Problems that will be discussed during this thematic session are:

- the technical complexities of changing from a bookshelf based library to an electronic archive [Th. Kahlisch⁴]
- document conversions (cf. also next session), automatic processing [G. Jaworek⁵]
- distribution of multimedia file types: which to choose [K. Taha & L. Petrucci⁶]
- coping with the distributed nature of electronic information [C. Moulin⁷]
- producing an added value to existing web resources, creating specialised webportals [V. Brasseur⁸]
- the accessibility of the electronic documents [A. Schmetzke⁹], cf. also the next section

A very tough aspect in information distribution is the handling of copyright issues: as electronic books are extremely simple to copy, often publishers and authors require

² <http://www.inrialpes.fr/brailenet/BV/recherche.htm>

³ A. Leeman, M. Oosting & M. Verboom, "Unlocking doors: Building an accessible on-line information node", ICCHP2002.

⁴ Th. Kahlisch, "DZB - A German library for the blind goes digital", ICCHP2002.

⁵ Gerhard Jaworek, "Perspectives and possibilities for the automated processing of scientific texts for blind and visually impaired people", ICCHP2002.

⁶ Karim Taha and Lori Petrucci, "ABA's Virtual Library Services for Blind and Visually Impaired people", ICCHP2002.

⁷ Moulin Claude, "A distributed document oriented architecture for rendering services to visually impaired students", ICCHP2002.

⁸ Vincent Brasseur, "Quick Access to Dictionaries for Visually Impaired People", ICCHP2002.

⁹ Schmetzke, "The accessibility of online library resources for people with print disabilities: latest research and strategies for change", ICCHP2002.

a trustworthy copyright maintaining chain up to the end user¹⁰. Sometimes legal measures are required to make sure that some documents can be made available at all¹¹.

2 Electronic Formats

2.1 Text, SGML, HTML, Word, WP

Electronic books and documents are made available in many different formats often depending on the abilities of the persons that are going to read them. For some time it was accepted that only pure text based (*ASCII*) documents were accessible or because of the many improvements in screen readers, also word-processing formats (*MSWord*, *WordPerfect*).

In the past several attempts have been made to come up with specialised formats, especially for persons with a visual impairment.

Since the beginning of the nineties however a general consensus on the use of mainstream (ISO) standards for structuring electronic documents has been reached. Thanks to the members of the voluntary association *ICADD*¹², active in that period (most members are now active in the *WAI*¹³), both in the US and in Europe a clear move towards the adoption of SGML (or sometimes HTML) was made¹⁴.

Document accessibility, even when written in one of these languages, is not always guaranteed and lots of work has been spent on producing guidelines for accessible documents (cf. the above mentioned WAI initiative). New insights will be given by Patil, Maetzel and Neuhold in this section¹⁵.

As is probably known, *SGML* documents never became popular on the web and HTML is layout oriented so HTML documents lack a lot of content-based structuring. As the number of HTML documents is so large, several specialised browsers (e.g. Cynthia, discussed in this session¹⁶) and add-on software packages have been developed that help visually handicapped readers to get a grip on the content of a webpage (e.g. Webformator¹⁷). Accessible interface design will be presented in this session by DeMeglio et al.¹⁸

¹⁰ Benoit Guillon, "A Secure Internet Architecture for Delivering Documents for the Blind", ICCHP2002.

¹¹ Klaus Miesenberger, "Harmonisation of the Copyright Law throughout the European Union: a challenge for all print disabled people", ICCHP2002.

¹² <http://www.rit.edu/~easi/itd/itdv02n2/icadd.html>

¹³ <http://www.w3.org/WAI>

¹⁴ B. Bauwens, F. Evenepoel, J. Engelen: "Standardisation as a Prerequisite for Accessibility of Electronic Text Information for Persons who cannot use Printed Material", IEEE Transactions on Rehabilitation Engineering, Vol. 3, no 1, pp. 84-89, 1995.

¹⁵ Basawaraj Patil, Klaus Maetzel, Neuhold, "Universal Usability Issues of Textual Information Structures, Commands, and Languages of Native Visually Challenged Users", ICCHP2002:

¹⁶ Mathieu Raynal, "CYNTHIA: An HTML browser for visually handicapped people", ICCHP2002.

¹⁷ <http://www.webformator.com/>

¹⁸ M. DeMeglio, M. Hakkinen, H. Kawamura, "Accessible Interface Design: Adaptive Multimedia Information System (AMIS)", ICCHP2002.

2.2 XML

The problems with HTML constituted the main reason why the *XML* (eXtensible Markup Language) was invented in 1995. This structuring language combined the rigidity of SGML with the simplicity of HTML to produce structured documents. XML documents e.g. do not contain layout and have to be used with stylesheets (or converted to HTML) to be displayed in visual attractive formats.

XML actually is a meta-language, a language that permits other languages to be produced. Therefore dozens of XML related standards are now gaining popularity not at least in order to be able to handle multimedia documents or to exchange information efficiently (e_commerce applications).

XML documents can be read with the current versions of the popular webbrowsers Internet Explorer and Netscape, but for efficient reading (including note-taking, bookmarks etc) specialised software is needed. This theme is discussed by B. Paepen and J. Engelen in this session¹⁹.

2.3 Daisy and eBooks

Because of the ever increasing popularity of XML at least two highly important groups have chosen to use it for their work.

The first of these is the *Daisy* consortium which initially aimed at producing a standard for talking books (assuming the audiocassette was going to disappear soon) but included navigational information or even the full text of the book in the same document. Hybrid books have been presented already at ICCHP 1996²⁰ but their current status and popularity is mainly due to the Daisy consortium.

The Daisy standard for DTB's (digital talking books) is currently at version 3. This standard describes the different files (XML and XHTML based) that constitute a Daisy Book.

Daisy books can be read by several hardware devices and by using a few public domain PC software packages (cf. the Daisy website). A rather recent evolution is the possibility to read Daisy books using Kurzweil software.

Another important evolution which is also followed up closely by the community of persons with a reading disability are the *eBooks* and especially the work by the Open eBook Forum. More details will be given in this session by OeBF chairman G. Kerscher²¹ and in the presentation by H. Petrie and G. Weber²².

¹⁹ Bert Paepen & Jan Engelen, "Using XML as a reading enabler for visually impaired persons", ICCHP2002

²⁰ ICCHP1996, Presentation by A. Arato and T. Vaspori on the Digibook project

²¹ G. Kerscher, keynote speech at ICCHP2002

²² Helen Petrie & Gerhard Weber, "Reading Multimedia Documents", ICCHP2002

Semantically Rich Markup, Should You Be Agnostic in Your Choice of a Vocabulary

George Kerscher, Senior Officer, Accessible Information

Recording For the Blind & Dyslexic (RFB&D)
Project Manager to the DAISY Consortium
<http://www.daisy.org>
1203 Pineview Dr, Missoula, MT 59802, USA
kerscher@montana.com

Abstract. At the end of the 1990's, I thought that it was critically important to have the perfect XML DTD that captured the semantics of a document. However, I have stopped searching for the "perfect vocabulary" and Started to encourage the community to look for the right mechanism to understand a vocabulary and its association to other vocabularies. This paper will briefly review the DTBook DTD, defined by DAISY3, the ANSI/NISO Z39.86-2002 specification and how other vocabularies may be associated with it.

1 Background

The DAISY Consortium's (Digital Accessible Information System) implementation of standards for Digital Talking Books (DTB) elevated the general understanding of those working through the National Information Standards Organization (NISO) as we started to develop the next generation of standards for DTB. The Current DAISY recommendation is 2.02 and is a stable specification with supported production tools, reading systems, and thousands of DTBs for users. However, this specification uses XHTML and SMIL version 1 (Synchronized Multimedia Integration Language) as the basis for the specification. It was clear that more could be achieved using the power of XML and SMIL 2 from the W3C.

On March 6, 2002, the American National Standards Institute (ANSI) approved the Standard submitted by NISO and this is now called DAISY3, the ANSI/NISO Z39.86-2002 standard. This was jointly developed by many organizations around the world, including many members from the DAISY Consortium. It is a comprehensive specification for providing DTB to end users. The specification provides the same text and audio synchronization from the DAISY 2.x, but goes much further in describing the semantics of the markup needed for a rich reading experience. The best place to go to learn about the DAISY 3, the ANSI/NISO Z39.86-2002 specification is at: <http://www.loc.gov/nls/z3986>.

2 Reading Requirements

Fundamentals of sound design demand that requirements be gathered. The European Blind Union (EBU) documented the features needed in reading systems for persons who are blind. Developments of the DAISY Consortium 2.x specifications used these as the basis for the functionality the reading system would deliver. In the NISO standards development process, end user requirements were also gathered that validated the work of the EBU and added some requirements discovered since that early report. This document is called the Navigation list and can be found at <http://www.loc.gov/nls/z3986/background/navigation.htm>

3 Theory behind the DTD

After identifying requirements, an architectural design, a strategy that guides the development of an XML vocabulary should be articulated. Among the members of the NISO Digital Talking Book Committee Numerous discussions about the proper mechanisms to deliver the required end user reading experience lead to the development of a solid theory on which to build. It is inappropriate to describe this here; it is better to read the original document at:

<http://www.daisy.org/publications/specifications/theory/dtbook/> this document does a nice job of describing the evolution and the thinking concerning the development of the DTBook XML DTD.

4 Call for Reading Systems That "UNDERSTAND" the DTBook Vocabulary

DAISY 3, the ANSI/NISO Z39.86-2002 standard is very new being approved in March of 2002. Reading systems that use the navigation model and can also take advantage of an "understanding" of the XML elements of the DTBook DTD are needed. There are different approaches that developers can take with the implementation of DAISY 3, but the one that has the best chance at providing the richest reading experience is one that uses knowledge of the semantics of the elements.

End user reading control is essential and the reading system that provides user control based on the current semantic context is the only way to deliver the ultimate reading experience. For example, while reading, if a person transitions from a paragraph to a table, the reading system should automatically understand the current context and offer the person different reading options. We have seen something similar with IBM's Home Page Reader. There are additional functions when inside a table or a form. This idea needs to be extended to all the elements defined in the DTBook vocabulary.

This type of functionality is what will differentiate one reading system from another. It is not only the presentation that changes depending on the elements as with Cascading Style Sheets (CSS), but also the synchronized auditory and possible braille presentation that must change. So the reading system must do four things: present the information visually, present the auditory information that is provided or render it synthetically, provide tactile output, and change the local navigation options depending on the context at the current spot in the DTB. I believe all persons with print disabilities are looking forward to these advanced developments; and I believe that persons with normal sight want this too, but they don't know it.

5 Current eBook Specifications Are Vocabulary Agnostic

The Open eBook Forum (OeBF) <http://www.openebook.org> defined the Publication Structure for eBook technologies. The first specification defined a basic tag set composed of a subset of XHTML. The specification also introduced the idea of an "extended" vocabulary where the publisher could use any well-formed XML element. The stipulation was that there must be a CSS style sheet associated with each element beyond the basic elements known to the reading system.

Subsequent <OeB> Publication Structure specifications are carrying this idea forward. In the Publication Structure 1.2, draft made available for public comment in May 2002, and the Publication Structure 2.0 under development, the design is vocabulary agnostic. This means that an author or publisher can pick an XML vocabulary that meets their particular needs and be assured that conforming <OeB> reading systems will visually render the information correctly.

Semantically rich XML vocabularies suited to an author or publisher's particular needs seem to be the right approach. Of course, some of the popular XML tag sets, such as the TEI or DOCBOOK from OASIS, will be used. However, the idea that we must search for the ultimate XML DTD or schema, which will never exist, is gone.

6 How Is Information Exchanged in a World of Infinite Vocabularies?

Fortunately, XSLT can be used to transform from one vocabulary in a namespace to another vocabulary in a different namespace, provided it is a sideways or downward transformation. The DTBook DTD is designed to be a conversion DTD, and I expect that publishers will want to have an XSLT transformation available to convert from their XML implementation to the DTBook vocabulary. The DTBook is well suited for a downward transformation and for upward conversion from print to a simple but highly functional XML implementation. However, this does not solve the real problem.

Yes, reading systems can present information visually using CSS without understanding anything about the semantics of an element. However, intelligent reading

systems, like the ones described in DAISY 3, the ANSI/NISO Z39.86-2002, need to understand the semantics of the elements to provide the rich reading experience the end user wants. The reason we need a semantic understanding is to provide this rich reading experience and many other uses for information that is richly marked up.

I am not attempting to answer this question in this paper; I am asking the question. It seems that current work with W3C specifications may hold some promise. The use of namespaces is clear. The Resource Description Framework (RDF) and the newly formed Ontology Working group could be relevant. I believe that these are important issues to people who love to read, and it is important to information system developers. I cannot resist stating that trying to stay informed about developments in these arenas demands time and highly talented people. It also seems that the highly talented people are having less and less time to work on theoretical problems of architectural design.

7 Short, Medium, Long Term

The DAISY 2.02 specification is stable and remains the current recommendation. Organizations can be confident in the use of this specification. The production tools, reading systems, training, and technical support are all here on a worldwide basis to assist with this implementation.

On a six to eighteen month timeframe, you can expect to see the beginning of the migration to DAISY 3, the ANSI/NISO Z39.86-2002. Plans are under way for the smooth transition to this new specification. We invite organizations to join with the DAISY Consortium to work on these technical developments. Additional plans are underway that will mean that more data will steadily become available in the DTBook XML format. To coincide with this expanded proliferation of the distribution of DTBs that are full text, there is a need for reading system developers to deliver semantically aware products that can take advantage of the power of well-designed information.

In the long term, the more theoretical and architectural issues need to be addressed. It is unclear where this work will or should take place, but it is clearly the domain of advanced high performance information science. It is the combination of agnosticism and awareness in the reading system that is the greatest developmental challenge we stand before.

Acknowledgements.



Fig. 1. Logo of the Daisy Consortium

DZB – A German Library for the Blind Goes Digital

Thomas Kahlisch

Deutsche Zentralbücherei für Blinde zu Leipzig, Postfach 10 02 45,
04002 Leipzig, Germany

Thomas.Kahlisch@dzb.smwk.sachsen.de

Abstract. The paper describes our approach to turn the talking book production of DZB, the oldest library for the blind in Germany, into the digital world.

The digital world for blind and visually impaired persons has a common name: DAISY (Digital Access Information System) is a standard and technology, which has to be developed, as a powerful tool, to produce accessible multimedia documents [1].

In a five-year time frame, DZB turns the production, archival and distribution process into a high technology level.

The presentation describes:

- How we will convert analogue tapes into a digital format [2].
- How staff members learn to produce digital magazines and to structure books.
- What kind of equipment is necessary in this process?

The main focus of this work is, to improve the access for blind people to information and provide them, with new technology, which is designed for all.

1 Introduction

A talking book library is traditionally an analogue working division, which takes care of producing, archiving and distributing books on tape to a particular group of users. To turn this library into a digital thinking and working division it is necessary to:

- educate staff members, to reorganize the whole production process
- help the readers, to use new equipment and
- very important, tell the “share holders”, that the process is expansive but useful and will be successful for all.

To get into the digital world, we began in Leipzig two years ago, with the production of different audio magazines on the computer. Staff members learned to cut and paste by using the mouse and to store audio data on disks.

Because of the remaining analogue world, most of the blind users are still using cassette recorders, we also need to work on mechanisms, to convert digital into analogue data.

Until now, the advantages of the digital audio representation, fast and high quality access to information, have not been provided to the main stream of the blind users in Germany. Currently, powerful mp3-players are available and become a less expansive alternative to the high end DAISY-Players. Many of the blind users are now familiar

with text reading systems, screen readers and Windows PCs. So that we can say, it is time for DAISY in Germany.

2 Digital Talking Book Production in the DZB

The approach described here, is the way, how DZB is solving the task. Other organizations may go different ways, depending on there current conditions.

To provide the user parallel with talking books on tape and on disk, it is necessary, to convert digital produced books back into analogue data. For this purpose, special hardware is needed, which is expansive and only necessary, until the library is not longer providing analogue tapes. We try to keep these costs low.

Also we have to consider, that the good old archive, available on tapes, needs to convert into the digital format quickly. At the DZB we have 100.000 open reels waiting, to become digital and structured into the DAISY format. If we want to solve this task in ten years, 10.000 tapes per year must be converted.

The following approach is set up to use hardware, which is already available in our studios and allow us, to provide both, the traditional cassette and the CD-ROM. That is why, most of the books are still read on tape and will be converted later into the digital format. The following section describes this digitalisation process.

3 Digitalisation of Talking Books

An analogue produced talking book is converted into the DAISY format and distributed to the users by proceeding the following tasks:

1. Analogue to digital conversion
2. Creating and structuring a DAISY book
3. Archiving and distributing digital books

3.1 Analogue to Digital Conversion

The conversion of analogue recorded data is done in five steps:

1. Analogue streams of 4 tape machines (2 tracks each) is parallel processed by a PC
2. Audio stream is stored on hard disk
3. reverse tracks are turned into the correct order
4. WAV files are checked by the operator
5. Files are stored on a DLT drive and can be used for the structuring process

3.2 Creating and Structuring a DAISY Book

DAISY technology allows to create books, which are consists of synchronized audio and text data. In the DZB we currently produce DAISY books with audio information

and a table of content (TOC). The TOC is the Navigation Control Centre of the DAISY book, which can be used by the user to explore and navigate through the structure of the book.

Structuring is a process, which has to be done by a human operator. Structuring means to define, whether a DAISY book can be navigated by using the structure elements of a book (chapter, section and subsection) and/or by page numbers.

Phrase detection and signal tones can be used in this structuring process to automate this task. DZB talking books are produced, without signal tones. That is why the operator has to do the whole process manually. In case of a novel, this is an easy task. To structure a schoolbook, it becomes to a time consuming process, which has to be carried out carefully. Staff members are trained to do this job.

3.3. Archiving and Distributing Digital Books

There are more than 7.000 talking books in the DZB, which have to be digitalized and structured. In this process different kinds of data will be produced and stored. The following kinds of data will be created:

1. WAV files are created in the A/D conversion
2. DAISY masters are created in the structuring process
3. Distribution masters are compressed DAISY masters

These data are currently stored on DLT tapes. If we get the appropriate money, we will set up a powerful archival system, which provides us with random access to the data. At the end it is estimated, that our archival system has to handle 60 T byte of information.

Distribution to the users will be on CD-ROM. To get one DAISY book on one CD-ROM, the information has to be compressed. By using mp3 encoding until 40 hours of reading can be stored on one disk. The user has one book on one CD-ROM and can use it on DAISY players like Victor or on most of the mp3 players like Rio Volt SP250, which are available on the free market.

One blind staff member in the DZB is responsible, to provide a user help desk to the customers of the library. This service is called LOUIS (Leipziger Online Unterstützungs- und Informationsservice für Sehgeschädigte Computernutzer) [3]. The service provides information via phone, e-mail and on the internet and helps the user to learn to use DAISY players and books.

4 Hard- and Software

To establish the approach described here, the following information technology is necessary:

1. Powerful production server
The server stores 1 T byte of audio data on a RAID system and is available over the network.
2. Archival system

A robot based archival system stores and refreshes t byte of data. Staff members will have access to this system by using there workstations.

3. Recording PC in the studios
All studios are equipped with analogue and digital recording systems.
4. A/D workplace
This workplace is used for the digitalisation process. It is a PC running a particular software “DZB Converter” and 4 good old tape machines, which are delivering the analogue input.
5. Authoring workstation
It is a pc to create and structure DAISY books.
6. Powerful CD burning and labelling system
It is used to create the distribution media.

The following special software is used:

1. DZB Converter and SAMPLITUDE
The “DZB Converter” is developed by a small company in Leipzig called Marian, Internet: www.marian.de. The software has been adapted for some other libraries for the blind in Germany. SAMPLITUDE is a main stream audio production software developed by SEKD in Dresden, Internet: www.sekd.com.
2. LPStudio Pro and LPStudio Plus
These are the DAISY production tools. The software is developed by Labyrinth Data Systems, Internet: www.labyrinthen.se.
3. Structured Editor
Is a powerful XML Editor to produce DAISY books. It is created by the Danish Library for the Blind, Internet: www.dbb.dk.

5 Time Frame

The DZB schedule is set up in a five years time frame, to establish technology to turn the production process into the digital world.

2002 is the year of planning the project and to start with the digitalisation. At the end of this year, we will have 100 DAISY titles available to our users. In autumn we will begin with 25 test users, to see what we have to improve before the full service can be provided to all.

2003 and 2004 it is scheduled, to set up a powerful archival system and to speed up the digitalisation process.

2005 and 2006 are the years we will look carefully to Braille and Large print book production with DAISY technology.

This is our time frame how it looks today. But you know, things often change rapidly in the digital world. And we do not know exactly how fast things will develop and what kind of requirements will guide us into a different ways.

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Harmonisation of the Copyright Law throughout the European Union – A Challenge for All Print Disabled People

Ruth Hammerschmid, Klaus Miesenberger, and Bernhard Stöger

integriert studieren – integrated studying, University of Linz, Altenbergerstrasse 69, A-4040 Linz, Austria, info@aib.uni-linz.ac.at

Abstract. On May 22, 2001 the European Parliament and the European Council launched the “Directive on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society” [1]. This paper wants to stress the importance of this directive for print disabled people in all European countries. The directive on the one hand is a chance to guarantee access to the information society – a thing all other citizens take for granted. On the other hand, the lobbying pressure of the publishing industry may cause more difficulties in the future. Following the directive, it is up to the national legislation to decide on exceptions and special paragraphs to take the needs of groups like print disabled people into account. This paper will present the most important aspects of the directive from the point of view of service providers for print disabled students. “integrated studying” is an Austria wide service provider for print disabled students who has managed to get more than 80% of the documents which have to be prepared for print disabled students in digital formats. Further on, this paper will review activities throughout Europe and outline activities how international exchange could and should support the lobbying at national level.

As a concrete example, the situation in Austria will be discussed: We shall outline the most important regulations of Austrian Copyright that are relevant for disabled users. Next, we shall closer discuss those aspects of the Directive that concern access to works for the print disabled. Finally, we shall present a proposal how a non-discriminating implementation of the Directive into Austrian Copyright Law could look like.

1 Introduction

Statistics, although varying considerably concerning definition criteria for disabilities, let us estimate that a range of 10 – 20 % of European citizens with disabilities and/or elderly people could benefit from access to documents in digital formats using Information and Communication Technology (ICT) and Assistive Technologies (AT). [1] Access to documents has to be seen as a fundamental human right in the Information Society. Fundamental advances in accessibility and usability of documents in the Information Society are already recognized as a democratic necessity. Without such advances a large part of the population would be excluded from the Information Society.

There are estimations summarising the need for a better access to documents for print disabled people: Only 1-3 % of all publications are currently made available to print disabled individuals.

2 The Need for a Legal Framework for Service Provision

Service providers for print disabled people have been and still are closely related to digitisation or access to documents in digital formats. The Gutenberg revolution brought forward print disabilities. With more and more books becoming part of everyday life, reading skills, access to books and education based on documents became a prerequisite for taking part in almost any part of society. Therefore not only more possibilities to choose, to store and to use knowledge were brought forward; people became forced to use these possibilities, which established print disabilities as a social problem. "Post Gutenberg", since the beginning of the 80ies, print disabled people get access to documents more independently and efficiently by using computers. Offering access to documents in accessible formats strongly depends on the rights to digitise, produce and distribute documents in accessible format.

On the other hand, usage of digital documents via the Internet asks for possibilities that publishers and authors can protect their rights and interests. Service provision for print disabled students therefore has to be integrated into the workflow management system of the publishing chain and especially has to employ Copyright Management Systems (CRM). In any case, the possibilities to get access to this business ask for a strong position in the negotiations what could be provided by the changes in legislation caused by this directive.

3 The EU Directive on Copyright Law: Impact on the Print Disabled People

We will outline critical areas of the directive [2] asking for engagement that the human rights of print disabled people in access to information are taken into account when putting the directive into practice:

1. The idea of the directive is to put an open European market of goods into practice. The directive therefore intends a high level of protection for the rightholder in the market and especially for intellectual property rights. Basically this intends a more restrictive legislation. Does this mean that print disabled people and service providers are dependent on the good will of stack holders in the future?
2. Making copies will be much more protected, especially the copying of digital media. Is a simple storage of a copy on a service provider's PC for making materials accessible allowed?
3. Presentation, distribution and publication of documents is the right of the owner. Is OCR allowed in the future for personal or service provider purposes? Can accessible documents be exchanged? Can service providers charge fees for their work?

4. National legislation can make exceptions, e.g. for people with disabilities. How could they look like? How to lobby for a personal right to get access, how to lobby for a legal framework for service providers?

4 National and International Activities

Based on the analysis outlined above the activities of an Austrian platform working for an adaptation of the legal framework according to the human rights of print disabled people will be presented. This platform prepares a proposal for exceptions and a petition to design the new law in a way that print disabled people can fully participate and benefit from the new Information Society. A discussion of activities in other countries and other organisations should reflect these activities (e.g. RNIB, European Blind Union, ONCE)

This paper intends to foster the activities of different parties around Europe working for a more open legislation taking the human rights of print disabled people into account.

5 International Activities: European Blind Union

The European Blind Union (EBU) constituted a Copyright Working Group. this group seeks to influence legislators and rights holders so that the above mentioned barriers can be removed and the right of the print disabled to read can be universally recognised.

1. As a result of the group's activities, at its meeting in Denmark on 12th May 2001, EBU agreed to recommend to the Liaison Commission and to the Board that EBU adopt the following set of criteria as a means of judging proposals for legislation in relation to copyright and visually impaired people. These criteria are to be seen as complementary to the position paper adopted by the Board in 1998. "We seek legislation which:
 2. asserts visually impaired people's right to equitable access to all published information ;
 3. enshrines rights, and does not merely create vehicles for permission or licensing ;
 4. is not tied to particular formats or particular technologies ;
 5. is future proof ;
 6. focuses on the individual end-user, not the format ;
 7. takes account of the fact that alternative formats may be legitimately produced by a wide range of organisations and by individuals ;
 8. acknowledges that access may be sought at or from home, school, workplace, library or any other context.
 9. acknowledges that the creation of alternative format versions from lawfully acquired originals on a non-profit basis, with controlled distribution amongst visually impaired people, does not constitute an infringement of copyright and thus requires no permission."

Further information about the EBU Copyright Working Group can be found in [3].

6 Relevant Aspects of the Austrian Copyright Law

If you want to produce alternative formats, you are necessarily faced with issues of copyright, especially with questions of reproduction. This can be seen from §42 Austrian Copyright Law – Reproduction for individual use.

§42 of the Austrian Copyright Law constitutes a central regulation that allows reproduction for individual use at least in a restricted manner:

§42 (1) Everyone may produce single copies of a work for individual use.

"Everyone" means natural as well as artificial persons. "For individual use" does not specify whether usage is done at home or within a company for business purposes. Thus, both are permitted.

§42 (2) Publicity: The first sentence addresses the purpose: An act of reproduction is not considered to be for individual use if its purpose is to make the copy available to the public. Since this regulation backs mechanisms of bypassing, the second sentence explicitly states that reproduction of a work with the aim of making it publicly available is not considered to be for individual use.

§42 (3) According to this, schools and universities have the right to make copies for teaching purposes, the number of copies allowed depending on the size of the class. It thus seems that §42 (3) might solve the problems of disabled students: For example, a portion of a piece of literature may be digitised and made available to a disabled person attending a course.

However, the last sentence of §42 (3) contains a constraint critical for disabled students: The right to make copies for personal educational use is explicitly denied for works which, by their nature, are meant for use in a school or teaching environment. Hence it is not permissible to reproduce scientific text books, not even parts of them, and to make them available to students.

§42 (5) imposes a constraint, inasmuch as the reproduction of a whole book or periodical requires in any case the consent of the copyright owner. This applies also if the reproduction is not based upon the book or periodical itself, but, for instance, on a digital version stored on a server. Downloading of such a digital version to a local hard disk would mean a reproduction of the whole book or periodical.

Exceptions to this forbiddance of reproduction are provided if the book or periodical is copied by hand, e.g., by typing from the keyboard, too. It also does not apply to works that are not issued or that are exhausted, and also not to works to which §42 (4) item 1 can be applied.

It can be readily seen from the above that the present legal regulations of free usage of works are not sufficient for disabled users.

Without consent of the copyright owner, the following aspects of work usage, although indispensable for those who need alternative formats, are forbidden to them:

- Digitisation of whole books or periodicals
- digitisation not even of parts of books which, by their nature, are meant for teaching purposes

7 Relevant Aspects of the Information Directive: Free Use of Works and Technical Protective Measures

7.1 Free Use of Works

Article 5: Exceptions from the actions that require consent according to Articles 2, 3, and 4:

Of special interest here is Article 5 (3), which optionally provides for exceptions to the reproduction right and to the right of public presentation: Should the Member States make use of one or more of these exceptions, they might also provide for an exception to the right of distribution.

Article 5 (3) b permits an exception for uses for the benefit of people with a disability, if the use is directly related to the disability and if it is of non-commercial nature, to the extent required by the specific disability.

Recital 43: It is in any case important for the Member States to adopt all necessary measures to facilitate access to works by persons suffering from a disability which constitutes an obstacle to the use of the works themselves, and to pay particular attention to accessible formats.

Article 5 (5) states that the exceptions provided for in (1), (2), (3) and (4) shall only be applied

1. in certain special cases, which
2. do not conflict with a normal exploitation of the works or other subject matters, and
3. which do not unreasonably prejudice the legitimate interests of the rightholders. (Three step test).

The application of the three step test can therefore lead to a claim for refunding or compensation also in cases that are not explicitly mentioned in Article 5.

Consequently, a free use of works for disabled persons must be directly related to their disability. A situation in which such a relationship can be seen occurs, for instance, when persons who are disabled by problems accessing printed materials require a reproduction in a digital format. "To the extent required by the specific disability" makes clear that this particular form of reproduction is allowed, whereas an additional printed copy is forbidden: For this kind of reproduction is not required by the specific disability, e.g., blindness; on the other hand, making a second copy in Braille might be legal.

In any case, however, regulations of free use according to Article 5 (3) are optional, such that it is up to the legislator which shall be implemented and how far the exceptions will reach in reality.

Recital 45: The exceptions and limitations referred to in Article 5 (2), (3) and (4) should not, however, prevent the definition of contractual relations designed to ensure fair compensation for the *rightholders* insofar as permitted by national law.

This means that, according to the Information Directive, it will be allowed to respect free use that, by itself, does not require the consent of the rightholders, within contractual claims of compensation.

7.2 Technological Protective Measures

Article 6: Obligations as to technological measures: This article binds the Member States to the creation of legal protection against the circumvention of technological measures designed for the protection of works against unauthorized usage.

Article 6 (4) states that the rightholders may, by making agreements or by taking any other voluntary measures, facilitate free use of works for favoured persons in spite of technological protection measures. In the absence of such agreements or other measures, however, the Member States are obliged to ensure that those favoured by free use of works may nonetheless access the works to an extent justified by due usage. All this, however, does not apply to works or subject matters which, by contractual agreements, were made available interactively (online) to the public. (Article 6 (4), subparagraph 4)

Hence, if the legislator implements free use of works for disabled individuals, he has to ensure also that lawful access to this usage is not prevented by technological measures, for the case that the rightholders do not make agreements with the grantees or take any other measures appropriate.

Article 13 (1) provides a time of 18 months for the implementation of the Directive into national legislation.

8 A Draft of an Implementation of the Information Directive into the Austrian Copyright Law, Issued by the Federal Ministry of Justice

This draft was compiled in the end of 2001 by the Ministry of Justice. It is the basis for a future government proposal, which shall then be presented to Parliament. It is up to Parliament to finally pass the implementation of the Information Directive.

§42 of the Copyright Law shall be altered as follows: According to the Directive, there will now exist several kinds of reproduction, namely, one for individual, and one for private use. Furthermore, a distinction of various storage media will be made:

Reproduction for individual and for private use

§42 (1) Everyone may produce single copies from a work on paper or a similar media for individual use.

(2) Every natural person may produce single copies from a work on other media than those named in (1) for private use, for ends that are neither directly nor indirectly commercial.

In the newly planned §42 (2), artificial persons such as associations, universities etc. are excluded, and only private use will be permitted. This means that digitisations are no longer allowed, e.g., for the purpose of an association or for purposes of business.

The regulation concerning reproduction for educational use remains virtually unchanged; it is only pointed out that copies on media other than those named in (1) may only be made for the pursuit of non-commercial aims.

Apart from this, as far as free use of works is concerned, the draft does not contain any essential modifications. A proposal for an implementation of Article 5 (3) b of the Directive, on the behalf of the Ministry, is still missing.

Also missing is a procedure to safeguard access to free use of works despite technological protection measures, as demanded by Article 6 (4).

9 A Concrete Implementation Proposal

The currently valid §42 (5) of the Austrian Copyright Law, that remained largely unchanged by the draft of the Ministry of Justice with the exception of the forbiddance of reproduction of musical notes and the renumbering to (6), shall get a new last half sentence which implements Article 5 (3) b of the Directive:

§42 (6) However, the following ways of reproduction are always permitted only with the consent of the rightholders:

The reproduction of entire books, entire periodicals or music notes, if it is not done through copying by hand, or concerns a non-issued or exhausted work, or under the hypotheses of (5.1), or for the use in favour of disabled persons on the media mentioned in (1) and (2), if usage is directly related to the disability and is of a non-commercial nature, to the extent required by the specific disability.

§42 (6) is to permit the reproduction of entire books, of entire periodicals, and of music notes for the benefit of disabled persons, on all media. As long as it cannot be guaranteed that the rightholders supply suitable formats for disabled users, it seems reasonable not to prevent, by legal constraints, at least the people concerned, but also others, from putting entire books, entire periodicals or music notes into suitable formats.

We interpret "for the use in favour of disabled persons" such that it must be possible both for natural and also for artificial persons to put works into suitable formats. It is hereby indispensable to allow reproduction on all media, i.e., on those mentioned in the draft, §42 (1) and (2), because only this way the technological possibilities available for disabled users, especially digitisation, can be employed without violation of law. The limit of the number of copies hereby has to be seen always relative to the circle of people who need alternative formats. The way of reproduction will depend on the requirements of the specific *disability*.

The current §42a shall be changed as well in connection with the implementation of the Directive. It provides that single pieces of reproduction may also be made at command for individual use of another party, namely free of charge, but, under certain conditions, with payment also. Now, since the division of the new §42 (1) and (2) will be adopted, herein an exception for disabled users needs to be provided for also:

§42a (1) Single pieces of reproduction may be also made at command and free of charge for the individual use of another party, in the fashion outlined in §42 (1).

(3) In another way than that mentioned in §42 (1), Reproductions according to (1) and their presentation are permitted for the exclusive use by people with a disability, if the usage is directly related to the disability and is of a non-commercial nature, to the extent required by the specific disability.

§42a (3) ensures that single pieces of reproduction can also be made at command for disabled people.

While §42 (6) is to allow the production of accessible formats to associations for their disabled members, to universities for their disabled students, to disabled persons for themselves etc, §42 (3) shall form the basis for the production of single works in

accessible formats at command also for persons not pertaining to a certain organizational unit.

This will furnish the legal prerequisites granting a disabled individual, at least at command, access to a work of his/her interest that a non-disabled person may buy, e.g., in a bookstore, without any problems.

The implementation proposal presented in this paper was addressed to the Federal Ministry of Justice by an Austrian "Copyright Platform", which consists of disabled people and institutions committed to the production of alternative formats for the print disabled. Unfortunately, at the time of writing it can not yet be reported whether, and in which way, the proposal is accepted.

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A Distributed Document Oriented Architecture for Rendering Services to Visually Impaired Students

Claude Moulin¹, Sylvain Giroux², Dominique Archambault³, Davide Carboni¹,
and Dominique Burger³

¹ CRS4 - Center for Advanced Studies, Research and Development in Sardinia,
VI Strada Ovest, Z.I. Macchiareddu, Uta (CA), Italy

{moulin, dadaista}@crs4.it

² Dept. of Mathematics and Computer Science, University of Sherbrooke,
Sherbrooke, Canada,

sylvain.giroux@dmi.usherb.ca

³ INSERM U483 / INOVA - Université Pierre et Marie Curie
9, quai Saint Bernard - 75252 Paris cedex 05 - France

{Dominique.Archambault,Dominique.Burger}@snv.jussieu.fr

Abstract. This document presents the elements of a flexible architecture that allow delivery of services adapted to visually impaired students. Services are published in a service portal so that they can be found from any station of an intranet. The architecture is open because it is possible to add new resources and services to the system without modifying any component. It is flexible because although foreseen for a distributed environment, it is possible, with some restrictions, to adapt it to a local environment. Sharing a common model, the services do not deal individually with the user's device but supply declarative knowledge that the system user interface interprets.

1 Introduction

This document presents a distributed and flexible architecture for deploying services adapted to visually impaired pupils. It is one Vickie project axis¹ whose main objective is to facilitate the integration of visually impaired pupils.

We begin presenting two situations that led us towards the design of the architecture. They put in evidence its fundamental elements and their respective roles: application server, service portal and user interface. The first use case shows a pupil working at school with a computer connected to an intranet; the second one shows the same pupil but working with a disconnected computer.

We then present the way that pupils are perceiving the system. They don't know whether they are using a net and they don't even know what is a net. They don't think about services but objects like books or games that they can open

¹ Vickie stands for Visually Impaired Children Kit for Inclusive Education

and close. We so adopt the metaphor of the desktop to hide the service level to pupils.

Next, we describe more in details the architecture elements in the distributed environment. Section 4 focusses on the multi modal user interface in order to introduce both the service model that the system requires and some document types that are exchanged between services and interface.

2 Designing the Architecture

2.1 Use Cases

First Use Case. At school, each room where a visually impaired pupil may follow courses is equipped with braille terminals linked to computers connected themselves to an intranet. Visually impaired pupils first have to launch an application, give their login and password for authentication and then can begin to work with their own objects. They can open a book, surf the internet, write duties in their diary, play with a game, etc. We called this application the Vickie User Interface (VUI). It is the user entry point in the environment. The same procedure may be followed from any computer by any pupil, which means that personal documents are not stored locally but on a server.

The second element of the architecture is the application server which is a piece of software running on the dedicated server station, that has to fulfil two roles: maintaining user sessions to deliver and update personal documents and deploying services. Services are pieces of software that allows users to work with their personal objects. They are deployed on the server station, move to the user's station where they can then be dynamically integrated by the VUI.

Services are independent from the architecture elements. So, the system is open and may receive new services without being modified. Obviously services should respect the model imposed by the system. Services are deployed and published by the application server in a place where they can be found later by the VUI from any computer of the intranet. This place is called the service portal and is the third element of the architecture (Figure 1).

Second Use Case. Pupils owning their own laptop would like to work both at school and at home with the same Vickie environment. We designed the architecture to take in consideration this demand. When arriving in the classroom, the pupil has to connect the laptop to the net and the VUI begins first by updating server documents with those on the laptop that may be more recent. Then the pupil's work reverts to the same as the first case. Before the pupil goes away, the VUI updates documents in the other direction, server towards laptop, and locally caches services. At home the VUI notices that the computer is not connected and discovers services in the cached portal instead of in the remote one. Similarly, those services look locally for documents to read.

Main differences between these two use cases are concerning the personal documents place and the service access. When the laptop is disconnected, the

VUI locally launches a reduced application server functionality locally creating an user session that allows documents to be read and written. Obviously in these circumstances, it is not possible to deploy new services. Not all services can be cached but it is however possible for visually impaired pupils to carry out duties at home just as sighted pupils do.

2.2 The Desktop Metaphor

Taking a typical classroom situation, when a teacher says to all pupils: “open your math exercise book at page 20”, it would be interesting to observe the sighted pupils taking their actual math exercise book out of their schoolbag while the blind pupils open their electronic math exercise book from their desktop. All the pupils are thinking of objects. But, the virtual math exercise book is managed by a piece of software that allows to read, write and change pages. We were guided by this principle to design the system architecture. We considered the Vickie electronic learning environment as much as possible as both an usual computer desktop and an actual classroom environment.

There, one can find objects like books, agendas, games or calculators. All these objects must be managed by software when in real life they are directly manipulated by people. We added also to the desktop, electronic utilities like browser, mail or library, and documents like texts, messages or HTML pages.

We thus defined a service as a piece of software, distributed or not, that delivers information on request and allows working with a document, an object or a utility. The desktop service presents the pupil environment as a list of things of these three types. The existence of applications that deals with them is completely hidden.

Each user possesses his/her own desktop. It is stored as an XML [9] file containing the desktop entries. A desktop entry may refer to a document and more generally to a resource, shared by all users or not. The following example shows a partial desktop.

```
<desktop>
  <vickie-desktop-object type="object">
    <name>Dictionary: English - Italian</name>
    <category>Dictionary</category>
    <service-identity>crs4.vickie.dictionary</service-identity>
    <reference>eng-ita-dic.xml</reference>
  </vickie-desktop-object>
  <vickie-desktop-object type="object">
    <name>Memory</name>
    <category>game</category>
    <service-identity>crs4.vickie.memory</service-identity>
  </vickie-desktop-object>
  ...
  <vickie-desktop-object type="utility">
    <name>Library</name>
    <category>room</category>
    <service-identity>vickie.library</service-identity>
```

```

</vickie-desktop-object>
</desktop>

```

3 Architecture Elements

We saw in the previous section that the dynamic element of the system is the service. Its life cycle illustrates the architecture and its three main components: The application server, the service portal and the user interface. In a distributed environment [4], each of these components may run on different hosts, but for convenience both application server and service portal may be on the same one. Obviously, the user interface has to be installed on any user workstation because it is the user entry point into the system.

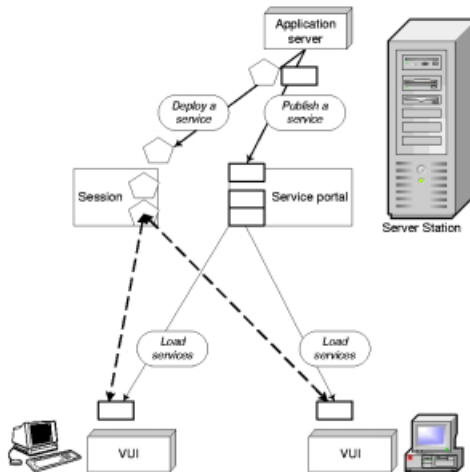


Fig. 1. Distributed architecture

3.1 Application Server

The application server has the duty of deploying new services. That means launching the server session of a service (the pentagon in Figure 1). This part of a service runs on the same workstation as the application server. It runs even if no users are connected to the system. The application server has also the duty of publishing services. That consists in storing a piece of each service (the service proxy represented by the rectangle in Figure 1) into the service portal; this part will move dynamically to any host that will require it. This object gets stored with additional information about the service. Deployment and publication are executed once for each service.

All services are persistent. For their deployment, the application server requires a packet with all classes and resources that allows the creation of the

objects that compose it. It also stores this packet. The application server normally runs continually but if necessary it is possible to shut it down. Thus, when starting up again it retrieves the saved packets and deploys all previous services.

The application server uses the server file system to store resources used by services as dictionaries or as any kind of document. From the application server, it is also possible to add new resources to be managed by installed services. It is also possible to remove a service from the service portal for example to substitute a new service version.

3.2 Service Portal

The service portal may be seen as a reservoir of objects, some of them being service proxies stored by the application server. When a user launches the VUI on a station, it begins by discovering all Vickie services, that means looking up the service portal and requiring all objects that have the Vickie signature. These service proxies move up to the VUI station. There, they are added to other code elements and can be exploited as all other VUI components.

Once arrived in a VUI station, they can contact their server session since they contain a reference about the server which created them. Subsequently services are completely independent of the service portal. This is useful because it simplifies service discovery and translation.

It might be interesting to exploit the service portal in another way: since any kind of objects can be dynamically stored there and thus discovered later, it is possible for running services to do just that, and so to communicate between them. We tested in particular, the implementation of events distributed between several stations but we still have to study further services that might use this possibility. To simplify the architecture and software installation, the service portal and the application server are both installed in the same station though they are completely independent.

3.3 Service

Services are entities split in two elements: a server session and a proxy. The server is committed to create and maintain the user sessions. These are work spaces reserved to users. Each service may store temporarily information concerning a user in the corresponding user session. The proxy is stored in the service portal and can move, or more precisely copy, to any user station. In normal situation, each service owns one server session and several proxies running in different user stations.

The service organization depends on the nature of the service and choices of implementation. The service work is divided between these two parts. Services with an empty server session, also called autonomous services, are maybe easier to conceptualize and implement. Service logic is then completely deployed by the proxy in the user station. Conversely services may have very light proxies that serve only to communicate with a remote part. Obviously, may exist intermediate solutions as well.

All services may use resources stored in the server file system. They only have to contact the application server. It knows how directories are organized and can deliver them. The resources may be shared between all users or belong to only one.

3.4 Local Environment

When a computer is disconnected, the VUI launches a local environment, but its use must be considered as a temporary episode between two actual sessions with net access. It consists in a local service portal and in a light version of the application server that can only read and write resources in a specific directory of the local file system.

The VUI must anticipate such local situations. First, it has to synchronize distant and local resources. Then it has to know what services may be serialized and cached locally when they are loaded. Services are published with additional information that the VUI can read. In the resulting service descriptor one can find the particular name that identifies the service and whether it may be cached.

When running locally, two functions of the environment are very different: The way to find services and the way to access resources.

4 Vickie User Interface

Many researches are concerning the design of user interface for visually impaired people. Even if they are more web oriented [10] results are very useful for us. The Vickie User Interface is the user entry point in the system. It is an autonomous application that runs on every local station. After the user identification, it looks for all vickie services and provides handles for them to the desktop service. The VUI consists mainly in two elements: the Service Interface (SI) that deals with services and the Device Interface (DI) that deals with devices (Braille terminal, screen, keyboard and text to speech engines).

For visually impaired people, any information has to be first transformed into the form of a text (lines of characters). This information comes from external resources or may be completely built on the fly. All services, even particular ones like games for example when representing boards, have to deliver texts. This information must be presented not only to impaired people but also to sighted people who follow them.

This multi-modality [1] is not assumed by services themselves: that would be a conception mistake in this kind of architecture [3]. Services do not build a user interface (UI) but they delegate [7] this role to the DI, sending XML documents that represent declarative knowledge for building it. Figure 2 shows a common communication sequence between services and VUI elements:

- 1: the first time the service is used, it receives a `getMainUI` message from the SI. It supplies three XML documents: The first will be rendered by the DI as a text to read and/or modify, the second as a menu and the third one

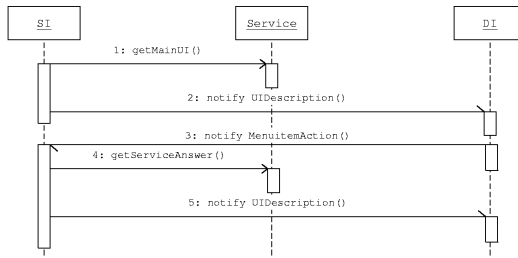


Fig. 2. VUI sequence diagram

contains the description of elements that the user may add in the text, for example a word underlining.

- 2 and 5: The SI notifies service answer elements to the DI.
- 3: The user activates a menu item and the DI notifies the SI, sending two XML documents: the first one is an updated version of the XML document it received and the second contains the selected menu item.
- 4: the SI gets an answer from a service after a user specific request, as in step 1.

We reused the concept of annotation [2] to structure the XML documents. The basic element, annotation, represents variously a menu item, an input field or an HTML link. The system defines some annotations but a service may add other ones. The element attributes give indications to the DI on the way how to represent it and serve also for the service to analyze user's answers. In the following example `tts` attribute gives the sentence sent to a text to speech engine. The `properties` attribute is a string containing key value pairs. The service which added the action key uses it to determine the next task to undertake. Since many services are multilingual, it is not possible to exploit directly the element content.

```

<annotation tts="select menu item"
  type="menu-item"
  properties="key=a;shortcut=ENTER;modifier=ALT;action=select"
  lang="en" >a - select a word</annotation>
  
```

5 Conclusion

Our system was designed to run on the most popular platforms such as Windows and Linux. We leveraged the use of standards for both implementation and documents writing. For these reasons, we chose Java as the implementation language. It is widely used throughout the world and includes many qualities that we needed. The Java RMI (Remote Method Invocation) packages allow easy remote object access. The JINI technology [6] based on Java simplifies service publication and discovery. With Java serialization and dynamic class loading, it is possible to move code from one station to another.

We chose XML [9] paradigms for writing documents exchanged in the system. We mainly used XML for writing service profiles (following the W3C guidelines [8]) and interface description, and for communication between services and VUI. This involves not only document structures, transformations [5] and presentations but also object marshalling to obtain documents.

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² The content of this paper is the sole responsibility of the authors and in no way represents the views of the European Commission or its services.

ABA's Virtual Library Services for Blind and Visually Impaired People

Karim Taha¹ and Lori Stefano Pertucci²

¹ Association pour le Bien des Aveugles et Malvoyants,
34, Place Bourg-de-Four,
1204 Geneva, Switzerland
ktaha@abage.ch

² Netfonix,
10, Rue de Blavignac,
1227 Carouge, Switzerland
lori.petrucci@netfonix.ch

Abstract. Today, Internet technology provides a multitude of low-cost solutions for small organizations to become on-line services providers. On the other hand, advances in assistive equipment and software interfaces expanded the opportunities for blind and visually impaired people to communicate and access information via Internet. In this context, the ABA conducted a pilot project with the aim to offer on-line library services to its beneficiaries. Several issues have been raised during this project concerning digital content production, access, protection and distribution via Internet.

1 Introduction

The ABA is a non-profit organization based in Geneva, Switzerland and providing different services for the blind and visually impaired people. Among its services, the BBR assumes the production, maintenance and distribution of Braille and Talking Books in the form of a lending library. During the past two years a pilot project has been conducted with the CUI from University of Geneva with the goal to provide:

- Digital equivalent for Braille and Talking Books archives.
- An up-to-date online catalogue of available transcribed Braille books and recorded talking books.
- An interactive loan system where users can retrieve books and order them.
- Online and Offline Talking book listening system accessible for blind and visually impaired people.
- An accessible web site general information about the library

For online distribution of content we must provide our publishers sufficient guarantees for protection and use of copyrighted material. Although juridical issues are still open and Digital Right Management technology is still young, we wanted to an-

ticipate by realizing a DRM prototype that can offer a set of guarantees we may be asked to provide in the future.

2 Digital Content Production

2.1 Current Production

The BBR maintains two production services: one for Braille books and one for Talking Books.

Braille Book Production. A Braille book is produced from original printed one, which BBR buys. It is scanned using OCR resulting in a draft book in digital textual format. The draft is sent to volunteers for proof reading. The corrected book is then passed to Braille specialists who add tags using a proprietary language. The marked up book is finally sent to a Braille Embosser. Due to copyright limitations, the original book is destroyed and the digital intermediate files are archived for backup. The processing time for Braille production is about three weeks.

Talking Book Production. The BBR has its own recording studio for analogue Talking Book production. Volunteers read books that are recorded in 90mn compact cassettes with an average of 6 hours per book. The master set of tapes is stored as archive collection and a duplicated set is circulating among subscribers.

Talking books are more and more used because the proportion of subscribers with low vision problems due to oldness is increasing. The inconvenience nevertheless is the loss of book's logical structure. As a result, moving from one page to another or going back and forth among chapters is rather cumbersome.

2.2 Moving to Digital Content: The Reasons

The question of moving to digital content production rose for many reasons. First, Digital Talking Books (DTB) and E-books can offer a better usability for our users. Formats such as DAISY [1] provide a new generation of standardized DTBs with navigation and access features equivalent to those in traditional media. The second reason is that we believe that within few years, analogue technology will be unaffordable and difficult to manage. The third reason is the opportunity to use Internet as complementary channel of services and content distribution.

2.3 Issues in Digital Archiving

To set up a system for digitizing our archive we had to make some technical and organizational assessments according to a set of requirements listed below.

Guaranteeing Perenniality. One major concern in building archives is perenniality of content. We still hold audiotapes dating from early sixties. 40 years old talking books can still be played and duplicated as long as our players are working and tapes surviving humidity. This chain of dependency is very short and implies two components: the reader and the medium. In digital world, the chain gets much longer. Longevity of medium, availability of readers, dependency between software, hardware and formats are additional influencing factors. Insuring optimal perenniality in this framework is not only safeguarding media but also making chain of dependency as weak as possible.

Choosing the Medium. Digital storage technology offers a multitude of possibilities within two mainstream technologies: optical and magnetic storage. We chose the first one for two reasons. First, there is a lack of a dominant magnetic tape standard. They are mostly used for professional purposes and it's very difficult to predict their popularity in the coming years. Second, magnetic tapes are more fragile and needs more strict storage conditions. On the other hand, CD-R is a well-standardized storage media; it is expected to be more future-safe and requires less precaution in handling.

Choosing the Format. Choosing the right format may avoid the situation where archived content becomes obsolete because of unaffordable software/hardware configuration to render the content. It is also a dilemma between size and future-safety. For textual content, ASCII remained popular because of its simplicity. In digital Audio the Wav format has similar advantages. MP3 could have been a possible choice but we think that as an end-user format, its popularity will decrease when less greedy format will be available. Another important benefit from wav format is the easiness to build homemade applications for processing digital audio from this format.

Choosing the Content Structure Another important issue in building digital content is defining the right master. It is matter of how can we insure that not only content will be perennial but also how to keep it tied to its metadata.

One great thing about digital storage media is that textual audio or any other digital content can be stored in the same medium. We therefore chose to include with every archive CD a textual metadata file additionally to the audio ones. This is an additional future-safety feature because it makes every item self-descriptive and loosely tied to cataloguing system. Of course, for library business it is also important to keep a reference pointing to management data in the catalogue. For encoding metadata we will use MARC fields.

3 The Virtual Library

3.1 Digital Services

The BBR provides traditional lending services for its beneficiaries. Members receive quarterly catalogues of novelty items in different formats: Braille, large characters,

audio or ASCII files. The circulation policy is based on the *wishes list* concept. Each subscriber fills a list of wishes and sends it to the library or simply submits it by phone. Books are sent to subscribers as soon as they are available.

Our goal in the pilot project is to provide digital equivalent of some of these services including: Online wishes list submission, Online lending system, Online up-to-date catalogue and Online listening system. We believe that Internet interfaces offer some features that will enhance the way visually impaired people access information. In the next section, we discuss the implementation of these services in our prototype.

Building Web Interfaces. W3C's Accessibility Initiative (WAI) provides a set of guidelines [2] for building web interfaces. They are essential but not enough. Each type of Web interfaces has its one requirement. The main problem is that complex pages with navigational features are bi-dimensional while assistive technology restricts blind people to a linear flow of information. We also have to keep in mind users with low vision. Text and Background contrasts, fonts must be considered.

In our prototype we implemented our virtual library with an Ecommerce-like web site including navigational and search features. We will not discuss how WAI guidelines have been implemented but we will focus on few tips that we found useful.

Indexes. To access relevant content, blind users often have to parse long, irrelevant and confusing parts such as indexes. They cannot get rapidly the information they need. On the other hand, indexes may be useful in other situations. To work around this, we added hidden links at the top of pages to jump directly to main content and moved vertical indexes to the left side of pages

Shopping Cart for the Wishes List. To add a book to the wishes list user can search or navigate through our catalogue. To add a book to its wishes list a user simply clicks on a link. He is then redirected to his shopping cart where he can chose to add, remove items or submit it to the library system.

The Accessible Online Listening System. On important service we are offering is the online Talking Book listening system. Users can listen to streamed content or download the whole file. For this purpose we integrated an accessible audio reader offering all standard controls. We also added a book marking system to memorize locally the position where user stopped the last reading. Users can manage also a virtual bedside that memorizes locally all books that are currently read.

Evaluation. As said earlier, there is a set of basic HTML encoding rules for accessible pages. These rules can be checked by validation tools such as Bobby [3]. However a Bobby approved site cannot claim to be fully accessible because colors, contrasts and some navigational features can hardly be automatically checked. It's important to have feedback from users. Tests have been conducted with some of our beneficiaries and professionals and the site has been tested with WebSound [4], Jaws [5] and Home Page Reader [6].

4 Content Distribution and Protection

As bandwidth is growing and getting cheaper, we believe that Internet will be an interesting complementary channel to traditional Talking Books distribution. People trained to Internet usage can use a web Browser to download or listen a Talking Book anytime and hopefully everywhere.

4.1 Legal Issues

The ease with which digital content can be copied and redistributed makes copyright protection a tedious task. Especially when dealing with content that has long-term value such as Talking Books.

In matters of copyright, the project raises important issues regarding the reformatting and distribution of digital content over the Internet. Lot of questions is still without clear answer. What titles can be published? How ABA's added value is considered? Can we beneficiate from exceptions since we are serving visually impaired people? These complex issues will not be discussed in this paper and we will limit our discussion to technical issues assuming that we are allowed to reproduce our current circulation model.

4.2 Digital Rights Management Systems

In short terms, a DRM system is a technology used for protecting intellectual properties from illegal or inappropriate use. A DRM system usually has three components: content protection software at the content holder side, a license server at a trusted party side and a content viewer at the client side.

4.3 General Requirements for DRM Systems

Evaluating existing DRM systems may be influenced by many general factors that can be of technical, commercial or organizational nature. In this evaluation both end-users and content providers' requirements must be considered.

Requirements for Users.

Portability: One ambitious goal of Internet-based distribution of digital content is offering access to information anytime and everywhere. It will be very constraining for users if they cannot listen their talking books while traveling or on their bed. Therefore DRM must be portable among devices.

Persistence of Rights: Users don't want to loose rights to access a specific content when they purchase a new device or any time a hardware or software failure occurs. There must be a mechanism to backup those rights on client or server side.

Ease of Use: users mustn't be annoyed by additional interfaces and procedures each time they access or purchase content or transfer it to other device. This is even more problematic if those interfaces are not accessible for blind and visually impaired users. DRM clients must provide most transparent procedures.

Privacy: Information about consumer usage of content is important and sometimes essential for DRM mechanisms. Privacy is therefore infringed. However, this is not a major problem for our system since librarians have always been informed about users' preferences. It is however important to inform about what is traced and what is not.

Requirements for Content Providers. Currently, no discussion has been engaged with editors. It is therefore difficult to predict their needs. However, some general requirements must be guaranteed

Unbreakability: There is no illusion about it. No DRM system is 100% unbreakable. Successful systems will always attract skilled and determined hackers. So how can a system be considered as reliable?

Experiences from pay TV and DVD industry shows that even breakable solutions can have commercial success. Security requirements seems to be more and more limited to how high is the bar that makes hackers and dishonest users' job as difficult and time-consuming as possible. Anyway, currently no DRM system can avoid digital Audio from being recorded from analogue output and re-digitized with acceptable quality.

Users Identification: In some distribution models content providers must ensure that only subscribed users access protected content. In this the DRM system must include reliable user authentication mechanisms.

4.4 ABA's Circulation Model

Because of copyright limitations, the ABA cannot distribute more than one copy of a Talking Book or a Braille Book at the same time. Every printed book that is transcribed or recorded is destroyed and the copy is kept.

Our traditional lending model is based on three constraints:

- Only users who have proven to be blind or visually impaired can lend a book from our library.
- Only one copy of a title is lent at the same time.
- The duration of loan is limited in time.

The goal of our DRM prototype is to reproduce this model in digital world.

4.5 Implementing the Circulation in Virtual Library

Rights to access, copy or transfer a Talking Book are materialized by a license. Since no remote control can be operated, the only way to protect from unauthorized use is to encrypt the content and prohibit the usage unless a license is acquired.

The DRM System. For implementing our distribution model we chose Microsoft's DRM solution (WORM SDK) [7] for two reasons. It was at that time the most documented system and it was easy (and free of charge) to get modules and licenses for developing and evaluating our prototype. The solution consists of set of tools that allows production of protected digital content. It involves the following entities

Content Producer: The organization or person that produces digital audio (it is not necessarily the right owner). In this framework, audio content should be encoded in Microsoft's Audio Streaming Format (ASF).

Content Packager. This entity secures content before distribution. At this side the WORM SDK is used to encrypt audio files by a private key

Content Distributor. This entity manages the delivery of secured content via a web site, a streaming service or in other medium.

The License Issuer. This entity issues licenses for packaged files. When a client requests a license for playing an audio file the license server generates the decryption key associated to the media file. The issued license is bound to user's computer. Additional business application can be run at this side for controlling license distribution.

The Client. At the client side, the media player checks if a license has already been acquired for the content. If not, the license server is located and requested. The issued license is bound to user's computer. The user has the possibility (if not limited by the rights) to transfer a media file to a portable device.

The Prototype. In our prototype, tests have been conducted with rights limiting number of plays. License issuing has been limited to its basic functionality without any business application.

We came to a set of conclusions: First, our current traditional lending policy can be implemented using this technology but needs to be completed by usage metering and license management modules. During license distribution process some interfaces were inaccessible for Blind users. We were obliged to use silent identification. Another limit is that this solution is not global. Only proprietary files can be protected and we need to implement a separate solution for textual books. One additional inconvenience is that licenses are bound to computers. This is a serious limitation for the "access everywhere and anytime" paradigm.

5 Conclusion

In this article, we presented current work to create a fully accessible virtual library for blind and visually impaired people. The goal of this library is to give online access to our catalogue, online lending interface and online Digital Talking Book listening system via a fully accessible audio reader. We have shown by our prototypes the feasibility

ity of most of our requirements in digital production and accessible interfaces and we are currently working to provide fully functional systems.

For protected distribution of content, a lot has to be done both on juridical and technical issues. Even if the prototype was limited to its basic functionalities, we learned a lot. The technology is evolving rapidly and we hope that in one or two years affordable and reliable solutions will be on market. This will allow our beneficiaries to experience new channels of information while ensuring content right holders that their intellectual property is not misused.

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Libbraille: A Portable Library to Easily Access Braille Displays

Sébastien Sablé and Dominique Archambault

INSERM U483 / INOVA — Université Pierre et Marie Curie
9, quai Saint Bernard, 75 252 Paris cedex 05, France
Sebastien.Sable@snv.jussieu.fr

Abstract. The TiM project intends to develop and to adapt computer games for visually impaired children. In order to achieve this project a library which allows to easily access Braille displays was developed. This library provides all the functions needed to write text on the Braille display, directly raise Braille dots as well as receive the keys pressed on it. On top of that this library works with many different types of displays and is freely reusable.

1 Introduction

1.1 The TiM Project

The overall purpose of the TiM project (Tactile Interactive Multimedia computer games for visually impaired children) [2,3] is to offer computer games intended for visually impaired young children of various levels of psycho-motor development. These games are planned to be used by the children in an autonomous way, without assistance of a sighted person, like it is the case for sighted children with hundreds of titles.

TiM games will be described in a high level generic language independent of the representation or modality. Those games scripts will be interpreted by a game platform running on most operating systems.

To reach the needs of the children aimed by the TiM project, the platform will be able to render those games to all the specific devices they use, each are corresponding to a specific modality:

- tactile boards,
- Braille displays
- speech synthesisers
- customisable graphical displays (scalable font prints, adjustable colours and contrast...)

1.2 Support of Braille Displays

An important issue for the TiM project is to supply the support for as many existing models of Braille displays as possible, that are used currently and that

each child may have, as well as being able to add drivers easily when a new model comes on the market.

Indeed, Braille displays are generally extremely expensive (starting at 5000 Euros). It makes it very difficult for organisations to have several different models to develop drivers and for users to buy a different model.

Since there was no existing standard library to access Braille displays, it appeared that the development of a Braille library (Libbraille [1]) was crucial for the TiM project.



1.3 A Collaborative Approach

The high cost of Braille devices, and the fact that many manufacturers do not release publicly the protocol of their devices, explain that there was no standard API for Braille displays. A way to bypass this problem appeared to make this a collective project.

By allowing other people to use and improve the library to suit their own needs, we could share our improvements and finally correctly support a large number of devices.

That is why the code of the library was released under the *GNU Lesser General Public License* (LGPL) [4] which is used by many projects including the famous Linux. This allows people to freely copy, distribute and/or modify the library as long as they provide their enhancements under the same license. Developers who want to use the library can freely link it to their programs without any restriction.

The library was also designed so that it could be as generic as possible. This means that it should be used in any project that requires Braille functionalities.

Indeed other projects had already been done that used Braille displays. Some like *BRLTTY* [5] or *BRASS* [6], where quite advanced, however they were complete screen readers and the Braille functionalities were not independent, so that it was very hard to reuse them in other projects. The protocols used in those programs were integrated in Libbraille when the license allowed that, but with a focus on re-usability.

2 Features of the Library

This library is responsible for all the low level interactions with Braille displays. Text can simply be written on the display, or Braille dots can even be directly raised independently. It is also possible to get the keys that have been pressed by a user when the device has such keys.

2.1 Architecture

The library is organised in a modular way. A first layer provides a simple API to developers who want to access the library. This is done through a set of functions starting with the `braille_` prefix, like `braille_init`, `braille_display` or `braille_read`.

At initialisation and according to a configuration file, this first layer will load a device dependant module. This module implements the low level interaction with a given Braille terminal protocol and depends on the manufacturer and model of Braille terminal.

This module must use a lower level layer that provides a set of common portable functions to all drivers in order to communicate through the serial port, or to log some debug information.

2.2 Internationalisation

The TiM projects aims to access the widest possible concerned population, and in this focus, multilingual features has been integrated from the beginning of the development.

Many different Braille tables are used in different countries and even among different users of the same country! Those tables make the link between the ASCII and Braille representation of a character.

The library already supports the ability to switch between many different tables and a user can easily create his own.

2.3 Portability

Another important concern was that the library should not be limited to one system. So it was developed using a very portable ‘C’ code. Then the library works under all versions of MS Windows (as a dll library) but also under most Unix systems (as a shared library). It should be easily ported to other platforms if needed.

It was also very important that the library could be accessed from different languages. Thanks to the “*Simplified Wrapper and Interface Generator*” [7] software, it has been possible to very easily generate bindings with others languages. Currently *Python* [8] is supported and a *Java* binding is under development.

Other languages supported by SWIG (Tcl, Perl, Ruby, Mzscheme or Guile) should be very easily added if needed.

2.4 Supported Displays

Here is a list of displays that are supported sorted by manufacturer :

BAUM Vario
HandyTech Braille Wave
EuroBraille Scriba
ONCE Eco - Braille 20
MDV MB 408S
Pulse Data International BrailleNote

Some of the models are quite recent like the BrailleWave (HandyTech) or the BrailleNote (PDI), and many of them have completely different features (like the number of cells and the number of keys). The library was designed in order to facilitate design of drivers for new devices.

Other drivers for the following manufacturers are under development or have not yet been physically tested: *Alva, Blazie Engineering, EuroBraille, Tactilog, Tieman, Telesensory Systems Inc, Navigator and Papenmeier.*

3 Usage Overview

3.1 Initialisation

Interaction with the Braille library is done through functions starting with the `braille_` prefix¹. Those functions are declared in the `braille.h` header.

The `braille_init` function should be called before any other function of the library. It will load the correct driver then initialise and configure the Braille display.

3.2 Displaying a Simple String

The simplest way to write something on the Braille display is to use `braille_display`. It must be called with a string and will display that string on the display. Simple!

```
braille_display("test started");
```

When displaying text, the Braille representation is calculated according to a Braille table which can be customised by the user.

3.3 Advanced Dots Displaying

There is a more complex function to display when a better control of what is displayed is necessary, for example when displaying something other than text. What will be displayed is a combination of text and a filter that directly manipulate dots.

¹ The source code of a complete example is available in the annexes.

Then you use `braille_filter` to modify directly some dots. The first argument of `braille_filter` is an unsigned char corresponding to which dots have to be activated.

The n^{th} dot (as shown on figure 1) can be activated by setting to 1 the n^{th} bit of the first parameter. So to activate dots 7 and 8, the value 00000011 in binary or $2^6 + 2^7 = 252$ in decimal must be given. There is a `BRAILLE` macro that calculates this value: `BRAILLE(0, 0, 0, 0, 0, 0, 1, 1) = 252`.



Fig. 1. Each cell is made of 8 dots numbered in the traditional way like represented on this figure

The second argument is the number of the cell which has to be modified, starting at 0. So in this example, dots 7 and 8 are set on the 24th cell of the display

```
braille_filter(BRAILLE(0, 0, 0, 0, 0, 0, 1, 1), 23)
```

Finally, `braille_render` is called. This function filters the text given by `braille_write` with the filter defined through `braille_filter` and send the data to the Braille display.

3.4 Typing with the Braille Keyboard

It is also possible to know which keys have been pressed on the Braille display with the `braille_read` function. This function returns a structure of type `brl_key`. This structure has an attribute named `type` concerning the type of key pressed.

If this `type` is `BRL_CURSOR`, the `code` attribute contains the number of the pressed cursor routing key starting at 0.

If the type is `BRL_CMD`, then a function key has been pressed on the Braille display. The `code` attribute contains a code depending on the function key. There are many codes which can be found in the `braille.h` header file.

If the type is `BRL_KEY`, then the user has pressed a standard ASCII code on its Braille display. The `code` attribute gives the ASCII value.

3.5 Stopping the Library

Finally, the `braille_close` function must always be called when closing the Braille library. It will unload the driver, free resources and close the library.

4 Current Status and Further Works

Libbraille is already a well working library used in different projects requiring Braille displays support.

The Free Software model appeared to be an excellent model for the development of devices drivers and many users contributed to the project.

Indeed other libraries were created following the same model for the TiM project (libspeech which can drives many speech synthesis and libboard a driver for tactile boards).

The library is far however from supporting all the existing models of Braille displays. This can only be achieved if this library is advertised enough so that owners of those devices can collaborate to improve the library...

The following enhancements are also planned to be included in libbraille:

- Support for more models of displays: it depends on the collaboration of people with those models or of manufacturers
- Java wrapper and in general any language if possible: the aim is to make of libbraille some “universal” Braille library usable by anyone
- Development of a virtual driver: with a virtual Braille keyboard displayed on the screen. This will allow developers to create Braille enabled programs, without owning an expensive Braille terminal for test purpose
- Development of a simple configuration front-end: at this time, the focus has mostly been on the developer aspect of the library. It is planned to improve the user friendliness by adding a simple configuration back-end
- Ability to configure keys layout: this is a medium term objective that should be very useful for users. It will allow users to customise the layout of keys on the Braille keyboard at runtime, depending on the software they wish to use

More information can be found at: <http://libbraille.sourceforge.net>

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Annexes

Usage Example in C

```
#include <braille.h>

int main()
{
    // Initialising the library
    if(!braille_init()) {
        fprintf(stderr, "Error initialising libbraille\n");
        return 1;
    }

    // Displaying a Simple String
    braille_display("test started");

    // Advanced dots displaying
    char *hello_msg = "more complex test";
    braille_write(hello_msg, strlen(hello_msg));
    // Raising dot 7 and 8 on characters 1 and 24 of the Braille
    display
    braille_filter(BRAILLE(0, 0, 0, 0, 0, 0, 1, 1), 0);
    braille_filter(BRAILLE(0, 0, 0, 0, 0, 0, 1, 1), 23);
    braille_render();

    // Typing with the Braille Keyboard
    while(1) {
        brl_key key;
        key = braille_read();
        switch(key.type) {
            case BRL_NONE:
                break;
            case BRL_CURSOR:
```

```

        printf("cursor: %d\n", key.code);
        break;
    case BRL_CMD:
        switch(key.code) {
            case BRLK_FORWARD:
                printf("reading further right on the display\n");
                break;
            ...
            default:
                break;
        }
        break;
    case BRL_KEY:
        printf("braille: %o, code: %d, char: %c\n",
            key.braille, key.code, key.code);
        break;
    default:
        printf("unknown type %d\n", key.type);
    }
    usleep(100);
}

// Stopping the Library
braille_close();
exit(0);
}

```

Usage Example in Python

```

$ python
Python 2.1.3 (#1, Apr 11 2002, 00:19:11)
>>> from libbraille import *
>>> braille_init()
libbraille 0.9.0
Processing file: /usr/local/etc/libbraille.conf
Braille device: /dev/ttyS0
Braille driver: libbrailleno (Fake)
Dot Translation Table: french.tbl
Braille display: 1 row of 40 cells.
1
>>> braille_display("hello world!")

```

CYNTHIA: An HTML Browser for Visually Handicapped People

Mathieu Raynal and Mathieu Serrurier

Daumas Informatique SA,
Paris Cyber-Village
204, rue de Crimée
75019 Paris, France
{raynal,serrurie}@irit.fr
<http://www.daumas-informatique.fr>

Abstract. This paper deals with an HTML browser for visually impaired people, named CYNTHIA. After a short description of the principle and techniques of interaction, we present the two conception approaches of the intern structure of this browser: the first one integrates VOICEXML and a structure for the visual information. The other one is based on a chained structure allowing both the interaction and the presentation of information. We compare these two approaches and give the results in terms of conception and time.

1 Introduction

Nowadays, a lot of documents are available on the Web. This wide range of information should theoretically be accessible for everyone. Although many studies were done, resulting notably in the WAI's recommandations [1], very few HTML documents follows these guidelines.

Currently two possibilities are offered to visually impaired people to have access to Internet: either they use a commercial navigator (Internet Explorer, Netscape ...) coupled with a screen reader such as JAWS [2] or VIRGO [3] or they use specialized navigators such as HOMEPAGE READER [4], PW-WEB SPEAK [5] or BRAILLESURF [6] for instance.

INOVA[7] studies which had led to the design of BRAILLESURF, allowed us to know the both blind persons' and partially sighted persons' needs for presentation. We aim at testing the contribution of new technologies to these specialized browsers. Moreover, for the visually impaired people, the vocal interaction is one of the main ways to present information. VOICEXML[8], which is a XML-based markup language used for the spoken man-machine dialogue, seems to be appropriate to convert HTML file and its graphical presentation into a vocal presentation.

This paper firstly presents our HTML browser CYNTHIA. We will then discuss two design approaches used for CYNTHIA development, one using VOICEXML and the other including a chained struture. We will finally compare those two methods by underlining their advantages and limitations of design and efficiency.

We aim at defining the efficiency of VOICEXML for the interaction through HTML documents for blind and visually impaired people.

2 CYNTHIA Description

2.1 Principles Retained for CYNTHIA from INOVA Studies

CYNTHIA is based on the principles already tested through the BRAILLESURF[9] navigator. We have integrated technologies which appeared to be able to improve portability (thanks to Java language) and interfacing (with SAPI¹[10] interface for the output). INOVA studies focus on blind person's and partially sighted persons' needs (fontsize, color ...). According to these ones, we created our user interface, with a specific presentation of information.

Before approaching the description of CYNTHIA's internal structure, we are going to introduce our system specifications.

2.2 The Techniques of Interaction

CYNTHIA's architecture allows to add new input and output modalities. Actually, to interact with the browser, the user can only use the keyboard. If interaction was only limited to browsing the HTML document, we could have used spoken commands, as these ones have already proved in the past their efficiency [11]. But the problem of the misrecognition in fields input remains. In order to avoid these errors, we decided to focus on the keyboard as the only input modality available for the moment.

The user interface combines the vocal and visual modalities. The visual modality enables the partially sighted to have a persistent access to the information. The vocal modality aims at giving the blind people the possibility to acquire the same information. The synthesized text is in parallel highlighted on the top of the graphical interface allowing to use both vocal and visual modalities simultaneously. And this allows the visually impaired persons to be able to work more easily with sighted persons.

2.3 Adaptability: A CYNTHIA's Property

With our browser, we give the user the possibility to configure its interface according to his needs. Once the configuration is realized, all the documents will be presented according to these specifications which are saved by the browser. Our hypothesis is that a user could have difficulties with certain configurations (like a black font on a white background). It is for this reason that neither the CSS², nor their extension Acss³ defined by the W3C are taken into account. Only the name of HTML tags and the arguments they contain are interpreted to present document information.

¹ Speech Application Programming Interface

² Cascading Style Sheet

³ Aural Cascading Style Sheet

2.4 The Functioning Principle

The functioning and navigation principles in CYNTHIA are the following one: after having recovered the HTML file on INTERNET, the purpose is to extract from it the textual information, to interpret those that are normally visual⁴ and to restore the whole to the user via the dialogue manager.

For the whole part concerning the analysis and the conversion of the HTML file into an internal representation structure, we analyzed two approaches of conception (see Fig. 1). On the one hand, we realized this part with an integrating structure of VOICEXML. On the other hand, we realized a second version of our navigator with a chained structure representing the HTML document, allowing to compare and to estimate the possible contribution of VoiceXML to the navigator.

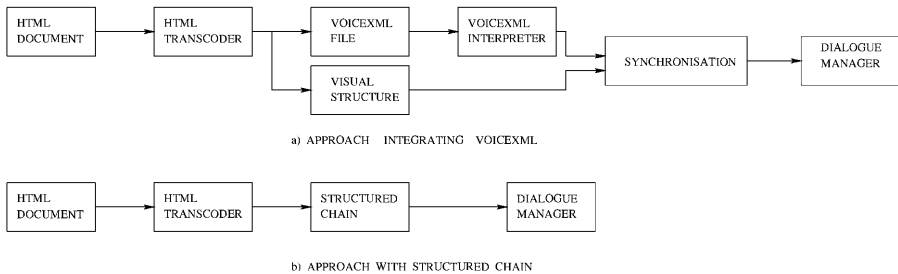


Fig. 1. Representation of the two conception approaches

3 Approach Integrating VOICEXML

3.1 VOICEXML Description

VOICEXML is a language published by w3C[12]. VOICEXML is based on XML principles: it brings an answer to all XML specifications, and offers description markers. This is one of its main advantage as many tools are available to create, transform and parse XML format [13].

VOICEXML is defined to design spoken man-machine system⁵. It offers to the user voice interaction technique based on ASR⁶ and TTS⁷. This appeared to be an advantage as we wished to offer voice as main modality. Moreover,

⁴ that is to say extract from tags the textual information which could replace the graphical representation, like the argument ALT of an IMG tag

⁵ VOICEXML is mainly designed for the conception of interactive voice system accessible by phone

⁶ Automatic Speech Recognition

⁷ Text To Speech

HTML and VOICEXML are two markup languages. So, the HTML conversion to VOICEXML seems to be relatively simple, for numerous concepts and tags.

Considering these main advantages, we realized a browser integrating an internal structure based on VOICEXML.

3.2 Structure Description VOICEXML

To integrate VOICEXML to our navigator, some preliminary tasks had to be completed before rendering to the user the HTML document information.

- on one hand, VOICEXML allows only vocal presentation of the information. To fulfill this lack of presentation, we realized a structure, called visualization structure, storing the necessary data to visualize the HTML document information;
- on the other hand, VOICEXML is an interpreted language. When receiving an HTML file, it must be converted into VoiceXML file. Once this preliminary step completed, the VoiceXML file must be interpreted, so that the user may interact with the file information.

To take into account these contingencies, the processing steps of CYNTHIA are:

- HTML file recovery,
- HTML file conversion to VOICEXML, with, in parallel, the visualization structure generation.

As soon as these steps are completed, a dialogue manager gives using commands to VOICEXML interpreter. It will be in charge with the information rendering to the user. Dialogue manager controls simultaneously the vocal output with the graphic interface.

4 Our Structural Approach

This method objective is to exploit the VOICEXML advantages and consider its contingencies. We therefore created a structured chain. Each node represents a part of an HTML file, which can be either text or data located between an opening markup and a closing markup, or markup arguments which may give complementary information to the user.

On one hand, in each node, the information is stored twice: there is firstly information which is display on the screen, and second time for information which is vocally synthetized. The information is stored for each output modality, because what will appear on screen and what will be announced by the synthesis may be slightly different.

As example, a link called "ICCHP website"
On a visual browser, the graphic interface will be:

ICCHP website

On CYNTHIA navigator, the graphic interface will be:

[**ICCHP website**]

and the synthesis will announce:

link ICCHP website

On the other hand, in each node, we have the possibility of allotting an action. This action represents the possible interaction with information contained in the node. Each type of interaction is represented by an attribute and / or a method in the node. If the interaction type is not mentioned for an information, the corresponding attributes will be null. Thanks to this process, we have a structure where nodes can represent any interaction type.

5 Preliminary Comparison of These Both Approaches

The both approaches for this navigator realization are based on its representation structure of the HTML content and interaction mechanisms. Despite the differences between the structures, the user interface and his option remain the same. Information presentation and navigation into the document also remain similar from a structure to another.

5.1 VOICEXML Limits for This Type of Application

Although some functionalities are similar between HTML and VOICEXML, these two languages differ on many points:

- The VOICEXML specification lies on information presentation under the form of dialogue. The dialogue is described by a tree which defines the different ways of reading a document. In HTML, the way of reading a document is suggested by its graphical representation, which is not systematically explained in the code (as an example, the sense of reading a table is not obvious). It often happens that a web page must not be read in the sense, in which it has been encoded.
- In many cases, the conception of a web page does not allow to read it entirely. The target is to access to information the faster possible, and to have the possibility of reading it more closely later. It is very difficult to generate automatically an accurate synthesis for a document, encoded in HTML: it then appears necessary to have the possibility of jumping a part of the document, of reviewing it or launching a research. But the VOICEXML specifications do not make it possible. If a research is launched, we may access to any part of a document, and this is impossible to be defined thanks to the dialogue tree.
- Some HTML markups are rather difficult to translate into VoiceXML. For example, there are anchor markups in HTML: the interaction is represented in the same way as a link, making possible to point up directly on a precise

part of the document, and not systematically on its beginning. This action, coming regularly in HTML documents, can not be realized with VOICEXML markups.

These differences make impossible to interpret in a standard way a VoiceXML document.

5.2 Performances Comparison

Tests processing. Tests have been carried out on processing execution times for these both representation structures. We aimed at calculating the time required to present the content of an HTML document. This time was estimated from the file reception by the navigator to the moment of the information restitution to the user. The tests were performed with a 1Ghz computer with 112Mo Ram. These tests were carried out on 7 differently sized files, containing the most representative HTML documents markups. Each file was tested on both version navigators of CYNTHIA, the first including VoiceXML and the second without VoiceXML (see Fig. 1). For each file, and each navigator, tests were performed 5 times. The 5 test results were so slightly different, that average result was taken as reference.

Results analysis. The experience times are mentioned in the Tab 1.

Table 1. The files sizes are indicated in ko. Times are indicated in milliseconds.

File size	Time VOICEXML	Time without VOICEXML
10	750	70
20	1200	150
50	2700	350
100	5500	800
200	13000	1550
500	35500	3500
1000	86000	8750

It appears that computing times are ten times superior with the navigator integrating VOICEXML. For explanation, the structure is more complex to generate: as already mentioned in the structure description, the structure consists of two parts. Even if the HTML file is converted into these two parts, we may think more time is required for this double conversion. But there is consequent difference between both structures: after the HTML file conversion, the VOICEXML structure has to interpret the VOICEXML file previously generated. This interpretation is only completed in this structure and represents a large analysis part. The second point is, whatever structure is concerned, times evolution according to the file size is linear.

5.3 Conclusion and Perspectives

When comparing these both approaches, VOICEXML structure appears not to be adapted for this type of application. Considering the language flexibility and the conversion process, the structural approach seems to be more efficient.

In the context of the European project VICKIE[14], whose aim is the conception of an electronic schoolbag dedicated to visually impaired pupils, CYNTHIA will be useful as base work. In this case, the navigator's using will be enlarged to different documents based on other VOICEXML languages. With the aim of interpreting more complex documents, VOICEXML limits are too consequent to carry out the project with this structure. The structural approach appears to be the most adequate solution, as it is not based on a specific language and offers more flexibility.

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A Secure Internet Service for Delivering Documents for the Blind

Benoit Guillon¹, Dominique Burger¹, and Bruno Marmol²

¹ Université Pierre et Marie Curie B23, INSERM U483,
75252 Paris Cedex, France

{benoit.guillon,dominique.burger}@snv.jussieu.fr,
<http://www.snv.jussieu.fr/inova/>

² INRIA Rhône-Alpes,
38334 Saint Ismier, France
bruno.marmol@inrialpes.fr

Abstract. The access to written information is essential for the inclusion of individuals in modern societies. At school, at work it is an important success factor. At home it is source of pleasure and cultural development. In this paper we describe a service that has been developed to improve the cooperation between the different actors involved in producing an distributing books in alternate formats for visually impaired persons.

1 Introduction

Different techniques can be used to produce documents for visually impaired persons : Large print, Braille, audio recording, digital audio, electronic publishing. In any case the format of the original book has to be modified in an alternate accessible format. The adaptation of documents involves a co-operation between three types of actors (figure 1)

- original publishers which own the Intellectual Property Rights (IPR) of the document. In many countries their agreement is mandatory for any adaptation of the original document, even if nor the content or the meaning are modified.
- adaptation centres which have the necessary expertise in producing alternate accessible formats. These centres ask permissions to original publishers. In some cases they obtain the electronic files of the documents in order to process them on computers. Finally, adapted documents are distributed to end users
- In some cases specialised printing centres use electronic files produced by adaptation centres to print the versions in Braille or large print [1].

In spite of efforts made by these organisations, the needs for adapted documents are not fulfilled. Most of the books that are published every year have no chance to be read by visually impaired people. The reasons are numerous :

- Very often adaptation centres and specialised printing centres are small sized organisation with a limited production;
- Original publishers give permissions too slowly - if not reluctantly.
- When provided by publishers, files of books are often in electronic formats that cannot be processed easily;
- Coordination is not sufficient. It is often observed that the same book is adapted simultaneously by different organisations.

The Internet and electronic publishing provide an opportunity to create a cooperative framework where :

- Adaptation and printing centres could cooperate;
- The adaptation process would be more efficient;
- Resources could be shared;
- IPR would be better guaranteed.

The masterpiece of this framework is a secured Internet server, Helene, which has been developed jointly by the INRIA and the University Paris 6 in France. It has been tested out in 2001 and 2002 with users in real situations and several aspects have been enhanced accordingly. The server Helene is currently run by the BrailleNet association.

This paper describes the features of this server.

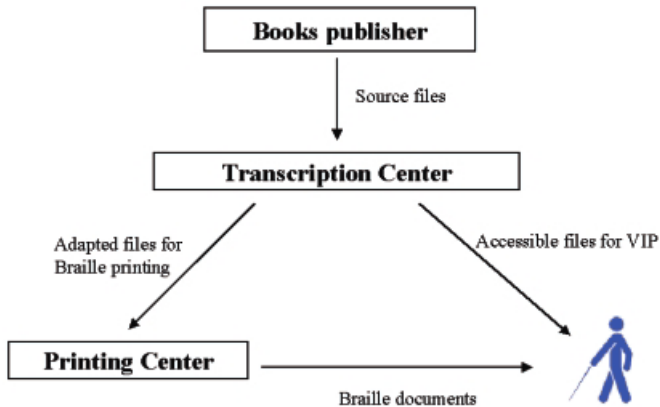


Fig. 1. Adapting books for visually impaired users.

2 Architecture

The figure 2 illustrates the main functions of the Helene server which are 1) to store files securely and 2) to deliver them to authenticated users over the

Internet. In this section we briefly describe the different parts of the Helene server.

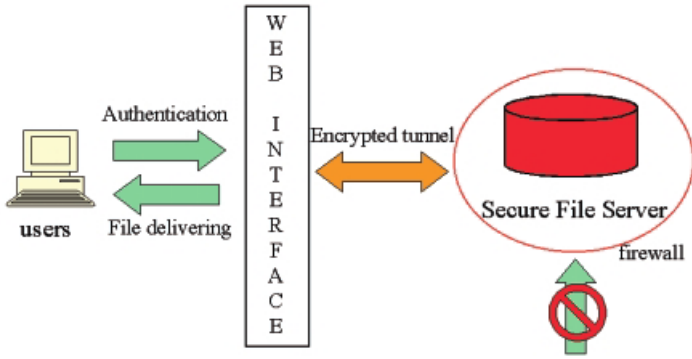


Fig. 2. General Architecture of the Helene Server

The Helene server is composed of two UNIX servers:

- A Document Server is used to store the files under copyright. It is insulated from the Web by a firewall based on the ipchains software provided by the GNU/Linux 2.2.x kernel. The integrity of the server is periodically checked by the tripwire software.
- A Public Web Server provides the interface between end-users and the Document Server. It provides a public catalogue describing the documents. Requests can be formulated according to several criteria. Bibliographical data are described in XML files, indexed in a MySQL database. Perl and CGI (Common Gateway Interface) have been used to implement the functionality of this catalogue, including : administration facilities (monitoring access to files), advanced search, a newsletter, ...

This Public Web Server also manages HTTP authentication of users who request secured files. Authentication is made on basis of a login and a password encapsulated into HTTP requests sent from the user to the Web Interface. The user interface is made of HTML pages in accordance with the WAI accessibility Guidelines [2].

The two servers uses a protocol HTTPS (HTTP over SSL [5]) to communicate in order to reduce the vulnerability in the exchanges. The SSL is a protocol providing a practical, application-layer, widely applicable connection-oriented mechanism for Internet client/server communications security. Note that this standard is widely used in online banking and online payment on many commercial Website.

3 Access Rights

Different types of files can be stored on the Document Server with different levels of security:

- Files of books in the Public Domain. No security is needed for their delivery. They are considered as having the lowest security (level 0).
- Files prepared for Braille print. These files have been processed for Braille editing so that information concerning the original layout, images, has been lost. Moreover the coding of the document uses specific Braille codes. Such files cannot be used to recover the original book format. They need a rather low level of security (level 1).
- Source files provided by the publishers. These files have to be secured at the highest level (level2).

Different group of users have been considered, each being allowed to achieve different operations:

- Administrators have full access to all documents (level 2) and administration front-end.
- Adaptation centres need to access source files provided by publishers in order to adapt them (level 2).
- Specialised printing centres access only files pre-processed for special print (level 1)
- Single end-user can access documents at the level 0.

4 Secured Documents Delivering

In order to respect the IPR of documents, files have to be sent confidentially to authenticated users only. In our implementation of Helene, this implies different steps :

- Authorised users are registered. They receive a digital certificate signed by the Helene Server, acting as certification authority, and including a private key. A public key corresponding to this user is also stored on the server.
- Users are authenticated. When a user sends a request to the the Document Server via the web Interface, after checking the password, the server verifies that the login of the user corresponds to a registered certificate.
- Before to be sent documents are encrypted. The Helene server uses asymmetric encryption, based on a pair of keys (public and private). The encryption is performed using the public key of the authenticated user. The encrypted document is provided to the user.
- The authenticated user opens the document. To open the document the digital certificate, including the private key, is needed. A password is also necessary to use this certificate.

E-mail constitute a simple method for delivering electronic data to targeted users. This is the reason why S/MIME [6] has been chosen to implement the whole process (S/MIME is a normalised extension of MIME), using openssl [4], an open source toolkit containing most of the existing cryptographic methods:

- public/private key generation, encryption, decryption, signature, ...
- X.509 certificate management,
- experimental SSL/TLS,
- S/MIME,
- digest generation (MD5, SHA-1, ...),
- S/MIME e-mail generation and verification, ...

The e-mail generated by openssl can be decrypted, verified and parsed by the most widely used software, like Microsoft Outlook, Netscape, Mozilla Mail, ...

5 Interoperability

Such a server could exist alone, but rapidly needs have appeared to interconnect it with other existing servers. For instance, the Helene server had to receive answer to requests coming from a server running a national catalogue of adapted books managed by the INJA (Institut National des Jeunes Aveugles). The Web Interface is a suitable place for running such dialogues between servers. It can also be used to send a request to several databases and to formulate an unified answer.

Two different solutions have been explored and implemented in the Helene Server, to manage this type of interconnection:

- Z39.50 [3] is a protocol for text-searching and retrieval, deployed in application domains as libraries. Originally an American (ANSI/NISO) standard, it is now ratified as international standard ISO 23950.
A Z39.50 client sends queries to a Z39.50 server and recovers matching records according to a protocol. It offers platform-independent interoperability, continuous segmented transmission of large result sets (unlike HTTP), item sorting, and a large set of other services. Z39.50 can be easily implemented over an existing program using specialized API available in most programming languages.
- XML via CGI. CGI scripts that are widely used to generate HTML contents can also return XML files when they receive a query. This method offers more flexibility than Z39.50 and does not require the installation of a standalone server. But it is limited by the HTTP protocol when retrieving large result sets and requires that the two parts agreed on a particular DTD. The returned XML file can be parsed using standard API available in most programming languages.

6 Conclusion and Perspectives

The Helene server has been opened in september 2001. Agreements have been signed with 22 publishing companies for the provision of more than 600 titles. Currently around 20 transcription and specialised printing centres have been certified and have used the Helene Server with success. This demonstrate the operability of the solution we are proposing and its the technical validity. The server Helene appears to be a suitable answer in the context of countries like France where legal restrictions on producing adapted books are severe. Nevertheless, the number of titles currently available should increase considerably to make the Helene server a real service. This objective could be reach if publishers would provide contents systematically. Discussions have started with their national representatives to obtain an extension of the agreements we have with a few to a national frame agreement.

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Virtual Libraries Initiatives with Usable Results for Print Disabled People

Marco Köttstorfer and Klaus Miesenberger

University of Linz, i³s³, Altenbergerstraße 69,
4040 Linz, Austria

{marco.koettstorfer, klaus.miesenberger}@jku.at
<http://www.integriert-studieren.jku.at>

Abstract. Digitization is one key objective at the beginning of the information society. More and more efforts are spent to make documents usable on computers and via the Internet. This also addresses a major need of print disabled people. Access to documents in digital format is the prerequisite to be able to apply assistive technology to get access to documents at the Human Computer Interface (HCI). This paper presents the initiative “Austrian Literature Online” (ALO) and how this project addresses the needs of print disabled people. A virtual library system was developed for presentation and preservation purposes of old and rare literature. This system and the documents handled are designed according to the needs of print disabled people. Till now copyright free literature has been made available in accessible formats. The system is also developed further to provide blind and visually handicapped students a convenient access to study literature. Other projects following the ALO initiative extended the project that the corpus of materials that will be available in the Document Management System (DMS) will increase dramatically in the next years. [1]

1 E-documents, E-publishing, E-libraries, and Services for Print Disabled People: Convergence of Interests

“Ante Gutenberg” blind people did not have a lot of problems with printed documents – not a lot were used. Speech was the major tool for communication and dissemination of knowledge. The Gutenberg revolution brought forward print disabilities. The more books became part of everyday life reading skills, access to written documents and education based on documents became a prerequisite for taking part in almost any part of society. Therefore not only more possibilities to choose, to store and to use knowledge were brought forward; people became forced to use these possibilities what established print disabilities for those without access to printed documents and who are therefore dependent on alternative formats.

“Post Gutenberg”, the age we are entering since the beginning of the 80ies of last century print disabled people get access to documents more independently and efficiently by using computers and assistive technology. Digitisation and handling electronic documents became a key issue in service provision. These are also key issues in business, administration, culture or leisure. Therefore we can find a

convergence of interests and concepts based on the separation of different layers in documents for content representation, handling (managing, storing, preserving) and presenting of information at the “Man Machine Interface” (MMI). As figure 1 wants to outline a standardised set of metadata offers the possibility to mark up documents in a way that the contents can be accessed and handled at the HCI in different ways according to the needs (preferences) of any user.

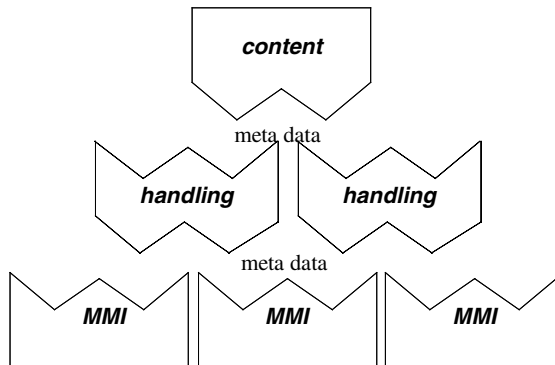


Fig. 1. Content access via HCI

In the moment of accessing the document is prepared for presentation and handling according to the needs of the user in a specific situation and environment. The same document which is enriched with metadata can be viewed and used in different ways. Due to

- the universal usage of “Information and Communication Technology” (ICT) in almost any aspect of our lives
- standardisation of interfaces between the different layers (metadata)
- the multimedia power and assistive technologies
- adaptiveness and pervasive computing

accessibility and services for print disabled people could become more and more as an integral part of the document management and publishing process and should not be treated, as in the Gutenberg age, as a special, separated service.

There is evidence that accessibility and usability of electronic documents for people with disabilities are ancestors and promoters to this multipurpose use of documents. Today’s challenging research and development areas like adaptive user interfaces, mobile, pervasive and persuasive computing [2] are widening the core concepts of accessibility and usability for people with disabilities. The increasing flexibility of MMI has been most important for those users who are not able to use standard interaction methods either because of a disability or functional limitations in special situations (e.g. a car driver who has to keep his hands on the wheel when he wants to fulfil other tasks like handling the radio, the GPS device, the mobile telephone or other). Often not more than an alternative for ordinary users, this has become a unique possibility for “extra-ordinary” users. [3]

As one librarian expressed it: working in the field of library service for print disabled people introduces to and employs first – at least at an experimental basis – the emerging and future ICT. Digital document management, copyright management, meta-data enrichment of documents, virtual libraries, e-books, ... have been in discussion in the field of print disabled people years before they became virulent for ICT and the Internet in general.

Standardisation and especially platform, user and situation independent description of content, handling and presentation using metadata also will be the most important area for service provision be it in the co-operating with authors and publishers, for workflow management or for client relationship. The most important and recent developments like DAISY¹, secure document delivery [4] but also areas like access to math and science [5] focus on the usage of metadata for better access and usability, on converting metadata for AT and on standardisation to improve the sustainability of these developments.

2 Mainstreaming: Publishing and Document Management – Points of Access for Print Disabled People

There is no more publishing without the usage of ICT: authors, editors, publishers, printing houses and today also readers make use of ICT. All versions of digital documents in this process could be seen as points of access. In practice major difficulties occur:

We know, as George Kersher from the DAISY consortium described it in a keynote speech at Techshare² in November 2001, that publishers are very reluctant in employing well defined models of metadata and workflows based on e-documents out of very doubtful reasons. Although the advantages for clients, society and publishers themselves are obvious economical fear, copyright issues and lack of competence make them sceptic. A coherent usage of mark-up languages supporting

- a) an up to date, flexible and multi media usage of documents
- b) an efficient internal workflow support,
- c) up to date customer relations,
- d) support of automatic cataloguing and long time preservation

are not employed or supported. These would be the basic necessities for an efficient integration of service provision for print disabled people.

Experiences show that the usage of set formats of publishers asks for major investments in converting their formats into accessible ones. Of course these formats contain metadata but they are proprietary, non standard and often differ from document to document. There are only a few big publishing houses in the German speaking area with a general, well documented and maintained set of metadata.

The experiences at *i³s³* show that authors, proof readers and editors do use standard editors and formats (MS Word, LaTeX). These are of course major points of access for service providers for print disabled people. Authors and proof readers also keep a

¹ www.daisy.org

² <http://www.rnib.org.uk/techshare/>

copy of these working documents – publishers most of the time don't, out of whatever reason. This also shows how badly documents and workflows are managed. Integration into and efficient co-operation with publishers to increase service provision for print disabled people depends on efficient workflow and e-document management; it is also a prerequisite for reducing the fears and misunderstandings concerning the exchange of e-documents.

What would be the ideal format? Several proposals which are mostly based on D. Knuths TeX system [7] were not able to overcome interests / problems of the publishing and editor industry. The usage of proprietary formats and a lack of interoperability led to the need of conversion but often also for re-editing and layout of documents when other or new versions of software tools became used or documents should be presented in an other way.

The Internet puts pressure on the situation to allow multipurpose, multi modal and user centred use of one source file. Today more and more publishers do follow concepts like XML³ what promises considerable improvements for service providers for print disabled people. Proposals to hand over electronic copies of published documents to National Libraries in well defined formats and according legal frameworks should help to save resources at both publisher's and National Library's side. This again would offer a promising point of access.

Last but not least access to documents is recognised as a basic human right in the Information Society. Copy Right Management (CRM) and secure delivery are again important areas of converging interests. The Internet and distribution of digital documents ask for a proper legal framework for e-documents. Access to information and the need for accessing documents in the format needed is not only an economic need of the Internet but has to be seen as a basic human right in the Information Society. Publishing is no longer only a right of stake holders but also a duty of serving the public including people with disabilities. The recent directive on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society (Directive 2001/29/EC of the European Parliament and Council) is an example that this is understood more and more as a necessity in an open and democratic society⁴. *i's*³ initiated an awareness campaign that the needs of print disabled people are taken into account in these changes of national law according to the EU directive. Without such technical and according legal advances the digital divide would grow and people with print disabilities would be put at a disadvantage. Technical solutions to the copyright problem have been proposed. Again the convergence of interests in digital documents seems to bring us closer to a solution.

3 Efficient Digitisation

Experiences with the publishing industry and their reluctance and inefficiency in co-operating with service providers for print disabled people often makes digitisation of printed documents more efficient than accessing e-documents. Improvements in digitisation can considerably improve services, especially in relation to metadata enrichment. Again we are in a field with strong convergences of interests with other

³ <http://www.w3.org/tr/rec-xml>

⁴ http://www.euroblind.org/fichiersGB/wg_copy.htm#comment

important players in the field: Libraries, archives and museums started their efforts towards cultural heritage and services based on electronic documents and electronic libraries. Especially this field which is closely related to university based research and development made substantial contributions to metadata sets and their standardisation be it in digitisation, long time storage or workflow management for electronic cataloguing and digital services. E-libraries and making cultural heritage available online have become a question of client orientation, prestige and cost effectiveness. A growing number of initiatives around the world pushes digitisation forward.⁵ These initiatives present several important sets of metadata which are on the way to become standards.⁶

As several studies show [6] metadata work uses more than 30% of the digitization resources.

4 META-e

The EU funded project **meta-e**⁷ in which *i³s³* takes part concentrates on making the digitization process and thereby the automatic or supported enrichment with metadata easier. The meta-e engine is designed as a comprehensive software package where all steps necessary for the digital conversion (re-formatting) of printed material (books, journals) can be conducted by a well trained end-user. The input will be scanned (still) page images, the output will be an "archival information package". The functionality of the software will include:

1. image creation (scanning, importing),
2. image enhancement and pre-processing,
3. importing descriptive metadata (MARC21) from electronic library catalogues,
4. OCR-processing,
5. creating technical and administrative metadata,

⁵ e.g.: Bibliotheca universalis - <http://www.ddb.de/gabriel/bibliotheca-universalis/bibuniv.htm>, Gallica - <http://gallica.bnf.fr/>, Setis - <http://setis.library.usyd.edu.au/ozlit/>, American Memory - <http://memory.loc.gov/ammem/>, MOA - Making of America - <http://www.umdl.umich.edu/moa/>, Dioscórides - <http://www.ucm.es/BUCM/diosc/>, Victorian Women Writers Project - <http://www.indiana.edu/~letrs/vwwp/index.html>

⁶ To name only a few:

Open Archival Information Systems (OAIS) or Ressource Description Framework (RDF) as a framework

Dublin Core (DC) for the description of meta data elements (<http://dublincore.org>)

Metadata Encoding & Transmission Standard (METS) for encoding meta data as objects in digital libraries

MARC21: for descriptive data like library catalogues (<http://www.loc.gov/marc/bibliographic/ecbdhome.html>)

DIG35 Specification: Metadata for Digital Images; Version 1.0. (<http://members.digitalimaging.org/shareddocs/downloads/dig35v1.0-sept00.pdf>)

MOAII - Making of America - document type definition as an implementation example (<http://sunsite.berkeley.edu/moa2/papers/dtd.html>)

URN for global and persistent identification of digital information (<http://www.faqs.org>)

⁷ <http://meta-e.uibk.ac.at/>

6. extracting structural metadata with strong automation support,
7. organizing permanent quality control on all levels and stages and
8. carrying out the digitization process either in a single or multi-user workflow environment.

The greatest progress will be made by introducing layout and document analysis as key technologies for structural and partly descriptive metadata capturing. A high amount of the typical "keying work", e.g. the ordering of text divisions such as chapters, sub-chapters or the linking of articles within a periodical will be taken over by the METAe engine. Page numbers, headlines, footnotes, graphs and caption lines are promising candidates for automatic processing as well. Different output formats like XML, TEI, METS are supported. An OCR engine, developed in conjunction with Mitcom – Finereader, for recognizing old fonts like gothic letters – for materials printed in the 19th and early 20th century, will help to improve access to old and rare books. An XML full text search engine called XTReSy⁸ will be developed further to meet the requirements of the METAe engine. With this search engine it is possible to search e.g. for words that only appear in footnotes and even much more powerful things are possible.

5 Austrian Literature Online – ALO

ALO is the heart for digitising literature at Austrian Universities and its striking goal is the digitisation of the 1000 most important books of the Austrian literature. The consortium (University Library of Graz, Institute for German Literature at the University of Innsbruck and the Institute for Information Systems for Blind and Visually Handicapped People at the University of Linz, *i³s³*) did research on how a virtual library could be set up.

All digitization is useless if there is no workflow management and document management system to manage the digitized data. We have also seen in previous projects that there is a demand for a more efficient workflow management based on catalogue data to manage the co-operation between all stake holders (clients, authors, publishers, financing organizations, service providers). "ALO" is a virtual library for presentation and preservation purposes of documents. This system and the documents handled are designed according to the needs of print disabled people. ALO gives access to documents via the Internet in three different formats:

- Facsimile
- Uncorrected Full text – quick and dirty access for print disabled users
- Corrected Full text (on demand) – following the guidelines and mark up of "Making of America II", a project done by the Library of Congress, Preservation Reformatting Division

The system is implemented in Java. A Java tool handles requests using Remote Method Invocation (RMI) and sends back results in XML files. First a MOAII file is loaded and coded in XML providing further links to facsimiles and the TEI encoded

⁸ <http://tresy.cribecu.sns.it/>

text and structure. MOAII, TEI and facsimile files are stored in a file system. The database handles a list of names and links to the physical elements in a file system. This slows the system down but makes preservation and management of documents easier in the long run.

The *user interface* provides three tools to search for books: *full text search*, *metadata search* and *list of books*. For all presentation functionalities servlets are employed using XQL-queries and providing XML files and XSL style sheets. Pages can be accessed with a certain page number. Buttons enable browsing a document. For reading the whole document or defined parts of a document a PDF or text file can be downloaded. Book-on-Demand gives access to cheap reprints. The interface employs skin technology to optimize usability for users with disabilities.

ALO did intensive studies for an efficient scanning, OCR, mark up, accessible user interface design, print on demand and document management. A prototype with the most important functionalities of a virtual library was set up.

The system is also used as a trial portal for services related to the preparation of study materials for print disabled people.

These days a new and professional version of ALO (the software is open source) is going online. ALO is also a typical application of the meta-e software. Meta-e will be part of the software package for digitization and e-library management. Further on the work concentrates on the integration of a copyright management system (today only copyright free documents are handled), a workflow management system and other tools to support the work of libraries and service providers, e.g. "Braille Print on Demand" should allow users to get access on embossed paper in a reasonable time scale. The system itself is now used and tested in the EU funded project books2u! which is a distance library loan system based on digitization and integration into an e-library.

6 books2u!

Interlibrary loan systems are very inefficient. Books are copied, packed and sent to the people who ordered them. This is done even if a book is ordered more than once, multiplying the effort by the number of users ordering the book. A much more efficient way used by books2u! is the use of a virtual library. The books are no more copied, the material is digitized and made accessible via ALO. Copyright protected material is made accessible only for the person who requested the material and only for a limited time. In this way the ALO system is growing and growing and the material has to be digitized only once. By use of the Meta-e engine described earlier it is very easy to create marked up full text also useful for print disabled users. This feature is only available on demand to minimize the cost of this service to be successful.

7 Conclusion

Every project that is done by the Austrian Literature Online initiative is extending the Document management system and the amount of materials has increased. It is

expected that, in Austria, the system will be used to digitize about 500.000 pages per year, from which print disabled users will benefit a lot. Also other developments that will improve digitization are on the way. One example for this is the outstanding automatic turn pages machine from 4DigitalBooks⁹ which integrates a professional book scanner. With this machine it is possible to digitize a book of 200 pages in 15 minutes (up to 900 pages / hour). When automation in this field will continue as it looks like it is possible that the amount of accessible documents will increase exponential.

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Unlocking Doors: Building an Accessible Online Information Node

David Crombie, Arne Leeman, Marian Oosting, and Maarten Verboom

FNB, Dutch Federation of Libraries for the Blind,
PO Box 24, 5360 AA, Grave, The Netherlands
projects@fnb.nl
<http://projects.fnb.nl>

Abstract. Strategies for enhancing access to information for the print disabled have increasingly focused on web-based information delivery. In the Netherlands, a major initiative is underway to construct an on-line information node which will act as a 'one-stop shop' for end-users. The underlying architecture of the portal is based on a modular design which can be easily extended and adapted to changing needs where required. Integrating advanced internet technologies with the latest accessibility standards, it has been possible to take full advantage of the flexibility provided by XML content creation. By offering personalised interfaces, users are able to access daily newspapers, magazines and eventually DAISY-compliant electronic books. This is achieved with a specially built XML viewer. Furthermore, by using the sophisticated navigation template facilities, it is possible to offer content hosting to external support organisations and significantly to enhance the accessibility of their information as well. Initial feedback is presented and suggestions made for future development and co-operation.

1 Introduction

The main objective of FNB is to facilitate access to literature and information for the print disabled. As more and more information becomes available in digital formats, new opportunities naturally arise. Some ten years ago a closed DOS-based network (*Elnet*- Electronic Reading Net) was established in the Netherlands for the distribution of daily newspapers. The network also provides an e-mail facility and group discussions and some 1500 clients make use of the service. However, the development of the internet has led many people to switch over to MS Windows based operating systems. An internal study showed that almost 80% of *Elnet* users now run MS Windows and 65% regularly browse the internet [1]. It was therefore decided to migrate the *Elnet* service to a Windows environment, and to extend the scope of the content provision to include access to all the digital services offered by the Dutch Libraries for the Blind. To this end an accessible webportal has been constructed and this paper examines the key considerations and initial outcomes from this process.

2 Computer and Internet Usage by the Print Disabled

Research by the Verwey-Jonker Institute [2] shows that the Netherlands has around 200,000 people with a visual disability (subject to their criteria). Almost 14% of this number use a computer with specially adapted software and those with a severe visual disability tend to use computers more often. Research in the USA [3] shows that regular usage of computers and the internet is significantly lower among the visually impaired than among the visually able: 21% and 13% respectively against 57% and 51%.

According to the World Dyslexia Network Foundation [4], the prevalence of dyslexia in the general population is between 5-10%. In the context of the Netherlands, this would suggest that some 87,500 people with dyslexia could potentially benefit from many of the services provided by the Dutch Libraries for the Blind. Similarly, there are some 250,000 people in the Netherlands with other print disabilities, such as aphasia, severe forms of rheumatism, mental or physical disabilities, autism or children with speech or language problems [5]. Although no specific data exists on computer and internet usage by these groups, there is clearly scope for beneficial support.

Access to printed information is a pre-requisite for full participation in work, study and leisure matters. The increasing availability of information through the internet helps to circumvent some of the existing difficulties posed by printed information, but also raises new challenges. Over the last few years it has become clear that the key barriers to full accessibility are:

MS Windows operating system. By no means all applications perform well within this environment and therefore good screenreading software is needed. In the Netherlands, computer applications are paid for by health insurance companies but in most cases this occurs only once every five years.

Unstructured WWW information. Even for people without a print disability the internet generates an overwhelming amount of information in which it is hard to find any structure. The use of cascading style sheets following W3C recommendations is helpful, but implementation of these and other guidelines has been at best partial.

Graphic information. The need to attract visitors to websites has generated the widespread use of graphics, many of which are likely to remain wholly inaccessible.

It is clear that while the print disabled are regular computer and internet users, the user interfaces are not always optimal given the general lack of coherent navigational structures and the heavy reliance on graphical information to represent concepts and convey information.

3 The Accessible Solution: www.anderslezen.nl

One of the tasks set by the Dutch Ministry of Education, Cultural Affairs and Welfare is to unlock information for the print disabled. As part of this objective, FNB has designed and developed an easily accessible webportal for the print disabled. The

webportal *Anderslezen.nl* [lit. *different reading*] is an online information node for people with a reading disability and as such covers four domains:

1. Accessibility and service
2. Document supply (products)
3. Community (meeting point)
4. Transfer of knowledge (information node)

The webportal is not intended to create a separate enclave on the internet for the print disabled. Rather the portal offers a concentration of relevant services and information for the target group and is an entry point to the internet as well. To other visitors, *Anderslezen.nl* offers the opportunity of exchanging specific information with the target group and of consulting an extensive database concerning the problems surrounding the accessibility of information.

Anderslezen.nl offers an opportunity to affiliated organizations to build and operate their own (sub)website within the portal. These sites can also be accessed through their domain names. The content management system (CMS) of *Anderslezen.nl* covers all the technical aspects, leaving the organisations free to concentrate on providing the content itself. All information can be obtained in two ways: either online via the website (pull) or offline by e-mail subscription (push). By subscribing to specific subjects, registered users can acquire a made-to-measure supply of information.

3.1 Accessibility and Service

The starting-point for constructing *Anderslezen.nl* was the accessibility guidelines from the W3C [6]. These guidelines are ranged in priorities and *Anderslezen.nl* is built according to guidelines with priority 2 and aimed at eventually supplying all services in accordance with the guidelines with priority 3. Priority 2 means, for example, that all graphic components of *Anderslezen.nl* are issued with Alt tags. It is also possible to view the site in any colour (or no colours at all), irrespective of the computer applications being used, and all the proffered documents are written in XML (*vide infra*) to provide a sound structure.

An accessible website is not solely built by adhering to guidelines: a good on-screen lay-out for one person could well be unusable for another. For this reason the user interface is designed according to the 'design for all' principle. Users can 'personalise' the interface according to their specific wishes regarding the presentation and arrangement of information. Nonetheless, every screen contains four basic components: navigation tool bar, menu, text and position bar. Each component can then be adjusted with its own colour palette. The position of the components on the page can be selected from four schemata: standard, narrow, muted and plain. These four themes reflect our ideas on good design combinations for different user groups and software applications, but they can be further adjusted by the individual user. *Anderslezen.nl* also offers a content hosting service to related organisations that want to distribute information through the internet but do not have the means to build a website. FNB builds the infrastructure according to the wishes of the organisation, incorporating the same accessibility used for *Anderslezen.nl*.

3.2 Document Supply

Documents are made available through Anderslezen.nl and they can be downloaded and read by clients and other visitors to the site. These documents can be newspapers, magazines or books as well as digital leaflets and brochures. For registered users there is a wide array of national and regional newspapers, magazines on various fields of interest (from computers to current affairs) and a wide choice in study and general literature. Besides this, Anderslezen.nl will distribute copyright free materials that could be of interest to the target group.

An important W3C criterion is to offer documents in a soundly structured format. Information written in eXtensible Markup Language (XML) can in principle be read as text by the print disabled. This language also has a structure enabling people to navigate large and complex blocks of text. Documents in XML format are encrypted to meet the publishers' demands. In this way people without a reading disability are prevented from misusing these files. Documents can only be downloaded and opened with a special key and this encryption is necessary to comply with the relevant IPR issues.

The actual reading of documents is done with the aid of a specially developed reading programme which is to be found on the website. The documents are downloaded from, or sent by, Anderslezen.nl and saved on the computer's hard disc. The documents can then be read off line. An early version of a reading program was developed in co-operation with the Catholic University of Leuven in Belgium, with a later version being devised and implemented by FNB. The reading program is freely available, but registered clients have a digital client pass to gain access to secure documents, such as newspapers and books.

The reading program provides a user-friendly way to navigate an Anderslezen.nl XML-document. On selecting a saved file the reading program will automatically start and open the document. The reader then sees a list of all sections or chapters of the document (1st level). On selecting a specific section or chapter any articles or paragraphs are shown (2nd level). On selecting a specific article the text of the article is shown. The program has certain key functionalities: placing bookmarks in a text, making notes and text searching. In future the reading program will be DAISY compliant [7].

3.3 Community

The internet, like no other medium, offers people the opportunity to meet one another virtually without being hampered by physical obstacles. Anderslezen.nl offers clients the chance to exchange information in discussion groups in an accessible environment. Furthermore, clients can set up and maintain their own forum on specific themes. The Anderslezen.nl editors will offer editorial support when necessary. In principle, these discussion groups are only accessible to registered clients. A number of groups will be semi-closed, although interested and registered parties will also be able to participate.

The purpose of these communities is threefold:

Firstly, they unite people who, because of their reading disability, share similar circumstances. They can exchange knowledge and firsthand information in a wholly new way.

Secondly, it gives participants the chance to contact others as a group, without going through the regular channels (institutions). This possibility promotes mobility and autonomy.

Thirdly, it gives participating service organisations the opportunity for greater interactive commitment to their clients. Within a theme-based community organizations can explore new ways to provide information.

A good example of the possibilities offered by these communities is the Kids Corner, which previously existed within ELnet. This is a discussion group for children with a reading disability. These discussions are conducted on a range of subjects, from computers, music and sports to schoolwork, stories and poems. The Kids Corner has already brought so many children in contact with each other that a special Open Day is now organised every year.

Another feature also being established through the community is the exchange of study and specialist literature from within the private domain of students and professionals, regulated through the webportal. A similar initiative, called Bookshare, already exists in the USA [8] and is proving very popular. For a small annual fee, the Bookshare website allows access to a collection of highly accessible digital books and other publications for those with a visual or reading disability.

3.4 Transfer of Knowledge

The Information Node section of the webportal will be a platform for providing more general information relevant to the target group itself. For example, this might be a collection of maps, information about relevant facilities, service providers or other support organisations. Anderslezen.nl also acts as a portal to other relevant websites such as those providing information about library services and general information about the arts (www.bibliotheek.nl).

Another important function of the Information Node is to act as an information platform for anyone maintaining or planning to build a website. Site and content developers can garner information about making a website easily accessible for print disabled people. In effect, the webportal will promote the construction of accessible websites. Organisations and individuals can have their website evaluated by a special user-panel consisting of clients of Anderslezen.nl. When this group has judged a website to be accessible a logo will be awarded which can be displayed on the qualifying website. This will not be a quality mark in itself, but it will show that the organisation in question is working on making its website more accessible.

4 Managing Content

All information contained in the webportal is stored in XML-format in a database. The HTML-pages are generated with XSLT and JSP. A checklist of technical and editorial criteria was used to find a suitable Content Management System (CMS) but it was found that suitable toolkits were too expensive, and that more reasonably priced toolkits were not based on the desired open standards (XML and Java) but on their own application servers with proprietary script languages. It was therefore decided to develop the necessary CMS components in-house using open source tools.

Apache is currently used as a webserver, Tomcat as a JSP/XSLT engine and MySql as a database. All the business logistics of the webportal are encoded in Java (see Figure 1 below).

The content of the webportal has been divided into four textual archetypes: *documents*, *articles*, *adverts* or *messages*. Each archetype requires specific techniques for presentation and access. By way of illustration, *documents* are files that are not read online but are downloaded for further processing on a user's PC and the content can vary (XML files, software, digital audio). *Articles* are editorial contributions that can be read online, and readers can react to their contents, thus making for interactive publications. *Adverts* are a specific form of article where reactions are sent to the author as e-mails. Lastly, *messages* can be read online as personal e-mail or as forum contributions. The advantage of using these archetypes is that this defines and reduces the number of reading techniques that are used and after a short training period users are able to access all the information without further instruction.

Information is stored within databases by category, with appropriate metadata tags such as title, author, date of publication, keywords, etc. Information-items are organised by subject and subjects are considered as separate objects in the database with their own metadata including (SISO) category, owner and content type. Subjects are linked to one or more layers of categories. Taken together, categories, sub-categories and subjects form the online menu structure of Anderslezen.nl. An internal search engine in the portal makes it possible to perform random searches for information within this structure giving subjects, keywords and content attributes such as title, author, and so on.

Access to information within the webportal is regulated through groups and roles. All registered visitors are a member of one or more groups. These groups correspond with access to specific information such as client, interested party, newspaper readers, student, etc. By subsequently linking categories and subjects to groups a flexible power structure emerges. The link determines what the group in question is authorised to do with the contents, such as read only or read/write.

5 Ongoing Co-operation

Within the Netherlands, FNB is an active participant in the *Drempels Weg* (lit. Barriers Away) initiative and co-operates with the National Bureau for the Promotion of Accessibility (LBT). The *Drempels Weg* project began in March 2001 and was initiated by the Dutch Ministry of Public Health, Welfare and Sport. The aim is to promote easy internet access for everyone, including people with a print disabilities. To this end, key organisations from the public and private sectors were invited to sign an accessibility covenant. Through the webportal development FNB wanted to show that the creation of an easily accessible website is neither boring nor impractical. In the Netherlands, this voluntary approach has thus far proved successful.

FNB also co-operates with organisations providing education, care and services to people who are blind or visually impaired; suppliers of Braille and low vision applications; pressure groups of people with a visual or other print disability; and

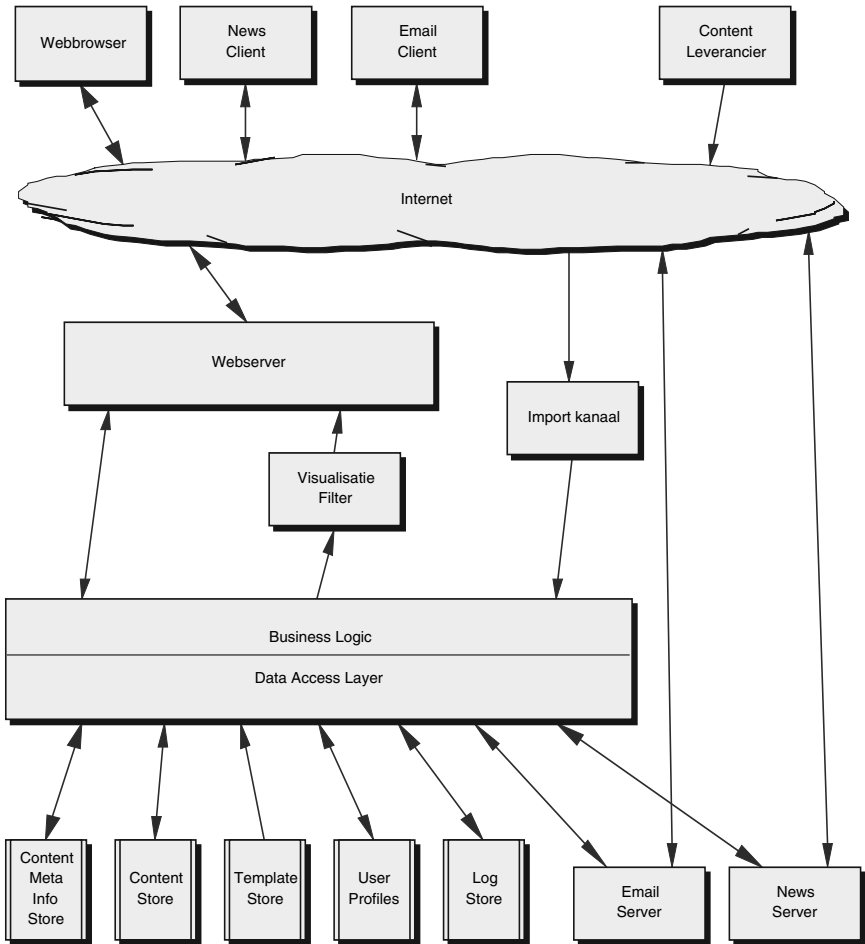


Fig. 1. Architecture of Anderslezen.nl. All information is stored in XML-format in a database. The HTML-pages are generated with XSLT and JSP. Currently the webportal uses an Apache webserver, Tomcat as a JSP/XSLT engine and MySQL as a database. All the business logistics of the webportal are encoded in Java.

public libraries. A collective effort is being made to inform the target groups about the potential of Anderslezen.nl and about the hardware and training needed to make full use of the system. Co-operation with other relevant organisations such as the Daisy consortium [9] will also occur further to develop the reading programme and to ensure that IPR is properly managed within the system.

6 Conclusions

The internet has become an essential medium for people with a print disabilities and it has the potential to enable them fully to participate in modern society. In its current stage of development, however, the internet remains barely accessible to many such individuals. There is a clear need to raise awareness of these issues and to encourage the promotion of solutions such as that outlined above. Only then can we further the full integration of people into the information age.

The general importance of metadata regarding the internet is well documented, but there is currently no clear consensus emerging for the implementation of XML. By demonstrating the positive effects of implementing existing standards, it is hoped that initiatives such as Anderslezen.nl help user groups, the public sector, government and website builders to appreciate the importance of a more uniform, standards-based approach.

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Using XML as a Reading Enabler for Visually Impaired Persons

Bert Paepen and Jan Engelen

Katholieke Universiteit Leuven
Research Group on Document Architectures
Kasteelpark Arenberg 10
B-3001 Leuven (Belgium)
{bert.paepen, jan.engelen}@docarch.be

Abstract. Reading large texts like books, newspapers and magazines, is still a hard task for visually impaired persons. Accessibility software such as screen readers and screen magnifiers are a valuable aid, but they give the reader only small parts of information at a time. Since XML (Extensible Mark-up Language) can add structure to information, it can be used to help visually impaired readers cope with large amounts of information. A special XML Viewer application can give the reader additional navigation and search possibilities, enabling a personalised and fast reading experience for visually impaired persons.

1 Problem Area

The emerging boom of the Internet has meant a revolution comparable to the invention of the television. Suddenly electronic information originating from the other side of the world has become accessible at the click of a button. Especially for visually impaired persons, this has created an enormous breakthrough. Thanks to the widespread existence of electronic information, visually impaired persons can now do things by themselves that they could not do before: buy groceries or CD's without the help of others, read the newspaper every morning, read their favourite magazine every week, etc.

Still, handling information using screen readers, text magnifiers, speech synthesizers or other accessibility aids remains a cumbersome task. These applications and devices typically offer information in very small chunks, for example line by line (screen readers) or on-screen area by area (magnifiers). As a consequence, visually impaired persons have to handle electronic information in parts; "seeing" the big picture mostly is impossible. For web sites this is not a big problem, since they tend to chop up their information in smaller parts using various ways of navigation. For large texts such as books, newspapers and journals, a much bigger problem exists. Large amounts of text are hardly ever presented in a structured way. They can contain chapters and paragraphs, like this paper does, but that does not mean that their structure is *offered* to the reader in a structured way. This paper shows how large texts can be structured so that it is much easier for visually impaired persons to read them.

2 XML

XML (Extensible Mark-up Language) is a *meta-mark-up language*: a mark-up language that can be used to create other mark-up languages. What is mark-up? That's easy: mark-up is a way of adding extra information to text. This extra information is called *meta-data* and mark-up is indicated using tags. So: XML uses mark-up tags to add structure and meaning to information. An example:

```
<section>
  <title>XML</title>
  <p> XML is a <em>meta-mark-up language</em>: it is a
  mark-up language that can be used to create other mark-
  up languages. </p>
</section>
```

The example above is an XML way of representing the information of the previous paragraph. Tags are marked with < and > signs. Parts of information start with a start tag and end with an end tag (which uses a slash). With XML you can create your own tags to structure your information in a meaningful way. HTML (Hypertext Mark-up Language) is also a mark-up language and thus comparable to XML, but there is an important difference. While HTML is mainly used to add *layout* to text, XML is used to add *structure* and *meaning*. In the example above, the term 'meta-mark-up language' is emphasised using the tag. This tag adds extra meaning to the term, saying that there is a special emphasis on it. HTML would put the <i> tag instead, saying that the term needs to be displayed in italic. The difference is subtle, but very important. If you use tags such as and <title> you know that these parts of the text have a special meaning. A lot can be done with this extra information.

Since its inception in 1996 and its birth as a W3C¹ recommendation in 1998, XML has proved to be a very powerful *enabler*. XML by itself does not do anything; it only provides a way of structuring, storing and exchanging electronic information. XML is only about tags; it is up to the developer to decide what to do with them. One of the application areas of XML is in helping to find your way in large amounts of information, like a digital library or (why not) the entire Shakespeare collection.

If you add meaningful tags to text parts, searching these parts can become more efficient. Keywords can summarise a text part, allowing search algorithms to maintain the focus on these keywords only. Taking this one step further, keywords can be extracted from documents to form a separate XML index of your documents, allowing quick search over this index. This way, XML can help overcome a major problem threatening the future success of the Internet: there is so much information out there that it is impossible for people to cope with it.

3 XML Benefits for Visually Impaired Persons

Albeit on a different level, the same is true for visually impaired persons. Because of their impairment, it is difficult for them to cope with large electronic texts such as

¹ World Wide Web Consortium

books, magazines and newspapers – texts that are much easier to cope with if you do not have a visual impairment. People reading a printed newspaper typically have a quick look at the large headlines, allowing them to browse through the paper in a couple of minutes. In this example, formatting helps people cope with large amounts of information.

Not only the amount of text can be an obstacle for visually impaired persons, but also the way this text is presented. If a blind person receives a digital copy of the same newspaper without special treatment, such browsing is impossible. He or she would have to read the newspaper line by line, not being able to see the difference between big and small headlines and not being able to skip uninteresting parts.

Furthermore, each type of reading impairment (blindness, dyslexia, colour-blindness, etc.) brings along different problems in electronic reading. Blind people do not see text formatting, colour-blind people have difficulties with certain colour combinations and partially sighted people need very big text formatting and vivid colours, depending on their specific type of impairment.

XML is very well suited in situations like this, where one information source needs to be displayed in various output forms (*single source, multi target*). XML brings an important principle to the accessibility world: *the separation of information from its presentation form*. If you maintain this separation, it becomes very easy to create different presentation forms for different kinds of impairment. If personalised presentation of information is often seen as a gimmick, for impaired persons it is a *necessity*.

Making information more accessible thus means restructuring both the information and the way it is presented to the reader. In order to make large amounts of information accessible to visually impaired persons, they need to be offered in a structured way, so that disadvantages of line by line viewing are diminished. Further, navigation and search must be enabled in a user-friendly way. Information must be presented in manageable chunks and the way it is presented must be very flexible and user-adaptable.

4 The XML Viewer

Using these principles as a starting point, the Research Group on Document Architectures (DocArch²) of the Katholieke Universiteit Leuven constructed an “XML Viewer” together with the “Federatie van Nederlandse Blindenbibliotheken” (FNB-The Netherlands). The XML Viewer is an application enabling visually impaired readers to read texts of any kind (books, articles, magazines, newspapers, etc.) in an easy-to-cope way.

The XML Viewer offers information in a structured way, based on the document structure (this is mostly what a table of contents presents). Information overload is avoided by presenting the structure of a text level by level. The reader can *navigate* through this structure using shortcuts or buttons, moving to a next or previous item on the same level or moving up to a higher level in the document structure.

An XML document can be regarded as an information tree. In a book, a chapter is the parent of several sections, which have at their turn several paragraphs as their

² <http://www.docarch.be>

children. Only the smallest parts of this document tree is presented to the reader as a whole. In the case of a newspaper, this is one article. In the case of a book, this can be a paragraph or a section, depending on the structure the content provider gave it. This way, information transfer uses *small chunks* at a time. Navigation allows fast browsing through these chunks.

A strict separation of text and layout is maintained: texts are stored in XML and for layout, a *style sheet* is used, containing instructions on how to present the text on the screen. These style sheets can be personalised, so that readers can use the layout that is suited best for them. *Personalised layout* is a key issue for many visually impaired readers. Readers can change the background colour, text colours, sizes and fonts separately for each type of information.

Additional features have been added in order to permit efficient document reading. *Bookmarks* can be used to fasten the reader's navigation experience. A reader can assign a bookmark to a part of the text, giving it a meaningful name. Later he or she can quickly jump to that particular part by referring to its bookmark name. An automatic bookmark is created when the application is closed, allowing a fast reference to the last position. Furthermore, *search* through the entire text is possible.

Several possibilities that paper documents have are imitated by the viewer. Readers can for example add *personal notes* to a certain part of the text, just as the reader of a book can write notes in the margin. Also, *page numbers* can be included, allowing cross-reference between the electronic and the printed version of a document. Both functions are interesting for visually impaired students using the XML Viewer on a portable computer and screen reader in a classroom situation, where a teacher refers to page numbers and makes remarks on certain parts of a study book.

A number of user settings make the application more flexible in use. Readers can choose a language for the user interface, change document locations, choose whether or not to show printed page numbers and change the name of the automatic bookmark.

Because content providers are not very keen to distributing their copyrighted material in an electronic form, a number of *security features* have been built in the viewer. Texts are encrypted in such a way that they cannot be read by other applications besides the XML Viewer. Once opened, a document cannot be printed or copied to an other application without the content provider's consent. Content providers often refuse to make their material available without these kinds of copyright protection.

5 Technical Approach

A standard Microsoft Windows application was chosen as operating environment. The application was developed in Microsoft Visual Basic 6.0, allowing fast development and easy plug-in facilities.

5.1 Architecture

Several e-readers offer a combined solution, containing both navigation and text-to-speech or Braille output in one single application. The FNB-DocArch XML Viewer

does not follow this approach. Instead a user-oriented architecture has been chosen. Since every person has his own preferences and special needs, letting her/him make the decision on presentation and optimum output channel is essential.

This principle is reflected in the modular architecture and design of the application. If different system functions are performed by different parts of the XML Viewer and other computer software and hardware, a very personal user experience is made possible. The functions of the XML Viewer are mainly restricted to user navigation and document display. Handling of the XML document is handled by the MSXML³ parser (see below). The accessibility software and hardware are strictly separated from the viewer, ensuring that the user can keep his personal settings and preferences.

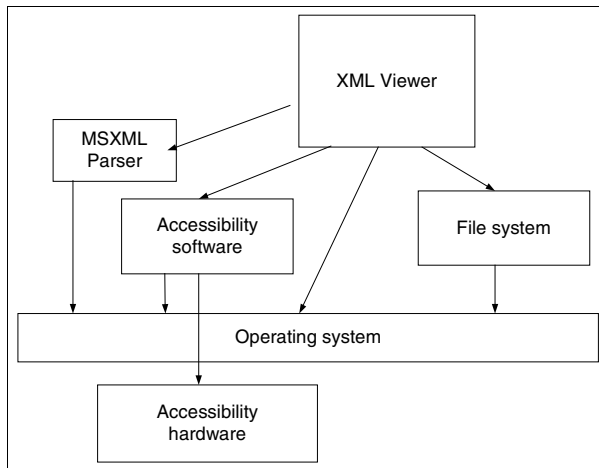


Fig. 1. Architecture

Because of this approach the XML Viewer is only an *enabler* for visually impaired persons in reading electronic information. Depending on their own choice, readers can use a screen magnifier, screen reader, voice synthesiser or any other device to ‘finish the job’ for them.

5.2 System Design

In order to obtain a flexible application, the design of the system is modular (see figure below). When a user opens a document, the Loader uses the FileHandler to get the document from the file system. Then the Decryptor decrypts the document and the Unzipper unpacks the different parts of the zip file. Through the MainModule the documents is passed on to the Tree Builder (see below) and further to the Browser.

³ Microsoft XML Parser

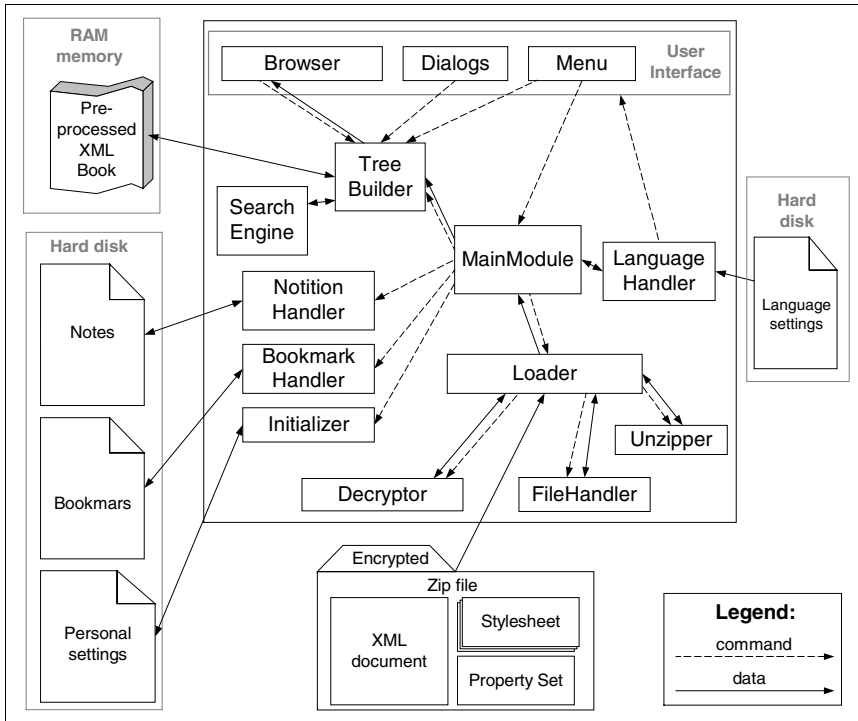


Fig. 2. System Design

A document that can be opened by the XML Viewer has the extension .exd⁴. This is an encrypted zip file containing three kinds of files: the XML document, one or more style sheets and a “property set”. Style sheets are used to translate the XML tags into layout. When a document is opened, the reader can switch dynamically between the available style sheets. Furthermore, the reader can adapt existing style sheets to his own preferences and he can create new style sheets.

Since XML is extensible, content providers are free to create their own XML vocabulary⁵. In order to allow this flexibility, a property set file is used with the XML file. In the property set a small part of the used XML vocabulary is defined. This way, the viewer can read almost every kind of XML document. The only restriction is that it is structured more or less like a book, with nested sections that have titles.

5.3 XML Processing

Before the content of a document can be displayed in the viewer, the XML needs to be processed. This processing is handled by the MSXML Parser, which reads the document into a tree structure in the computer’s memory. As long as the document is open, this structure remains in memory, allowing quick navigation through the tree

⁴ Encrypted XML Document

⁵ Set of tags that can be used by an XML document.

nodes. The Tree Builder module handles all navigation actions performed on the XML tree using DOM⁶.

5.4 Rendering

One of the most complicated tasks to be performed by the viewer turned out to be the rendering of text – in other words the on-screen display – in an accessible way. During development, the Browser module went through a number of important changes due to these difficulties.

In a first stage, the Browser module used the Microsoft Internet Explorer component for displaying the document structure and contents on the screen. The advantage of this component is that it can “understand” XML by itself. If an XML document together with a style sheet are sent to the browser, it takes care of the entire rendering and display process. A major drawback turned out to be the component’s accessibility to screen readers. Internet Explorer is a browser, meaning that it does not provide a cursor like editors do. As a consequence the screen reader software cannot position itself to the spot where the user wants to start reading⁷.

A further problem was the interference of the Explorer component installed for the XML Viewer and the full Internet Explorer application already present on the computer. For the viewer, at least version 5 of this browser was required, meaning that users who were running previous versions would have been forced to upgrade. While for most persons this should not be a big problem, for visually impaired persons changing a well-functioning configuration is not that obvious: there is always a risk that your accessibility software is not well suited for the new configuration.

These problems led to a thorough study of existing browsers and editors in order to find a component that is suited for the job. It should be able to render the XML using a style sheet (browser) and it should show the text on screen like an editor does (using a cursor), without allowing the user to edit the text. A number of existing editors and browsers were examined, such as XMetal, Opera, Stilo and XML Spy. Although these applications all have their unmistakable value, the conclusion was that what we were looking for, a combination of an editor and a browser, did not exist. In a second phase of this study the possibility of re-using existing browser architectures, such as Amaya and Mozilla, was examined. Since these browsers are based on open source software projects, it is possible to re-use some parts for the XML Viewer. The problem is that these browsers are not available as components usable in a Visual Basic application. Using them would mean rebuilding the entire XML Viewer application within one of the two browser architectures (instead of the other way around).

5.5 RTF

Finally an approach was chosen using standard Windows components without needing additional browser components for rendering. In the final approach, the navigation through the document tree takes place in a list box, while the display of the

⁶ Document Object Model: an API for processing XML using a tree-like memory structure.

⁷ This is not true for *all* screenreaders.

node content happens in a so-called “RTF box”. RTF⁸ is a layout-oriented language that contains special tags that determine how the text must be displayed.

A major advantage of this approach is its accessibility. The RTF box has a cursor, allowing positioning by a screen reader. In spite of this, several disadvantages do remain. The RTF box is purely text oriented, meaning that it will not support any kind of multimedia⁹. Furthermore, there is no direct link between a text part on the screen and its corresponding node in the XML tree. This makes it hard to implement some additional functionality.

6 Conclusion

In this paper we have demonstrated that producing documents in XML format has many advantages for visually impaired readers. As such this is not new because our opinion is shared by several users and user groups including many national organisations and the international Daisy and eBook consortia. But we found out that actually no good XML reader, offering a minimal set of extra features besides pure reading, did exist. The market of XML-aware browsers and the available browser components was studied carefully in this respect before accepting this conclusion.

Therefore, in collaboration with FNB, the Dutch Federation of Libraries for the Blind, a special XML viewer was developed by the DocArch group. In the beginning of 2002, it has been offered as standard XML viewer for the large collection of documents available through the Dutch Web portal "Anderslezen".

Due to the great need for feature-rich XML viewing, it can be anticipated that several new developments, including several commercial ones, are upcoming. Making sure that there will be enough electronic documents available in XML remains therefore of utmost importance.

Acknowledgement. The development of a basic XML viewer prototype by the DocArch group was made possible through a grant of the Cera foundation. The work on the current XML viewer was funded partially by the Dutch Federation of Libraries for the Blind.

⁸ Rich Text Format

⁹ Some support is possible, for example hyperlinks and pictures, but these are not standard RTF functionality.

The Accessibility of Online Library Resources for People with Print Disabilities: Research and Strategies for Change

Axel Schmetzke

University of Wisconsin-Stevens Point Library, 900 Reserve Street,
Stevens Point, WI 54481, USA
aschmetz@uwsp.edu

Abstract. As more and more learning in higher education takes place in cyberspace, the accessibility of online resources to all people, including those with disabilities, has become an important issue. This paper reviews the research on the accessibility of library web sites and selected online information resources, and it discusses the role that future research should play in facilitating an inclusive learning environment.

1 Introduction

Recent developments in telecommunication—particularly the coming of age of the internet—have had a strong impact on higher education. Over the past decade, the way information is disseminated in the campus environment has undergone drastic changes. Increasingly, print-based information is being substituted with its digital equivalent. Today, the web, along with email, provides the main, if not the sole, channel for a variety of education-supporting resources: official campus web pages with crucial administrative information, class syllabi, course readings, and web-mediated distance education programs. Libraries are particularly strongly affected by this digital revolution. The shift from the physical to the virtual permeates almost every aspect of their operation. There is hardly a single type of library resource that has not shifted, at least to some extent, to a digitized, web-based format. Catalogs, indexes and full-text article databases, dictionaries and encyclopedias, e-books and e-journals, reserve materials, virtual reference services as well as information about the library itself are now commonly accessed through library web sites.

With the growing importance of digitized, web-based information, the issue of access to information is no longer limited to the physical realm. Just as there are enabling and disabling conditions in the physical environment, so are there conditions in cyberspace that result in the inclusion or exclusion of people. To some extent, the ability to access web-based information is a question of the proper assistive technology, such as a modified computer keyboard, an enlarged screen display, or a properly configured screen-reading program. However, assistive technology alone cannot overcome the barriers that are created at a more basic level: the format in which content is presented. If not properly formatted, or designed, online resources

are not accessible to people with certain disabilities—no matter how advanced and plentiful the assistive technology available to them may be.

While the notion of universal design has been discussed extensively in the architectural and exterior/interior design literature, its application to the electronic environment was, until a few years ago, rarely addressed in traditional print media. Instead, the theme was mainly carried by a rather tightly knit network of dedicated people who gathered at disability- and web-related conferences and shared their insights in form of presentations, white papers and web-posted articles. It was not until 1996 that accessible web design emerged as an issue in the professional library literature. The past three years have seen a noticeable increase in library-related journal publications that seek to raise awareness concerning the need for accessible web design and provide practical tips [1, 2]. In 1998, researchers began collecting data on the accessibility of library web sites. The first studies on the accessibility of online library resources (other than web pages) will appear shortly in two special-theme issues of *Library Hi Tech* (2002, Vol. 20, Issues 2 and 4), guest-edited by this author. Methodology and findings of these studies will be described in the following sections.

2 Web Site Accessibility Studies

24 studies investigating the accessibility of web sites are known to this author. Of these, 10 include library web sites. Most of the institutions targeted are in the United States. Caution is advised in extrapolating from these findings to the situation in other countries.

2.1 Methodology

With very few exceptions, all studies relied exclusively on the automated checking capabilities of “Bobby,” a tool created by the Center for Applied Special Technology (CAST) to help people evaluate the accessibility of their web pages [3]. The downloadable version of Bobby, which runs as an application on a personal computer, is capable of testing larger sets of web pages on a given web site. For each page checked, Bobby provides information pertaining to the type, number, and location of accessibility errors—both minor and major ones. Bobby also issues a summary report for each set of web pages.

Within the context of this article, the term “Bobby-approved” is used, in a rather lax manner, to indicate that no major access barriers (“Priority 1” errors—in the terminology of the 1999 Web Content Accessibility Guidelines established by the World Wide Web Consortium’s Web Accessibility Initiative) were detected by Bobby’s automated function. Strictly speaking, this use of the term is incorrect: Full Bobby approval would also require a “manual” evaluation of those Priority 1 items that Bobby cannot automatically check.

The exclusive use of Bobby’s automated function for evaluative purposes is also problematic for other reasons, which this author discusses elsewhere in much detail [1, 2]. Suffice it to say here that Bobby testing will result in some falsely negative and positive findings. Despite such shortcomings, Bobby is a good evaluation tool in studies where the accessibility of hundreds or thousands of individual web pages are evaluated and a rough measure of accessibility will do.

2.2 Findings

Table 1 summarizes the data yielded by library-related web studies. Average accessibility in the various library data sets ranges between 19% and 75%, and the average number of errors per page varies between 1.3 and 6.1. Web accessibility tends to be higher at academic libraries than at public libraries. While web accessibility has improved in some pockets (University of Wisconsin libraries), larger data sets show no progress. Perhaps most remarkable is the fact that the web pages of North American library schools tend to be particularly inaccessible. It is reasonable to assume that such disregard for accessible web design reflects not only the attitude of web designers but also that of the library school faculty and staff, who hire the designers and give them directions. The low web accessibility at library schools also has another consequence. Students with print disabilities have a lower chance of successfully passing through library school programs.

Table 1. Average accessibility of library-related web sites, by type of institution and study, in terms of the percentage of accessible web pages and errors per page

Study/Data Set	Year	Geographic Focus	Accessibility-	Accessibility-	
			Home Page	Top Layer	errors/page
			%	%	
<u>Academic Libraries</u>					
Blake [4]	2000	Arkansas, U.S.	37	–	–
Craven [5]	2000	U.K.	37	–	–
Lilly & Van Fleet [6]	1998	U.S.	40	–	–
Schmetzke [7]	2002	Wisconsin, U.S.	64	75	1.3
Schmetzke [7]	2001	Wisconsin, U.S.	69	43	6.1
Schmetzke [7]	2000	Wisconsin, U.S.	54	40	2.9
Schmetzke [7]	1999	Wisconsin, U.S.	–	31	3.6
Schmetzke [1]	2002	U.S. (49 sites)	51	47	5.0
Schmetzke [1]	2002	Canada (7 sites)	43	53	5.9
Schmetzke [1]	2002	U.S. (24 sites)	71	53	4.2
Schmetzke [2]	2000	U.S. (24 sites)	71	59	2.8
Yu [8]	2001	California, U.S.	38	–	–
<u>Public Libraries</u>					
Kester [9]	1999	N. Carolina, U.S.	21	–	–
Lilly & Van Fleet [10]	2000	U.S.	19	–	–
Ormes & Peacock [11]	1999	U.K.	<31	–	–
<u>Library Schools</u>					
Schmetzke [1]	2002	U.S. (49 sites)	31	33	8.0
Schmetzke [1]	2002	Canada (7 sites)	14	36	5.0
Schmetzke [1]	2002	U.S. (24 sites)	38	30	10.1
Schmetzke [2]	2000	U.S. (24 sites)	38	23	8.0

3 Accessibility of Online Resources Other than Web Pages

To the best of the author's knowledge, the only studies on the accessibility of online library resources other than web pages are those soon to appear in two special-theme issues of *Library Hi Tech* (Vol. 20, Issues 2 and 4, 2002). This section contains a selective overview of the findings, pertaining to the accessibility of online catalogs, aggregated journal indexes/databases, e-journals and reference works. Space limitations do not permit to include the findings of the second special-theme issue, which will include discussions of electronic reserve systems and courseware.

3.1 Methodology

The methods to evaluate accessibility varied from study to study. Two major approaches were used: compliance checking and functionality testing employing assistive technology. For the former, authors selected major search-related screens and then checked their design for compliance with established accessible design principles, such as the W3C/WAI guidelines or the Access Board standards issued in connection with Section 508 of the U.S. Rehabilitation Act Amendment of 1998. This compliance check was done either "manually" or with the aid of an automated evaluation tool, such as Bobby. For functionality testing, authors selected some basic search-related tasks and then attempted to perform these tasks using assistive technology (typically screen readers, such as Jaws and Window-Eyes). Some authors, of whom at least one was blind, did these searches themselves; others collaborated with sight-impaired users already familiar with the assistive device. With one exception, all studies focused exclusively on search-related pages or the pages that function as a gateway to full-text material. Only one author, Coonin, who assessed the accessibility of e-journals, also looked at the format of the full-text material.

It must be pointed out that the findings reported below should be treated with caution. The interfaces of some finding tools, such as the Voyager online catalog, can be customized to some extent by library staff. Accessibility of the overall system is therefore also affected by the customized features selected by individual institutions. Furthermore, the data reported here, which were collected in spring and summer of 2001, may no longer be current.

3.2 Findings

Online catalog. Two online catalogs were studied. Axtell and Dixon looked at the Endeavor product Voyager, an integrated library management system widely used in North American Academic Libraries [12]. Focusing on Voyager's public access component, the researchers arrived at the overall conclusion that, with some effort, the system "can be successfully navigated by experienced users of assistive technology." They recommend, among others, the following improvements:

- Add a mechanism on each page to "skip navigation links."
- Convey the association among a group of buttons not by visual cues alone.
- Modify Javascript code in the "sort by" list box.

- Add label tags to the range buttons on the limit screen.

Johns looked at Epixtech’s iPAC 2.0, an online catalog system more likely to be found at public libraries [13]. She concludes that “many accessibility features are currently coded and provide solid accessibility in the product. Johns recommends, among others, to improve the logical order for tables, lengthy displays, sequences of links and split screens, and to be more consistent when using elements such as buttons, edit boxes and combo boxes. She was pleased that the product developers were open to constructive criticism and eager to improve their product.

Indexes and databases. Five studies examined the accessibility of online indexes and databases, including those with broad-range coverage, such as Ebscohost and Proquest Research Library, and those that are subject-specific, such as Medline and Cancerlit. The findings are depicted in Table 2. The categorization of the evaluation results in this table—a five point scale ranging from “very accessible” to “absolutely inaccessible”—were established by this author. Most authors of the original studies agreed with this categorization scheme and the placement of their findings within it (i.e., this author’s interpretation of their research findings in terms of his descriptive categories).

Table 2. Accessibility of indexes/databases

Index/Database	Evaluation Results*				
	Very accessible	Mostly minor problems; mildly reduced accessibility	Accessibility significantly reduced	Major problems; severely reduced accessibility	Absolutely inaccessible
Ebscohost		Bowman [14] Horwath [15]	Riley [16]		
Proquest Research Lib.			Bowman [14]		
Lexis-Nexis Acad. U.		Bowman [14]			
OCLC FirstSearch		Byerley et al. [17]	Riley [16]		
InfoTrac Web (Gale)		Byerley et al. [17]	Riley [16]		
Ovid	McCord et al. [18]				
Cancerlit		McCord et al. [18]			
Electric Library Plus			Horwath [15]		
Hazardous Sub. Data B.		McCord et al. [18]			
MSDS--Cornell U.		McCord et al. [18]			
MSDS--U. of Vermont		McCord et al. [18]			
MedlinePlus (NIH)		McCord et al. [18]			
PubMed			McCord et al. [18]		
Toxline		McCord et al. [18]			

As Table 2 reveals, ten of the fourteen resources studied are included in the “mildly reduced accessibility” category. For the three (out of these ten) resources that were evaluated by more than one research team, the findings are typically close but not identical. Riley found Ebscohost, OCLC FirstSearch and Infotrac (Gale) to be less accessible than other research teams. Altogether, six of the fourteen resources are included in the “significantly reduced accessibility” category. While only one index/database interface is described as “very accessible,” none of the resources fall into the “severely reduced accessibility” or “absolutely inaccessible” categories.

Reference Resources. Horwath’s study includes the electronic versions of two traditional reference resources: the Encyclopedia Britannica Online and the Oxford English Dictionary (OED) Online [15]. She found only the former to be very accessible. The OED contained barriers that significantly reduced its accessibility. The accessibility of the Encyclopedia Britannica Online comes as a surprise to this author. When asked about its accessibility for people with disabilities at an exhibition during the American Library Association Conference in 2000 (summer), the publisher’s sales representative denied, rather briskly, any knowledge about this aspect of this product and discouraged any discussion about the topic.

E-Journals: Coonin [19], who examined the accessibility of e-journals of eleven providers (see Table 3), found, with one exception (Kluwer Online), some major accessibility errors in the “basic access pages” (introductory, basic search or result pages) of all e-journals. Lack of alternative tags for images was the most frequent problem. Alternative tags for image-map hot spots were missing among the pages of four of the e-journals. Four e-journal providers neglected to title all the frames.

Table 3. Accessibility of e-journals by provider: number of major accessibility errors in “basic access” pages and electronic file format of e-journal articles (Coonin [19])

E-journal provider	Major Accessibility Errors	Electronic Format of E-Journal Articles			
		HTML	Text PDF	Image PDF	Other
BioOne (SPARC)	5	X	X		
Catchword	3		X		RealPage
Emerald	3	X	X		
HighWire*	4	X	X		
IDEAL	3		X		
JSTOR	4			X	
Kluwer Online	0		X		
Project MUSE**	4	X	X	X	
Science Direct	4	X	X		
SpringerLink	4	X	X		
Wiley Interscience	5	X	X		

*Some journals in text PDF only. **Some journals in image PDF only.

As indicated earlier, Coonin also took notice of the format in which the articles themselves are provided. Six of the providers offer an accessible html format option for their e-journal. Of the five providers who do not offer this option consistently, three utilize a text-based PDF format, which, for the most part, is an accessible product. All of JSTOR's, and some of Project Muse's e-journal articles, are provided in image-only PDF files, which cannot be accessed with screen readers. Systems, such as Kurzweil 1000, are emerging on the market that are capable of converting the image-based text information into ASCII text with the aid of optical character recognition (ORC) software, but the converted product contains errors and is thus considered by many to be an unacceptable long-term solution.

4 Discussion: Research as an Instrument of Change

The research findings reviewed in the previous two sections reveal a mixed picture: Even at academic libraries, where web site accessibility tends to be higher than at public libraries, people using assistive technology often encounter access barriers. On the positive side, few of the online resources reviewed—catalogs, indexes/databases, reference works, and e-journals—were absolutely inaccessible. For most of these, accessibility was reduced—but not to the point of absolute inaccessibility. While the above picture is not as grim as it could be, much needs to improve to make library resources fully accessible to all users. It is particularly disturbing that library schools do not appear to take on the leadership role that they should. If the low accessibility of library schools' web pages is any indication of the level of awareness at these institutions, new librarians will not enter the profession with the knowledge and attitudes conducive to the creation of a barrier-free online environment.

Accessibility research may help to bring about change in three ways: First, by providing a general picture of where libraries are and where they need to go, it provides impetus to the rewriting of existing policies in more inclusive terms and to putting into place adequate mechanisms for their implementation. Second, to the extent that web site accessibility studies identify individual institutions, those with low accessibility may become motivated to improve their "ranking." No institution likes to stick out negatively in comparative studies. Also, with the publication of these data, institutions that do not respond to documented access deficiencies may find themselves in a particularly vulnerable position should legal complaints be filed against them (as it may happen, for example, in the U.S. under the Americans with Disabilities Act). Third, information about the accessibility of commercial products is badly needed by librarians making procurement decisions. Most librarians have no idea whether the many electronic resources to which their libraries subscribe, or the resources that they are considering for purchase, are accessible to people using assistive technology. The reason for this is simple: There is hardly any information out there. Product vendors are only beginning to understand the issue, and those who do provide information, tend to couch it in vague phrases ("compliance with the Americans with Disabilities Act") and are typically unable to answer more specific questions, such as questions about the methods used to evaluate the accessibility of their products. While, thanks to Bobby and other such tools, it is relatively easy to get a rough idea about the accessibility of ordinary web pages, the evaluation of dynamic interfaces exceeds the expertise (and time constraints) of most librarians. The studies

soon to be published in *Library Hi Tech* constitute a first step towards filling this information vacuum. Hopefully, these issues will stimulate further evaluative research in this area, help librarians to make informed procurement decisions, and provide information that may encourage vendors to develop truly inclusive products.

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Quick Access to Dictionaries for Blind and Visually Impaired People

Brasseur Vincent¹, Mohamed Slimane¹, Nicole Vincent¹, and Dominique Burger²

¹Laboratoire d'Informatique de l'Université de Tours, E3i, 64, avenue Jean Portalis
37200 Tours, France

<http://www.li.univ-tours.fr>

²BrailleNet, INSERM U483, UPMC B23, 9, quai Saint Bernard 75252 Paris cedex 5, France
slimane@univ-tours.fr

Abstract. Editors publish more and more electronic books on CDR or online. Generally, they use their own databases to create the web pages. But this pages are often not or badly adapted to visually impaired (frames, use of columns...). We propose a tool that use those databases to create accessible web pages for visually impaired readers.

1 A Solution for Quick Access to Dictionaries

The access to dictionaries and encyclopedias is essential at school, university or work. Traditional techniques, like large print or embossed Braille, would result in many bulky volumes making quite uneasy their reading. A few years ago, the emergence of dictionaries on CD-ROM and more recently on the Web, provided new opportunities for the visually impaired to access dictionaries. Nevertheless, in spite of the fact that some of these dictionaries are accessible with Screen Readers, the user interface has to be optimized for improving the reading process.

The general trend in the publishing world is to build databases whose content is independent of the reading interface, using structured languages like XML (eXtensive Markup Language). These well structured source files may be used to create automatically interfaces for visually impaired users.

Indeed, HTML provides a simple and efficient way to create accessible documents in respect of the WCAG guidelines of the W3C/WAI [1][2]. Thanks Cascading Style Sheet (CSS) techniques, people with low vision can use standard screen, with customized fonts, sizes, colors and contrasts. Blind users use Braille devices or speech synthesizers.

In this context, we have developed a tool for creating accessible HTML pages from the database of a popular encyclopedia, published in France by Hachette-Multimedia [3]. The main part of the technical work consisted in developing functions for the conversion of the XML files into adapted HTML files. We have used Web techniques that are supported by most of the different technical environments. The programming language is PHP, used to parse XML files, to interpret each element, and to handle the query dialogues with users. The pages are build on the fly in response to user's requests.

2 The Reading Interface

The structure of the database used by the publisher has been analyzed, as well as the functionality provided to end-users. Then a model of non-visual interface has been proposed and a make-up HTML interface was prepared giving access to a few definitions. This make-up was tested out by 2 blind users. Finally the accessible interface was developed made of 3 main HTML pages : First, the user access a general page for specifying an entry which is sent to the search engine. The answer is a page containing the list of the corresponding articles in the database. The users select an article to receive the full article and links additional information (Fig. 1). Each article starts with a table of contents. Some facilities have been added to improve the robustness of the whole process, like a phonetic search, for example.

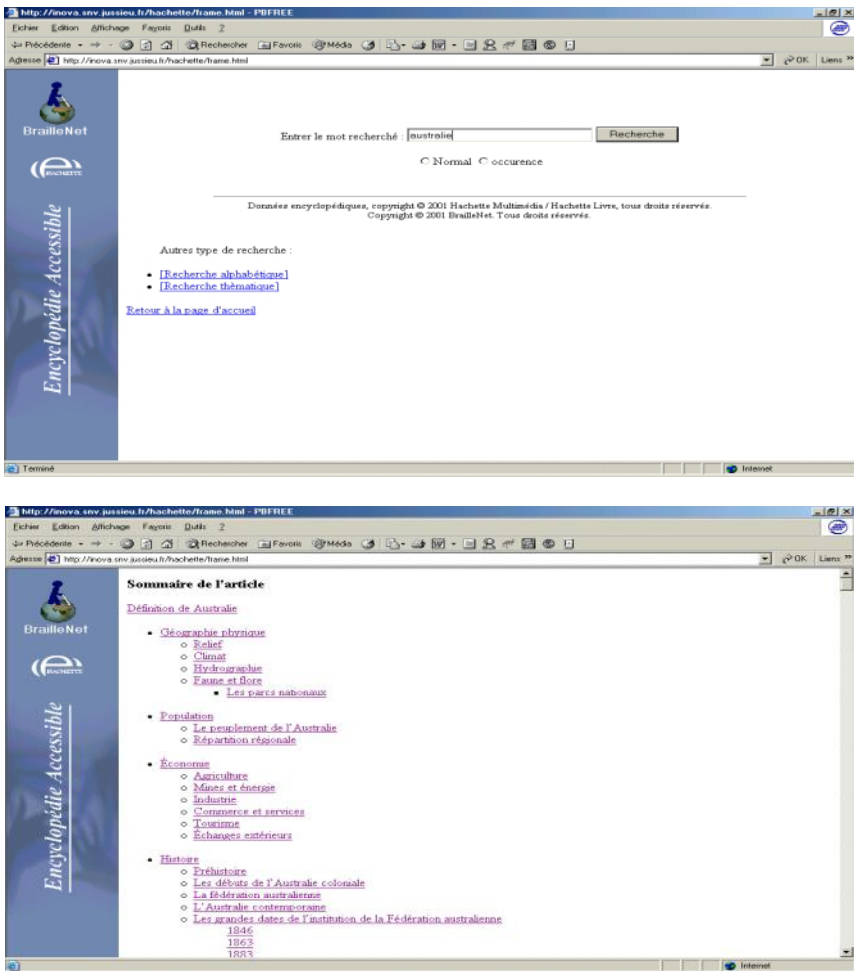


Fig. 1. Adapted User Interface: Examples of a query page and an answer page

To conclude :

The Encyclopedia has been made available on a Web site for evaluation by a larger panel of users.

The use of Web techniques guaranties that the end-user can take advantage of any new version of the encyclopedia which the publisher would distribute further, provided the general structure is respected.

The development work appears to be quite affordable and the principle could be transferable to other contents, and applications. It could fit in with the needs of other handicapped end-users.

This adaptation work is coherent with the efforts made by the Open E-book Forum [4] toward the normalization of XML formats making possible the access of documents on different platforms.

Acknowledgements. This work would not have been achieved without Neil Minkley, Claude Toulon and the kind collaboration of Hachette-Multimedia.

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Perspectives and Possibilities for the Automated Processing of Scientific Texts for Blind and Visually Impaired People

Gerhard Jaworek

Universitaet Karlsruhe (TH)
Study Centre for Blind and Visually Impaired Students
Engesser Str. 4
76133 Karlsruhe Germany
jaworek@szs.uni-karlsruhe.de
<http://szswww.szs.uni-karlsruhe.de>

Abstract. In this presentation I would like to point out the possibilities which could be open to us in using XML for producing electronic texts for this target group. In XML you can describe how a document's formatting should be presented.

This means that a document which is written in XML could be transferred in an optimised form for reading with a braille display, in an optimised form for visually impaired or in a form which is suitable to be read by a computer's voice output.

I want to show the most important qualities of XML. A greater part of this presentation will be a generalisation of the problem. The disadvantages of the systems used traditionally shall be compared with the advantages of XML.

1 Introduction

A very important service of our institution is the preparation of scientific literature for our blind and visually impaired students. We receive the literature in very different formats, e. g. in WINWORD, Postscript, LATEX or in hand written form. The materials are transferred into an electronic form which based on ASCII. For describing of mathematical formulas we use a special script language which was developed in Karlsruhe to describe mathematical contexts in a linear form. This script language is called AMS. Today no possibility exists to convert all textformats in an optimised form for seeing damaged people. XML will be a powerfull tool for solving this problem.

2 Layout and Context

A problem of converting different formats in others is the difference between layout oriented or context oriented formats. For example it is possible to put mathematical formulae which are written in AMS into a HTML document. This

format doesn't include a construction which tells your browser that a text part is a mathematical formula. There are only elements to describe the layout of a text in HTML. This means that it is very difficult to find mathematical formulae for converting them for example into a text format which is optimised for a speech synthesiser or a braille display. Text preparation for different groups includes knowledge about the used software and knowledge about the different kinds of terminals (speech output or braille display). The problem is a bit similar to the fact, that today the WEB is accessed with different terminals like screens, mobil phones etc. This implicates that we use a text format in which the text structure and the text objects is to the fore.

3 XML and Its Properties

- XML describes the objects of a document.
- XML is expandable.
- XML doesn't fix how a text object, e. g. a mathematical formula is presented.
- In XML documents are described in an abstract form.

4 XML and Automated Text Preparation

The following aspects talk for preparation of literatur with XML:

- XML and its concepts (DTD, XSLT and DOM) is very common in the world.
- XML guarantees the quality of the literature because it is defined in the document type definition for this problem.
- XML is a formal clear language.
- If a document is parsable and if it fulfills all rules which are defined for the preparation of documents for blind or visually impaired people it is guaranteed, that you'll get a visual damaged friendly output.
- Your software XML-Handler decides what should be done with a XML document.

Universal Usability Issues of Textual Information Structures, Commands, and Languages of Native Visually Challenged Users: An Inclusive Design Framework

Basawaraj Patil, Klaus Maetzel, and Erich J. Neuhold

Fraunhofer Institute for Integrated Publication and Information Systems
Dolivostrasse 15, 64293, Darmstadt, Germany
{patil, maetzel, neuhold}@ipsi.fraunhofer.de

Abstract. Current textual languages (e.g., textual information structures, command and query languages, and programming languages) are neither accessible nor adaptable to the computing requirements of native visually challenged users. In this paper, we identify semantic, syntactic, linguistic and cognitive issues and accessibility factors at various level of human-computer interaction and proposes a inclusive, universal design framework, that enables not only linguistically handicapped users but also visually challenged users to command and operate computers, and learn programming.

1 Introduction

A majority of Universal Design (UD) methodologies and Assistive Technologies (AT) neglect a large section of global population, including people with special needs called “native visually challenged (NVC)” users. The NVC users referred to here, include blind or visually impaired students and adults, from non-English speaking geographical regions (e.g., Asia, the Middle East, Africa, Europe) and prefer to interact in native languages, social-cultural environments using native Braille (e.g., Asian, European, African Braille) or native voice interactions. We use the generic term “textual languages” to cover the broad spectrum of textual information structures, command and macros, query and programming languages used in diverse computing applications that are inherently textual in nature. For example, how to support textual interfaces and interactions in African Braille Kiswahili (grade 2) and Kiswahili native languages that satisfy the native computing requirements? Lack of enabling and assistive technologies that support “Universal Access” to textual languages, lack of appropriate linguistic and cultural content, and native Braille or native voice interfaces in diverse computing applications have been a serious impediment to harness the power of Information Technologies. In the worst case, it may lead to – “Internet Apartheid”. Especially, in educational computing, the native visually challenged users neither have linguistically and culturally enabled educational computing resources nor native Braille or voice technologies to acquire the IT skills and programming expertise.

2 Native Visually Challenged Users and Universal Usability Issues of Textual Languages

In general, a majority of NVC users are novices and their medium of education is in native languages and socio-cultural environments and prefers to acquire the skills of programming. Their computing problems are compounded by the fact that, they not only linguistically and culturally handicapped but also visually impaired! From universal usability engineering perspective, the majority of textual languages “neither speak the native languages nor native Braille”. In brief, major issues are:

- **Syntactic Inflexibility:** The majority of syntactic elements or vocabularies, punctuation, commands and programming conventions of textual languages are based on “English paradigm” of syntax and semantics and native visually challenged users encounter serious difficulties syntactic and lexical levels of HCI interactions [8].
- **Semantic Mismatch:** In general, native languages, cultures and locale conventions influence the native Braille representations and transcriptions. The semantics of textual languages do not match well with the concepts and semantics of native natural languages [7]. Hence native visually challenged users encounter linguistic and cognitive barriers.

3 EQUAL Universal Design Principles and Framework

EQUAL is universal, inclusive design and development environment mainly focused on the universal usability of textual languages catering to the computing requirements of not only linguistically and culturally handicapped users but also visually challenged users [8]. Recent research studies addresses the issues of teaching and learning of programming languages using dialogues [2,3] and programming paradigms [1,4], voice programming [5] and user interfaces for visually impaired users. These research studies focus on complex languages and programming paradigms and are not flexible to support novice NVC users’ computing and programming preferences and requirements, but offer valuable insights into the programming issues of visually impaired users. The basic concept of EQUAL universal design is to represent the “grammar” of textual languages in a language neutral, culture independent, adaptable assistive mechanisms and HCI factors, and map onto the concrete implementations satisfying the computing and programming needs, preferences and requirements of NVC users. The universal design principles and guidelines of EQUAL are:

- Support high degree of naturalness at syntactic, semantic and cognitive levels of interaction and programming constructs in various native Braille encoding.
- Enable native Braille transcribing mechanisms to transcribe the native Braille to textual languages and vice-versa.
- Enrich NVC user’s programming environment with native syntax-directed editors and voice technology [6].
- Support native multi-modal interactions (e.g., languages, Braille and voice).
- Support enabling, assistive and scaffolding mechanisms to acquire the skills of programming and programming paradigms.

4 Conclusions

In this paper, we have discussed the syntactic and semantic, cognitive issues and accessibility factors encountered in the interactions of textual languages. We believe that, a rapid prototyping environment based on inclusive design concepts, principles, and universal design methodology offer deeper insights in the universal usability issues of textual languages. The EQUAL design framework will be realized in a prototype and helps in conducting universal usability studies of textual languages. It also and the offers unique opportunity to NVC users to enhance their quality of life, acquire IT skills and programming expertise.

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Accessible Interface Design: Adaptive Multimedia Information System (AMIS)

Marisa DeMeglio, Markku T. Hakkinen, and Hiroshi Kawamura

Japanese Society for Rehabilitation of Persons with Disabilities (JSRPD), Tokyo, Japan
{marisa,hakkinen}@dinf.ne.jp, hkawa@attglobal.net,

Abstract. This paper provides an overview of the concepts and design of the Adaptive Multimedia Information System (AMIS). AMIS is a software application for the playback of natively accessible content (DAISY and DAISY/NISO books), and of accessibly authored HTML pages. DAISY playback includes support for SMIL elements and the Navigation Control Center. AMIS retrofits HTML documents with a navigation overlay that enables accessible presentation through synthesized speech, large print, and Braille renderings. AMIS employs a flexible XML-based architecture that allows for adaptation of the standard interface to meet the needs of both users and assistive technologies. The mutable application interface allows it to adapt to user preference, content delivery mode, and assistive device capabilities. Users may customize font size, color contrast, spacing, volume, playback speed, and presence/absence of interface regions. Core interface features are derived from both the DAISY playback model and the W3C User Agent Accessibility Guidelines. AMIS XML documents describe application components (controls, content layout regions, dialogs, content renderings) aurally, textually, and visually. The default application interface allows for visual and aural output; and touchscreen, mouse, and keyboard input. Through the use of the AMIS Plug-in SDK, developers can write interfaces to a variety of assistive devices. These devices can gain access to the same application functionality and content as does the native interface. Localization is also very easily obtainable in AMIS, because every aspect of the interface is customizable. Labels on buttons and regions are all imported directly from the system's Interface Markup documents. The plug-in architecture allows for the addition of new input methods, to accommodate techniques such as IME (Input Method Editor generally used for East Asian languages) and on-screen keyboards. The adaptable interface framework and the content rendering capabilities, coupled with the use of open standards, enables the customization or addition of features to meet a broad range of user requirements.

1 Introduction

Information technology has brought about significant advances that can enhance interactions between persons with disabilities and society. Digital content, such as that found on the world wide web, can now quite easily be made accessible. Blind users may use synthesized speech and a Braille display, rather than rely on volunteer readers and large Braille books. Deaf users may talk in real time, without the assistance of a sign language interpreter, using text-based chat. People with Dyslexia

can use reading software that highlights word order. Those with cognitive disabilities can speed up or slow down the content playback speed to suit their preference and need.

1.1 Accessible Interfaces at Present

However, when we examine not only the content but also the interface (the means through which a user obtains the content), we see that basic accessibility may serve one disability group well, while failing to meet the needs of others. Certainly there has been great progress made in developing interfaces for the visually impaired, but even these are inadequate at times. Interfaces for users with cognitive disabilities are few in number, and are not yet incorporated into mainstream interface design. When considering persons with multiple disabilities, we see tremendous room for progress.

Often, operating systems will include a suite of tools aimed at improving ease of use for disabled users. While these tools are adequate for getting around a desktop, the user experience they provide does not replace that of a non-disabled user. Adaptive devices also provide a layer of accessibility, but here flexibility is limited to the requirements of users as predicted by the device manufacturers. In reality, user requirements far outnumber this.

1.2 Universal Design

Universal interface design aims to solve this problem by being "all things to all disabilities". This is what must exist in interfaces before they can claim to be completely accessible. There are two major aspects to universal design: features of a device's native interface, and means of communicating with other devices' interfaces.

There have been a variety of approaches taken to address the challenges of universal design. In all cases, the motivation is to create an interface that will result in an application being usable by the broadest set of users and abilities. EZ Access [6] defined a cross disability hardware and software interface that could be incorporated in information kiosks, automated teller machines, and hand-held devices such as mobile phones. Stephanidis & Savidis [7] describe their work in with the Avanti project, which is a set of tools and interface features that allows a web browser to be adapted to a range of user abilities. The concepts developed by Stephanidis [8] are applied to a broader goal of the Unified User Interface Platform, an architectural framework for designing accessible interfaces. In addition to these research efforts, operating system platform vendors have incorporated accessibility enabling Application Program Interfaces (APIs) (e.g., Microsoft Active Accessibility and Sun's Java Accessibility), which permit assistive technology vendors to provide unique interface solutions. Standards for the physical interface between systems and assistive devices are also in development, such as INCITS V2 [4].

In the examples above, we see hard-coded solutions (EZ-Access), automatic adaptation (Avanti), and low-level APIs that require significant software engineering expertise to implement. Mark-up languages, such as XML, can offer flexibility in designing interfaces, and open the design and implementation process to individuals with specific expertise in a given disability (rather than a software engineering

background). The success of HTML as a design tool for the masses is a case in point. Projects such as the User Interface Mark-up Language [1] further demonstrate that XML can play a role in standardizing and the definition of application user interfaces.

1.3 Combined Approach: DAISY and AMIS

User requirements are so varied that they preclude us from making design assumptions beyond that we must provide access to interfaces in an open, multimodal, and highly navigable fashion. This is the aim of the Adaptive Multimedia Information System (AMIS). It is being developed as open source DAISY (Digital Accessible Information SYstem) playback software. The interface of AMIS can be fully customized by a non-technical user. Communication with external devices is made possible by the AMIS plug-in architecture. Like DAISY, the interface of AMIS is defined by multiple synchronized media types (text, audio, graphics). By creating an interface that operates in many modes, or combinations of modes, and combining that interface with DAISY's native accessibility, we can hope to reach as many ability levels as possible.

2 Accessible Content Needs an Accessible Interface

2.1 Accessible Content: DAISY

DAISY is the newest advancement in accessible content. It is the new generation of digital talking books, but its capabilities are not limited to digital versions of print books. A DAISY publication may be text, text and audio, or audio only. Publications can be further enhanced by graphics, video, and other Synchronized Multimedia Integration Language (SMIL, pronounced "smile") elements. The content is built from synchronizing modalities (for example, text and audio) using SMIL files, and then defining navigation points. The navigation points are extracted and listed in a file called the Navigation Control Center (NCC or NCX). This is a very powerful feature of DAISY publications because it allows quick access to chapters, pages, footnotes, references, or other publication features [3]. We can see it as a flexible, accessible interface to multimodal content.

Libraries for the blind around the world are producing DAISY publications. International training seminars on creating DAISY content have generated great interest in countries such as Japan, India, Singapore, and Thailand.

2.2 Accessible Interface: AMIS

The concepts of the AMIS interface come from the DAISY playback model and the World Wide Web Consortium's User Agent Accessibility Guidelines. The underlying design is based on a very simple set of elements: frames, controls, and multimedia rendering viewports. Each interface element is externally defined in multiple modes: textual, aural, and graphical. Frames contain controls and viewports. Frames have titles, represented in textual, aural, and graphical ways. Controls are also labeled in this way. Controls do not contain other elements, but they have an associated

command. It is very simple to create your own customized version of AMIS, simply by defining what frames look like, what multimedia viewports they contain, and what user controls exist. You may wish to "tile" the background of a frame with your own picture, or use a default color scheme. You can add sound clips to the controls, as an audio label or as confirmation of a user's action.

DAISY content is presented with many rendering options, and the user may adjust, among other things, font size, color contrast, line spacing, volume, and layout of viewports. This meets guidelines 4 and 5 of the W3C User Agent Accessibility Guidelines (UAG). They are, respectively: "Ensure that the user can select preferred styles (colors, size of rendered text, synthesized speech characteristics, etc.) from choices offered by the user agent..." and "Ensure that the user can control the behavior of viewports and other user interface controls..." [5]. Rendering via external assistive device is possible by making use of the AMIS plug-in architecture. This satisfies the UAG recommendation that applications: "Implement interoperable interfaces to communicate with other software (e.g., assistive technologies, the operating environment, plug-ins, etc.)" [5].

By making the entire application—interface, rendering, and interaction with other devices—customizable, and providing several ready-made customizations, we can enable both disability specialists and novices to find what works best for their target user group.

3 Flexibility

Next we will look at the architecture of AMIS. We will see how DAISY implementation requirements, use of XML and other configurable files, and the plug-in API define the system's flexibility.

3.1 Implementing DAISY

DAISY playback software typically has very few dependencies on external components. The recommendation for developers is to make use of an XML Parser, Media Playback, HTML/XML Rendering, and SMIL engine (optional) [2].

The AMIS application is built from an XML parser, an HTML parser, and multimedia rendering components. SMIL playback is done by AMIS; no engine is used. User interface elements are limited (purposely) to frames, short text display, and control buttons. Use of these common interface elements enables AMIS implementations to exist in many operating environments.

3.2 Use of eXtensible Markup Language and Configurable Files

AMIS relies upon a series of external files to specify user preferences about the interface style and available options. The AMIS interface is generated from a series of XML documents, called the interface markup files. These files give the placement and order of screen elements exposed to the user, such as button-style controls and multimedia viewports. The properties of these elements, such as label and associated command, are also defined in the interface markup files.

The screen element labeling system consists of `<xLabel>` XML elements. An `<xLabel>` has a type associated with it ('title', 'select', 'toggle', 'hover') and three representations of a label: text, audio, and graphic. Depending on the parent element (frame, control, prompt, or other descriptive context), there could be several `xLabels` in series, each with different type attributes. For example, a control might have a 'normal' type for when it is idle; a 'select' type for when it is chosen; a 'toggle' type for when its function changes (mute to unmute, perhaps). Visual rendering consists of text, text and graphic, or graphic only. Rendering is adjusted by turning on or off the 'show' attribute in the text field, and entering or leaving blank the graphic's filename. Aural rendering occurs as the user navigates the screen elements, using a control, keyboard key, or external device.

Controls with associated commands must specify a command name to use, as defined in the user command subset document. AMIS has a set of system commands, many of which are customizable. For example, let's look at the system command "applyStyle". This is used to apply a stylesheet to an HTML region. This is a command that must be customized to specify which stylesheet and what HTML region. The corresponding line in the user command subset file might look like:

```
<implementCMD id="Style1 main "
  paramValue="sysHTMLContent:oversize"
  refID="applyStyle"/>
```

where `paramValue` gives the required parameters, in the form of `REGION:STYLESHEET_ID`. When a control wishes to implement the command, it simply references `Style1_main`. Other ways of customizing commands are to use a system variable or to use a dialog to get a parameter value. Examples of system variables are `CURRENT_FRAME`, `CURRENT_CONTROL`, and `CURRENT_REGION` (instead of the specific region `sysHTMLContent`). An example of a dialog interaction command is shown by:

```
<implementCMD id="Exit"
  paramValue="AMIS_DIALOG:ExitApp"
  refID="exitApplication"/>
```

where the system command is 'exitApplication', the command to be referenced by controls is 'Exit', and the parameter (a yes or no value) is the value returned by the 'ExitApp' dialog. The prefix 'AMIS_DIALOG' is required to tell the system to launch a dialog window.

Another XML-based feature is the HTML rendering configuration file. HTML rendering is called for when the content is to be read using text-to-speech (if no prerecorded audio is available). Specified in this configuration file are the list of tag types to be rendered, the associated audio effect, what descriptive phrase to say before the tag is read, and where to get the tag's contents. For example, if the HTML tag looks like this:

```
<h1>Introduction</h1>
```

The rendering could be:

{audible sound} 'ding.wav'

{text-to-speech} "Heading one"

{text-to-speech} "Introduction"

Two other configuration options are important for AMIS: cascading style sheets (CSS) and internationalization. Because DAISY text is in HTML format, we are able to offer the user a great deal of customization in appearance by using CSS.

By editing profile settings, a user can specify CSS documents as well as sets, or groups, of CSS documents. For example, someone wishes to have control over the contrast settings of the HTML display. They can define a group of CSS documents called “contrast” and then customize the “cycleNextCSS” command to use their CSS group by giving it a parameter of “CURRENT_REGION:contrast” (or whatever their target region is). When a user chooses the control associated with this command, they will see the first (or next, depending) style of the “contrast” CSS group. CSS gives AMIS great flexibility in font size, color, and spacing; all important for types of print impairments.

Internationalization is easily achieved in AMIS. Simply by editing the interface markup documents and changing the text and font associated with interface elements, the keyboard commands, and any pre-recorded audio or locale-specific graphics, AMIS can be customized to any language supported by the operating environment. The text element of a label can reference an external file, so it is possible to change all the interface text by swapping the text string file with another. Also, it is important that all HTML and XML documents read by AMIS have the appropriate encoding attribute specified.

3.3 Input and Output Devices

AMIS natively supports keyboard, mouse, and touchscreen as input devices; and audio and monitor display as output devices. While programmatically, its behavior is similar to that of a mouse, a touchscreen is a much more intuitive interface for those who do not routinely use a computer. Keyboard support is strong, with an XML document defining command mapping. A keyboard interface has access to every command available to an on-screen control. These three native interfaces help us to reach a variety of users, but their experience is not limited to the use of these three devices.

AMIS is designed to communicate with input and output plug-ins by using a simple API. An engineer may wish to interface his human interface device (also called HID. e.g., a gamepad) to AMIS. He simply writes the appropriate code to interface his hardware with the computer, and incorporates this code into his AMIS input plug-in. When there is HID activity, the engineer’s code finds the command he has associated with that particular button or switch, and sends the command to the AMIS system by using the specified event messaging method. All commands are available for use in the plug-in API.

An output plug-in is constructed in a similar fashion: an engineer interfaces her new refreshable Braille display invention to the computer. Then she writes an output plug-in so AMIS can communicate with the Braille display. Whenever there is new interface or content data, AMIS notifies the output plug-in and sends the data in XML format. The format for interface data is the same as defined in the interface XML documents: frames, controls, and descriptive xLabels for each.

4 Future of AMIS

The first development in the future of AMIS will be to launch an open source project. Information about this will be available at <http://www.amisproject.org>. It is our hope to get input from users, engineers, and interface design experts, so that AMIS becomes a more powerful and easy to use system. The license will be GNU General Public License or one similar, and the project will be managed by the software development team at JSRPD. The target programming language is Java and releases are expected to be platform-independent.

Another area of collaboration will be in the advancement of the plug-in architecture. It is very important that we develop a robust text input plug-in system for use with such technologies as the Input Method Editor (IME, common in East Asian languages). For this we would like to work with engineers in those locations in order to develop the best strategies to meet the needs of users in those communities.

The next important step in the AMIS project is the creation of the Interface Generator application. Such a tool is very important for fast creation of interfaces. With a drag and drop or hierarchical approach, we can provide users with an easy way to “skin” their copy of AMIS. We would like to provide an online library of AMIS skins, free for use, so that people may access them and contribute their own creations.

The ultimate goal of the AMIS project is to provide users of all ability levels with DAISY playback software that is built from the ideas and contributions of users worldwide.

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Reading Multimedia Documents

Helen Petrie¹ and Gerhard Weber²

¹Centre for Human Computer Interaction Design, City University, Northampton Square,
London EC1V 0HB, United Kingdom
h.l.petrie@city.ac.uk

²Kiel University – Multimedia Campus, Theodor-Heuß Ring 140, 24143 Kiel, Germany
g.weber@mmc-kiel.com

Abstract. Multimedia titles use technology which offers a good basis for use by print-disabled people. However, lack of appropriate document structures and difficulties in navigating multimedia titles limits the readership. We propose a new approach to design of multimedia documents by separating contents from interaction techniques while using XML standards. From these XML-based documents and their mapping the final multimedia title can be generated using industry standards.

1 Introduction

Electronic documents are becoming more and more omnipresent as distribution of books, newspapers, manuals, dictionaries, encyclopaedias, edutainment software on CD-ROMs and DVDs grows. The immense amount of storage which can be hold by affordable disks contrasts with a demand for efficient and effective access to information stored in electronic form by everyone. The term eBook widens the concept of letters arranged into sentences and chapters towards a rich presentation of contents and – also for ease of reading – provided through a multiplicity of presentation media. Figure 1 compares current uses of multimedia applications.

eBooks are to be read on eBook readers – either PC-based software or dedicated portable devices such as personal digital assistants (PDAs). Pioneered by multimedia computer games on PCs and “playstations” can hardware for audio playback, 3D rendering of sound, speech and images be packed into portable and even wearable devices. A watch with MP3 audio player can be used for listening to a recipe and a mobile phone with a video player can be a versatile device for reading a gourmet guide. But selection of a title from a set of audio tracks or selection of restaurant tips on a mobile phone remains to be time-consuming and requires either visual or auditory control and sometimes even both. Lack of control of multimedia documents imposes therefore a barrier for people, who are blind or deaf. In the following we want to propose mechanisms and a new design method for the information stored in multimedia titles in order to facilitate integration of print-disabled people into the information society.

2 Limitations of Multimedia Titles

A good example for implications from lack of access to audio or graphics is an encyclopedia such as MS Encarta [7], which is otherwise a very successful multimedia title demonstrating the added value of multimedia. Encarta contains articles on subjects enhanced by pictorial material, films, and even audio. Many words in Encarta can be looked up for spelling and pronunciation within a dictionary.

For example is John F. Kennedy described and his life is illustrated by pieces of his inaugural speech as well as a video of his speech on the cuba crisis (Figure 1). In this entry of the encyclopedia the word "inaugural" can be looked up in the dictionary through a hypertext link.



Fig. 1. Snapshot of a multimedia article

Access to the article on John F. Kennedy by deaf people requires to transcribe spoken text at least into captions and more preferable into sign language. Layout of the visual information is already compact in Figure 2 and an additional video (or animation) requires to modify the layout considerably.

Access to Encarta's text by blind people is partially possible (see Figure 2) by a screen reader for graphical user interfaces [8]. A screen reader allows to explore the windows contents including symbols denoting links to multimedia elements, if the screen reader has been properly trained for that task by a sighted person. Limitations arise due to lack of access to the controls of time-dependent single media objects (SMOs). In Figure 1 video and audio SMOs occur. Additionally it requires to verbalize the image of Mr. Kennedy and to transcribe the phonetic encoding of the word "inaugural" into Braille code.

Newer versions of Encarta allow reading out the text using speech synthesis. Verbalization of phonetic symbols for speech output is lacking, and would require appropriate mark-up. In addition, navigation in spoken text based on keyboard input

is sub-optimal and may lead to the “lost in space” situation if synthetic speech is mixed in parallel with speech playback of the inaugural speech.

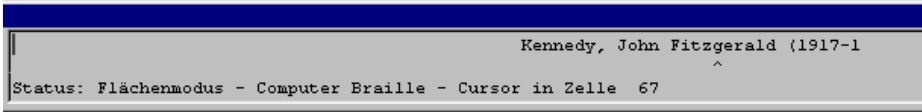


Fig. 2. Braille view of fig. 1. highlighted section

Access to Encarta by people with low vision to text is provided by screen magnification software. A multimedia title with images, video or audio however requires high resolution encoding of SMOs or alternative data format suitable for high-bandwidth requirements. Magnification of images encoded in the usual screen resolution of 75 dpi produces largely unreadable results if a factor of 4 or higher is applied. Magnification of videos cannot be achieved by most current assistive devices.

3 Editing Alternative Contents

The example of an encyclopedia article demonstrates the need for *enriched multimedia* titles in order to address as many users as possible. An enriched multimedia title consists of redundant contents from which appropriate combinations for viewer’s needs can be selected. Current technology of digital versatile disks (DVDs) can be considered to be an enriched multimedia title, as it includes audio tracks for all languages besides the movie as well as subtitles written in each of these languages. DVDs may include more documents than the film alone, such as a description of the making of the film. We want to call a DVD an enriched multimedia title, if redundancy of media is provided for all parts of the production and navigable.

DVDs are statically enriched multimedia titles as only overlay of visual output can be achieved and no modification of navigation techniques is possible. Dynamically enriched multimedia titles are able to modify the presentation according to user requirements by substitution and by modifying rendering of SMOs. If in addition interaction, for example for navigation, is dynamically modified then we call such a multimedia title *semantically* enriched.

In the following we discuss some examples for static enriched multimedia titles suitable to print disabled people, illustrate requirements for dynamically enriched multimedia titles and give an outlook on features of semantically enriched multimedia titles based on temporal modeling [15].

Static enrichment of multimedia titles not only takes into account the user’s language. For blind people the addition of a braille version of text is necessary, as well as a spoken version of all text. Deaf people besides captions prefer a movie of a signer or animation of a synthetic avatar to accomplish verbalized presentation. Support for magnification for images requires different encodings among which according to the user’s profile can be selected.

For multimedia titles, services to transcribe from print into Braille or audio books and from spoken language into sign language should be seen no more independent

from each other. Print-disabled people have been described as a group being excluded from access to written and printed material. Various services such as newspapers for the blind [2] or accessible browsers [9] have been developed. Encarta has acknowledged this partially by allowing for three font sizes. But these otherwise hardly comparable user groups demonstrate the need for a new round in defining print-disability by identifying special needs in interactive systems namely eBook readers and the need for a more flexible design and encoding of multimedia titles.

3.1 Braille as a First Class Medium

The term Braille itself depends on the user's language and moreover may be one of contracted braille (grade 2) or uncontracted braille (grade 1). Some braille readers even expect computer braille, which is a one-to-one mapping between characters shown on the screen and a braille character.

A common technique to avoid editing of a braille version is to generate braille through appropriate conversion software from a text version. However, for a simple phrase-based form of contracted braille or for computer braille, generation of braille through screen readers is an accepted approach. More successfully, a text version which includes sufficient mark-up information, can be used to dynamically generate well-formed braille text using language specific converters.

Limitations exist for mark-up languages such as HTML as documents may include expression written in the programming language JavaScript. While HTML is a context-free language, does JavaScript add context-sensitive elements such as "mouseover" attributes which arbitrarily modify the presentation depending on the user's input. Automatic transcription of such a document is limited to HTML elements.

3.2 Audio

Auditory media consist of verbal or non-verbal expressions. As audio is a time-dependent medium the temporal structure and granularity of speech (prosody) and of sound is important. Audio as part of movies consists of possibly large pauses. During these pauses further descriptions of the movie can be inserted. If audio is enriched by audio there may arise conflicts which result in a sequential arrangement of the presentation and hence may extend the time needed to listen to audio by blind people.

Besides speech playback offers speech synthesis a cost effective mechanism to generate verbal audio. Its quality can be improved considerably if speech attributes such as pitch, gender, head size, prosody, etc. are taken into account. Just as braille can be transcribed from textual mark-up information can high quality synthesized speech be dynamically generated from text enhanced with mark-up information. Cascading Stylesheets have been developed to accomplish audio rendering [12]. However only together with transformation languages such as XSLT contents can be dynamically modified.

3.3 Signing

Lip reading and signing are two different methods of reading used by people who are deaf. Signing is a time dependent manual effort which depends on a particular language. The upper body of a signer and his/her limb's movements are shown. Expression are formed which either correspond word by word with text or are a description of the meaning of the text using syntactic elements of a signing language. Figure 3 shows a sign for "Germany" [3].

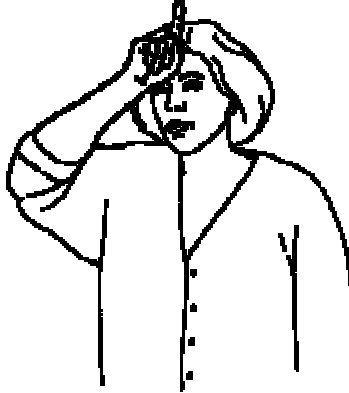


Fig. 3. German sign language example for "Germany"

Signing is part of TV broadcasting in various European countries. User needs have been recently investigated for the layout of signed videos, the use of captions, navigation in program guides, and requirements for media production within major broadcasting company [11]. To summarize, acceptance depends on the particular design of the presentation and varies from TV show to TV show.

Synthesis of sign language is possible through avatars. An avatar is a placeholder of somebody within a virtual world. A signing avatar is taking only little of the screen space and is created through modern rendering algorithms for an animated human body. In general, avatars are less accepted by deaf people, but future research may identify better transcriptions from text to signs [10].

3.4 Coherence of Media

As suggested by ISO 14915 is a multimedia title to be designed by structuring it into smaller units and by indication of parallelism and sequential constraints of each media stream. Figure 4 gives an example of such a design.

The approach of ISO 14915 is very well suitable for enrichment of multimedia titles as well. If for particular media streams alternatives have been incorporated then their duration depends on the duration of another interval. Hence rich multimedia titles require parallelism for particular media.

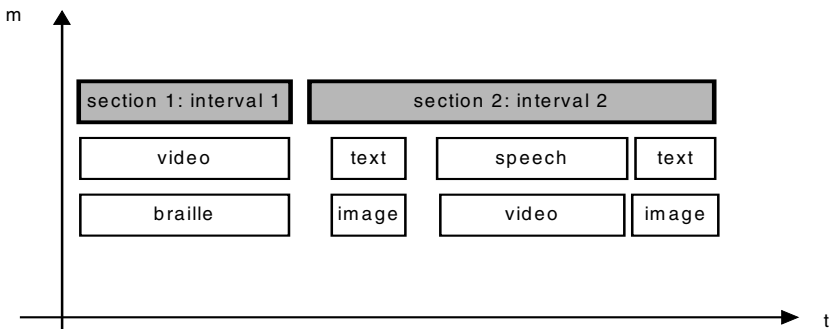


Fig. 4. Designing multimedia presentations

Even if users with some need for alternative presentations as described above are addressed then the structure of the multimedia title specifies clear intervals within which all presentations are to come to a common end. In case a particular medium has to extend the presentation because it is synthetically generated, it appears possible to lengthen the interval accordingly without degrading the quality of the design too much.

For example may a movie with subtitles be accomplished by a signing video. Signing may be chosen to be just long enough to fit with a scene of the movie. But more reasonably we can assume that it extends the scene's interval to cover all of it's contents. In this instance, the movie has to be paused (frozen) in order to ensure parallelism between the two different media streams.

4 Mark-up and Interaction

Temporal dependencies of presentations are described in a standardized way through the Synchronous Multimedia Integration Language (SMIL) [14] which is similar to the Amsterdam Hypermedia Model [4]. Unlike HTML is SMIL concentrating less on visual details. Documents written in SMIL specify a screen region and various presentations together with their detailed temporal dependency as to be shown in these regions. For example may a radio station use SMIL to relate a song to a commercial advertisement for buying the corresponding audio CD. SMIL 1.0 seems to be very well suitable for enriched multimedia titles and passed a WAI review. Industry standards such a Flash, Quicktime or Windows Media Format, however, try to achieve the same but are less accessible. Moreover it appears possible to generate these file formats from a SMIL presentation. The recent development of SMIL 2.0 adds more scripting functionality in order to address interaction techniques. SMIL 2.0 is available together with HTML as TIME currently only for one browser.

The discussion so far does neither take into account the method of browsing through a rich multimedia title, nor the more general design of multimedia interaction objects used in edutainment titles. Already figure 2 contains such an multimedia interaction object. It consists of buttons and sliders to control a movie's presentation.

Like SMIL and XHTML are a particular XML document type definition (DTDs) there are DTDs available to describe interaction objects. XUL is being defined within the Mozilla project ([1], VoiceML is a W3C standard [13] for voice input driven interaction. These interaction objects become usable through an appropriate screen reader for all users mentioned so far.

The integration of interaction techniques within temporally dependent media such as audio, animations, etc. introduces a complexity that makes it difficult to add to multimedia titles subtitles, signing videos, explanations of scenes, etc. Successful integration of interaction techniques with time dependent media requires coherence among the media streams. We define coherence as a quality of the perception of multiple time-dependent presentations of interaction techniques, which control their temporal granularity.

Designing multimedia titles for coherence requires an explicit representation of both the media's temporal granularity as well as the interaction technique's temporal constraints. Figure 5 shows a multimedia title's user interface which is generated from two different XML-based specifications. The complexity of the user interface is higher than the complexity which can be achieved by using a XML DTDs alone. A mapping between two DTDs possibly can be context-sensitive.

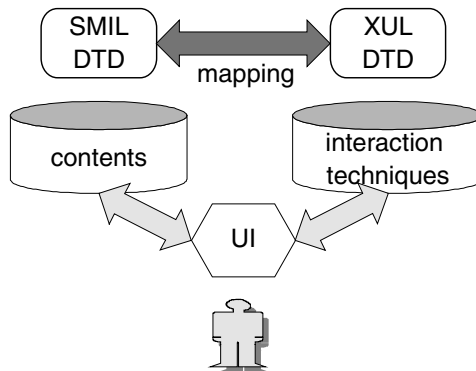


Fig. 5. Mapping contents and interaction techniques

Using state of the art approaches technically such a mapping can be based on a linkage between two DTDs based on XLink [5] or TopicMaps [6] or on the generation of script expressions.

The implications of such an approach are wide ranging as technological requirements may be taken into account while constructing the multimedia document or in a separate process.

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Comparison of Various Interface Modalities for a Locomotion Assistance Device

Yacine Bellik¹ and René Farcy²

¹ LIMSI-CNRS, Bât 508, Université Paris XI, B.P. 133, Orsay, 91403, France
bellik@limsi.fr
<http://www.limsi.fr/Individu/bellik>

² Laboratoire Aimé Cotton, Bât 505, Université Paris XI, Orsay, 91405, France
Rene.farcy@lac.u-psud.fr

Abstract. We have developed a triangulating laser telemeter adapted to the space perception for the blind: the "Teletact". Two parts compose the "Teletact". The first part is a laser telemeter, which detects the distances to obstacles, and the second one is an interface, which presents these distances to the blind user. The "Teletact" was developed originally with an auditive interface. Due to the long time training required by this interface we have tested some new interfaces based on other modalities (tactile and force feed-back). In this paper, we present all these interfaces and discuss them.

1 Introduction

The long cane is the most popular navigational aid for the blind. It is relatively easy to use, light and not expensive. However its reach is very limited and it is only used to scan the ground one meter in front of the walker. Therefore blind people must be in a permanent state of muscular contraction to be able to stop suddenly at every moment. A system of high angular resolution providing information about the surrounding area in a range of a few meters could relieve blind people of some of the actual constraints and stress when walking. Previous works in this field [1] [2], have shown the importance of such a system for mobility assistance for the blind.

2 Description of the Laser Telemeter

The "Teletact" is a hand held laser telemeter [3] [4]. The distance to the first obstacle encountered by the laser beam is measured with about 1% accuracy in the 10cm – 10 m range. Fig. 1 gives the basic scheme of the telemeter, and Fig. 2 is a photograph of the original commercial device. The blind user perceives the direction he points thanks to the internal consciousness of the position of its members (proprioception). To identify an obstacle it is necessary to scan the environment.

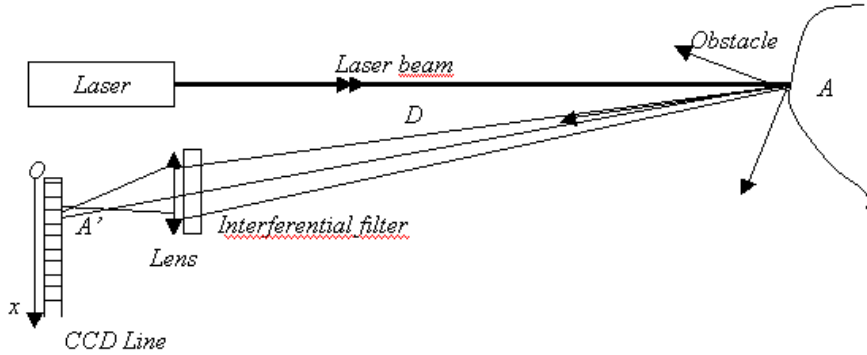


Fig. 1. Basic principle of the Telemeter.

The laser diode emits a collimated one milliwatt 670 nm laser beam. The beam meets the obstacle at a distance D and creates a laser spot A . The image of the laser spot A through the lens on the CCD line is A' . The position of A' on the line gives the distance D . As we can see on the figure, for $x_{A'}$ great, D is short. The basic principle is very simple, the main difficulty is to achieve immunity to diurnal light (i.e. up to 200klux summer sunny days), that need some optical and electrical additive systems. A continuous laser power of 1 mW (at 670 nm) is enough to obtain a signal up to 30 m. For ocular security, the system is a class II laser product. There is no risk by using the laser even if the blind user involuntarily points it to the eyes of a passerby.



Fig. 2. Photo of the “Teletact”.

3 Description of the Experimented Interfaces

In this section we describe the principles of the different tested interfaces: the auditive interface, the tactile interface and the force-feedback interface. We have excluded electro-tactile interfaces because they are very uncomfortable and their installation is too complex [5] [6]. In the next section we will compare and discuss these three interfaces.

3.1 The Auditive Interface

To communicate to the blind the information of distance, we use 28 different musical notes, which correspond to 28 unequal intervals of distances (intervals are smaller at short distances), the higher the tone, the shorter the distance. The telemeter gives a precision of about 1% on the distance measurement. The number of available musical notes is then the limitation for the precision. We use flute sounds over 4 octaves of the major scale (131Hz, 2.1 kHz). We have finally 28 useful notes. The range 10 cm - 30 m is divided in 28 unequal intervals of distance so as to reduce the width of the intervals at short distances.

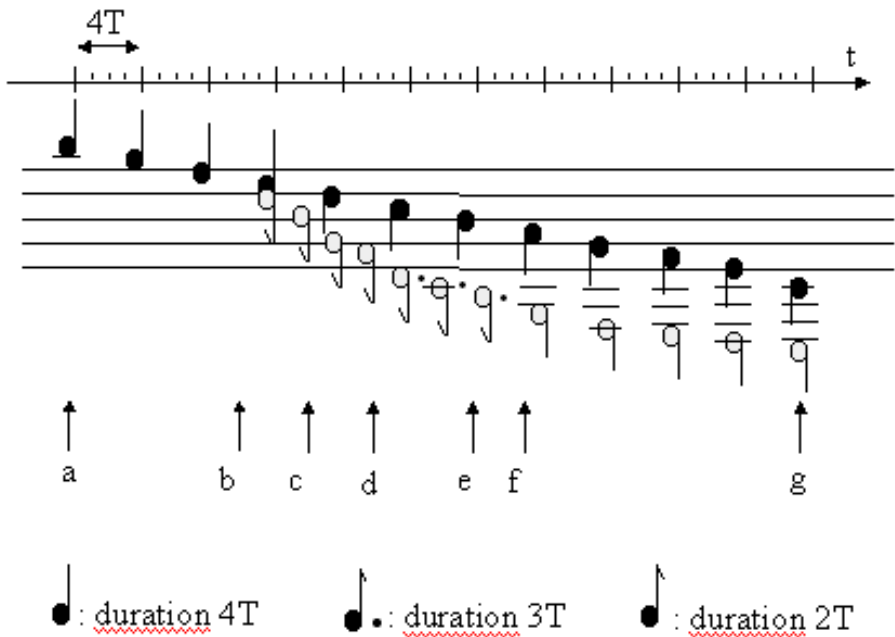


Fig. 3. Musical lines corresponding to 2 profiles: down stairs and flat floor.

Fig. 3 represents musical lines corresponding to 2 different profiles. The lower line in white notes concerns the profile of a down stairs in a moving up movement of the

wrist. The musical line in black notes represents the reference profile obtained with the same movement of the hand if the floor was remaining horizontal, without stairs. In this example, the white and black colours should not be interpreted as note lengths. We use this 2 colours just to distinguish the 2 profiles. The distance intervals corresponding to the different musical notes are chosen so as a flat floor would correspond as best as possible to a temporal regular musical scale (in the case of a fluid movement of the wrist). In other cases neither the succession of the intervals between the notes, nor the duration of the notes are regular. We can see in Fig. 3 that for the down stairs the distance increases more rapidly than for a flat floor and that the profile discontinuities of the stairs are reverberated on the note succession and duration. The identification of the down stairs relative to the flat floor do not result in practice to an analyse note by note of the correspondence between musical note and distance. A flat floor corresponds to a particular melody, and a down stair corresponds another one. Actually, the perception of space profiles are done thanks to melody identification processes developed by the users.

3.2 The Tactile Interface

To obtain a silent device and to avoid the long training phase required by the auditive interface, we have developed a new tactile interface using vibrating devices localised under fingers. We have tested this tactile interface through 3 experiences. In the first experience we have used only two vibrating devices. In the second one we have used eight vibrating devices. And finally in the third experience we have decide to use 4 devices.

Using Two Vibrating Devices. To code the distance between the user and the obstacles, we used two effects on the first vibrating device: the vibrating amplitude increases as the distance to the obstacle decreases, at the same time the period of the vibration decreases. So a decrement of the distance to an obstacle is coded by an increment of the amplitude of the vibration and a decrement of the vibrating period. We have decided to use two simultaneous vibrating effects instead of one, to improve the sensitive discrimination of the tactile vibrations. The second vibrating device is used to code the detection of discontinuities on the floor; we use a 50 ms strong burst of vibration.

Using Eight Vibrating Devices. Using only 2 devices appears to be not precise enough. We decided then to experiment the use of eight vibrating devices (Fig. 4). The principle is that each vibrating device corresponds to a particular distance interval. The users can use this interface in two different ways depending on their preferences. The first way consists in putting the index finger on the vibrating devices to feel the vibrations. The second way consists in putting a different finger between each couple of two vibrating devices. This method requires using four fingers.

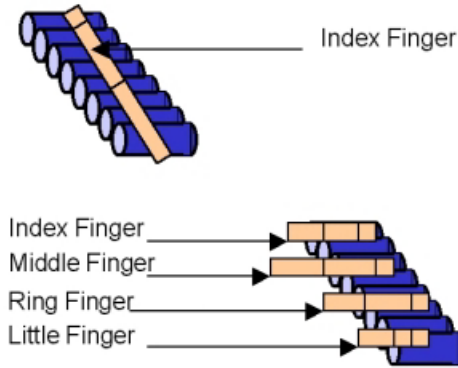


Fig. 4. The 2 ways of using the 8 vibrating devices interface.

Using Four Vibrating Devices. The success of the second way of using eight vibrating devices leads us to experiment a new interface which uses four vibrating devices. The principle of this method is very simple. Each finger (except the thumb) is in contact with one and only one vibrating device (Fig. 5). Each vibrating device is allowed to a distance interval. If an obstacle is present within one of the four distance intervals, then the corresponding vibrating device is activated.

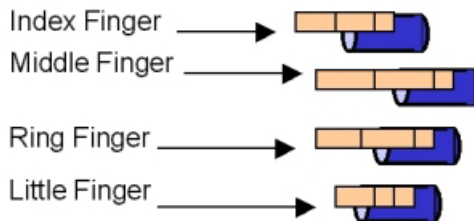


Fig. 5. The four vibrating devices interface.

3.3 The Force Feedback Interface

The principle of the force feedback interface (Fig. 6) consists in using a linear potentiometer. The cursor of the potentiometer can be used as a mean to adjust the length of a virtual walking stick. When the user moves the cursor forward the length of the virtual walking stick increases. When he moves the cursor backward, the length decreases.

When the virtual walking stick reaches an obstacle, the user feels that he cannot increase the length of the stick because the cursor is blocked.

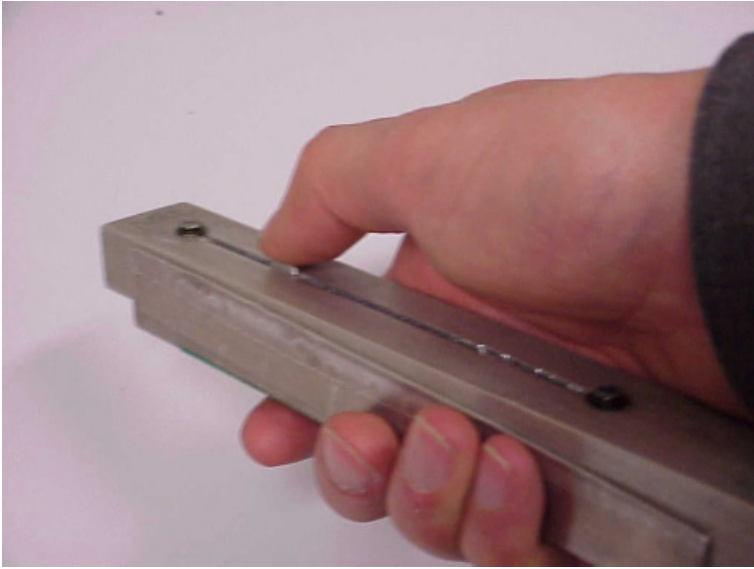


Fig. 6. The force feedback interface.

4 Discussion

The auditive interface has various defects. To make the difference between musical sounds and street sounds is not really a problem. An earphone is used to clearly hear the information. When the ambient sonorous level often fluctuates it is possible to adjust the acoustic level. The real problem is that some people have difficulties to merge rapidly the auditive information with the proprioceptive one (movement of the wrist) to deduce spatial data. This information merge has to become instinctive after learning, and if the person has to think about it, using the device becomes a too difficult intellectual work. The most important information revealed by our tests is that identification of the musical notes is not very important. However, the sense and the rate of their variations, in other word the transcription of the profile of the obstacles into a "melody" is essential.

Using the vibrating interface is easier; the perception is more direct and intuitive. Beginners generally prefer it. People trained to auditive output say it is less precise but sufficient. The 8 vibrating devices interface seems to be better than the 2 one and users prefer to use it according to the second way. But the best tactile interface for the users is the four vibrating device one, probably because it is very simple to learn and be-

cause it offers a very good sensitive discrimination. Besides, a patent concerning this interface is under filing.

The force feedback interface is a promising solution but it still presents some technical problems. The device presents watertightness problems. So, it is not possible to use it under raining weather. Another technical problem is that the motor used with the potentiometer presents some weakness after a long time use.

However we are now sure of different points: in its actual form, using the “Telectact” needs a good spatial representation, a good proprioception, and an active attitude: to scan to look for obstacles. It is very difficult for blind from birth to use it because of lack in spatial representation. For old persons (although we get some exceptions) it is difficult because of the long learning period. The main advantage of the device is the good anticipation users get and the optimisation of the navigation. For the moment it is a system for typically very active 20-40 year blind persons who have seen before.

The auditive interface has been evaluated with about 50 persons. The tactile interface is still under evaluation and the results presented here have been deduced from preliminary tests.

Finally, it is important to notice that the long cane is not only an obstacle detector for blind persons but it is also a mean which allows sighted people to recognise blind people. Consequently, the device must be used complementarily with the long cane because it is not an indicator of blindness. Particular attention has been paid to the design of the new version to allow an easy mounting of the device on a cane (Fig. 7).



Fig. 7. Mounting the device on a cane.

5 Conclusion

We have presented a laser profilometer dedicated to the spatial perception for the blind. We have tested the auditive interface with about 50 blind persons for detection of obstacles, avoiding holes, using the orientation of a wall to find his way... A training course is necessary to use correctly the profilometer. For congenital blindness, the procedure is longer, the three dimensional spatial representation of space and perspective laws have to be learnt [7]. It is developed in association with the centre of locomotion of the Association Valentin Haüy (Paris). The tactile and force feedback interfaces are still under experiment, but the tests we have made with 3 blind persons gave us very encouraging results. These interfaces still have large possibilities of improvement. In particular we will try in the future to experiment multimodal interfaces [8] [9] combining touch with sound, for instance by using touch in normal situations and sound in dangerous situations.

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Providing Help for Visually Impaired People's Navigation in an Urban Environment Using GPS

Vivien Guillet, Beatrice Rumpler, and Jean-Marie Pinon

INSA de Lyon LISI - Dpt. Informatique
7 Avenue J. Capelle Bat. 502 Blaise Pascal
F-69621 Villeurbanne CEDEX
France

vivienguillet@lisi.insa-lyon.fr, beatrice.rumpler@insa-lyon.fr,
Jean-Marie.Pinon@lisi.insa-lyon.fr
<http://lisi.insa-lyon.fr/>

Abstract. The goal of our project (“*Ouvej*”) is to conceive and realize a navigation helping system for disabled, and more specifically visually impaired people, designed around a Global Positioning System (GPS). In this article, we firstly describe the general situation of navigation in an urban environment for disabled people and the context in which our project takes place. Then we describe the global architecture of the project and the prototype that has already been built. In the third part, we clarify the expected profits of using User Modeling (UM) and Case Based Reasoning (CBR) techniques and then describe our user model. Finally, we indicate our plans and future works.

1 Context

Impaired people are scarcely taken as a parameter in the construction of cities, thus making their everyday travels an ever-difficult task to accomplish. Despite the fact that modern laws nowadays tend to put more emphasis on the ease of move for such people (e.g. access ramps near stairs for people in wheelchair), existing difficulties are sometimes increased by architectural habits, such as large open places, that as pleasing to the eyes as they are, nevertheless make it almost impossible for blind people to find their way, thus reducing dramatically their autonomy. Using the GPS technology along with electronic maps makes it possible to track down a pedestrian in his moves, therefore providing him assistance. Automatic assistance, preferable to human one for obvious reasons (availability in time and for many simultaneous users), can lead to difficulties, especially in terms of user adaptability, fault-tolerance, and temporary geographical information updating (e.g. what happens if road works break a path). Therefore, security and adaptation to the user are the main points we have to focus on. Our system is designed to suit the needs of all kind of disabilities, but we will mainly focus on visual impairment.

Subsequently, we will call *the system* all the hardware and software capable of providing the functionality we briefly described above. The *user* will be the person, deficient or not, who use the system to find his way.

2 Project Architecture

2.1 Brief State of the Art – Preliminary Choice

Projects similar to our most necessarily involve a mini-PC as user-terminal.¹ These machines must be capable of reading CD- or DVD-ROMS in which electronic maps are stored.

Such projects focus on *autonomy*: the user is actually autonomous from any distant data² server, because everything (software and hardware) can be accessed locally. But a major drawback can be seen in this approach, which is related to an important characteristic of geographical data: their fickleness. A little change in the topography can lead to most important changes for the ride of a blind user. The less he can expect from the system is to be aware of such changes, if not correctly guided anyway. As a result, he will be unconfident in the system, hence reducing his *actual autonomy*.

We could also imagine most of the system similar to the one we develop capable of inter-connection and interoperability (for instance map sharing), using a standardized API (application programming interface). However, it seems that strategic shares in the market certainly won't let things go this way.

Our approach is *network oriented*. We geographically separate the user interface from the effective computation and data storage and updating that can be accessed indifferently with a phone, a PDA, a computer, etc. Moreover, the connection established between the user and the database allows us to gather informations about the use of the system. More specifically, a collaborative data gathering becomes possible, permitting for a user to turn other user's experience to profit.

2.2 Basic, Validated Project Architecture

The preliminary tests of our architecture took place in the campus of the INSA and Claude Bernard University, Lyon (France) in September 2001. The prototype used for the test needed human intervention. An operator was tracking down a visually impaired subject who was moving on a computer map and led him successfully to his destination. Fig. 1 highlights the main points of the architecture of the system.

From a technical point of view, our project is built upon MapInfo, a GIS (Geographic Information System), Oracle 8i for the DBMS (Database Management System), and the VoiceXML technology for the voice-based user interface, typically materialized by a cellular phone.

The most considerable difficulty we have encountered is related to the lack of precision of the GPS, especially visibility restrictions near buildings. It is possible

¹ We don't know much about such projects because the goal we try to achieve is now know as potentially *profitable* by the industry, so the *concurrent* works are kept secret by their holders

² which might be geographical or not

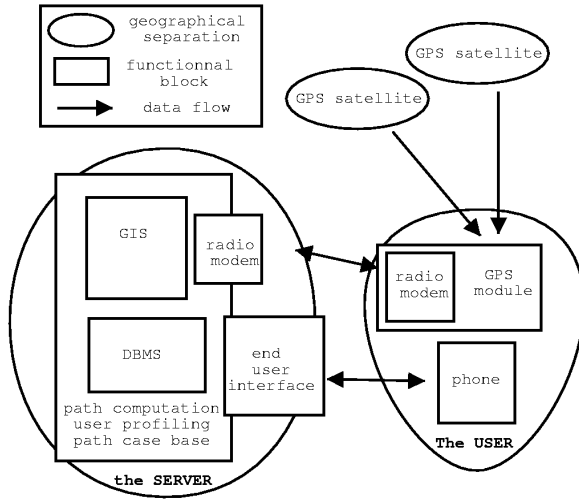


Fig. 1. Global architecture for project “ouvej”. The figure is a geographical representation of the system. The GPS position is collected by a module carried by the user, and transmitted to the server when asked to do so (radio transmission). The user uses his cellular phone, but could use PDA as well

to reduce it; using concurrent techniques.[1] for instance, suggests the simultaneous use of GPS, radio positioning, dead reckoning, barometry and altimetry for a more reliable and precise positioning.

2.3 Multimodality in Our Web-Based Architecture

Our system will be adaptable if a wide range of deficient people (with different deficiencies) are able to use it: blinded people certainly will prefer a voice-based interface, while people in wheelchair can take advantage of a graphical one.

One way to improve our system’s *adaptability* is to use *multimodality*. It means for the user that there are multiple ways of interacting with the system (for instance, in a common computer, using the mouse and the keyboard). In [2], two characteristics of such interfaces are emphasized: multimodality has to be simultaneous (ie. one can use voice *and* Dual Tone Multi-Frequency (DTMF), i.e. the telephone keys) and must concern input (user to system) and output (system to user).

The standardized interface (detailed in Fig. 2) provided by a web architecture allows this multimodality: a separation is actually made between the data extraction and the medium used to inform the user, and the medium used by the user to question the system. Each potential web terminal can be easily inter-

faced in our projet (cellular phone, Personnal Data Assistant (PDA)., desktop computer, WAP, etc.).³

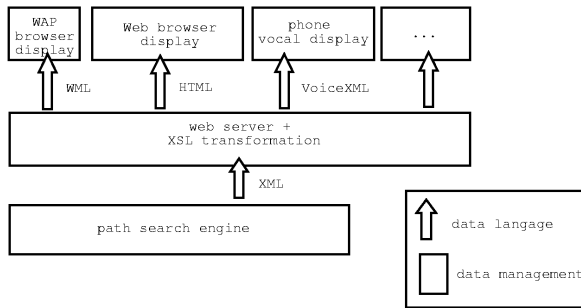


Fig. 2. Multimodality and the web-based architecture for project “ouvej”. The XSLT transformation

3 “Knowledge” Reuse – User Modeling and Case Based Reasoning

3.1 Consideration on a Navigation System for Pedestrian and Path Description

The navigation system that can be found nowadays in modern vehicles (e.g. cars, armored vehicles) cannot suit the needs of pedestrian navigation, especially if the handicap of the user is taken as a parameter because users are then more different from each other than two drivers. Sight-deficiency, for instance, cause people to have a characteristic moving way (walk in straight line when possible), to consider non-visual signal for localisation (often sound), and to have a different representation of space (no visual map representation, but a set of places connected to each other), and maybe time[4]. Another difference is in guidance itself: road imposes direction whereas a pedestrian can head for everywhere.

As we want sight-deficient people to be able to use our system, we have to provide a very detailed description of the path, suitable for being vocally communicated to the user. A simple ontology for path description has been written, based on [5]. As it only concerns the French langage, it won’t be described here, but can be found in [6].

³ Details concerning the web architecture, especially XML, HTML, WML, VoiceXML, and XSLT[3], which is used for the data transformation are located on the World Wide Web Consortium at <http://w3.org>

3.2 Path Calculation

We call *path calculation* the operation in which the system determines the path a user will have to follow to walk from the place where he is to the place where he wants to go (as he told to the system).

This calculation can be achieved using two approaches. The first one is based on the exclusive use of maps and data stored in the GIS, as it would be done for a robot. The obvious benefit of the use of this approach is that, considering a place covered by the map, any path can be calculated, wherever the starting and ending point are situated. Feasibility of this solution relies on the granularity of the geographical datas: the more this granularity will be precise, the more the path will be accurate. The second approach for path calculation, based on *predefined pathes*, is a network of choosen important points corresponding to real-life important places, and a commented way to go from one to another.

Whereas the first approach seems more generic and the second one more specific, the fact that existing electronic maps don't (and maybe can't) contain all the data needed for the path computation has led us to chose the second one. To completely put all the data we need (each pavement, each tree, each cross, etc.) would take a huge amount of time for the system to be securely used. The predefined path approach is more secure because each existing path of the database can be certified usable to the user. Moreover, new path can be rapidly added so that there is no need to wait for the completion of the geographical database to begin using the system⁴.

The dynamical aspect of this approach (progressive completion of the path database) makes it possible to consider cooperation between users of the system: a path followed by a user can be kept in the database and reused by a user sharing a similar profile, then be evaluated by this user or automatically. This "knowledge reuse" is detailed in next section.

3.3 Way of Achieving Knowledge Reuse

An effective way of achieving information reuse is CBR (Case Based Reasoning) [7].⁵ CBR is more precisely based on the reuse of *cases*. A case corresponds to a *situation*, a *question* and an *answer*. Two similar questions are expected to have two similar answers. The CBR process consists of two steps. Given a question Q we want to have an answer to, the first step, situation assessment and retrieval, is to find the most similar question Q' (and to retrieve its case C') in the set of existing cases. The second step is to adapt the answer A', using the differencies between the questions Q and Q', and find the answer A which corresponds to the question Q. The new case formed by Q and A can be added in the database of existing cases, if relevant.

⁴ The first approach may concurrently be used to give minimalist situation informations to the used, if used cautiously, though.

⁵ Other systems exists, among which the multi-agent [8] systems. We plan to study their possible benefits on our system in a near future, but we prefer now concentrate on the solution which seems the most suitable for our system.

Difficulties in the conception of a CBR system reside in the modelisation of a case (situation, question and answer), in the determination of a similarity function for the cases, in the adaptation of a solution, and in a possible evaluation of the correctness of the found solution to decide whether or not it should be adapted to the case database. Some efforts are currently made to conceptualize and generalize these different aspects[10], which are often very related to the application domain in which a CBR system is used, and some portable solution are now in the marketplace.

The modelisation of a case implies in our case the modelisation of a path, basically its beginning, its ending point and the situation in which it had been used. This situation is relative to the user who used the particular case. Other users which may use the case may share some characteristics if they want to use the same path. They should, for instance, have the same disability. This profile is also useful as a memory for one user: the description of a path can be shorted by the system capable of determining that it is well known by an user.

We use a vector model (sometimes called vector space model)[9], because of its simplicity, and its adequation with the CBR system and the user modeling.

3.4 CBR and UM Definitions

The user profile and the path case definitions are detailed below. Only the main points of each definition are commented⁶, as they are directly related to the expected benefits of the use of user modeling and case based reasoning approaches for our system:

- Personal benefits (for each user). Information is adapted to the deficiency, history-based guidance.
- Global benefits (cooperative system). We can re-use information collected from users belonging to different classes of handicap.

The user model uses a vector representation. Each vector can nest other vector, but the terminal vector (i.e. used for computation) is an integer or a boolean, in order to permit the use of simple similarity function (i.e. comparison between two profiles of two situations).

User profile definition

```
user {id, usage, activity} usage {
  [handicap list],
  preferences,
  situation
} preferences {
  synthesis speed, detail level, ...
} situation {
  grade, ...
```

⁶ For instance, the detailed rules used to alterate both user profile and path base used by the CBR engine is out of the scope of this document and are described in [11]


```

} activity {
  [path case list], system habit
} system habit {
  number of time used,
  frequency of system use}
}

```

The “path case” used in this definition is defined below.

Path case definition.

```

path case {
  question,
  answer
} question {
  starting point, ending point, [handicap list]
} answer {
  path, [evaluation list]
} path {
  starting point, ending point,
  path description,
  [handicap list]
} evaluation {
  [handicap list],
  subjective estimation, automated estimation
} subjective estimation {
  comfort, subjective length
} automated estimation {
  average length, success rate
}

```

Both *question* and *answer* in the *path case* include a *handicap list*, which might may be different. The handicap list of the question corresponds to the handicap list stored in the user profile, rather than the one relative to the real path.

The *estimation* parameters are used in the CBR process in order to decide whether or not a new case has to be added to the case database, or to suppress/modify an existing one. Our model provides both subjective and automated estimation because the subjective one, that is more accurate (we don't have to *guess* how well it suits the needs of the user), requires the participation of the user. Automated estimations are computed by a constantly following the moves of the user.

Multiple deficiencies are possible, so we have to store a *handicap list* rather than a single handicap. Moreover, this is a way to store what an user can't actually do rather than the name of the deficiency. By using this handicap list, we know the user better, so the subjective estimation can be more deeply understood (e.g. we can modify the handicap list of a path case answer if the only users who dislike a path share a given handicap).

The *path description* stored in the path is a semi-structured description. It includes a verbal description that can be used by a speech synthesis, and a geographical description (i.e. a list of vertex on the electronic map). The verbal description is ordered by *detail level*, used in correlation with the user's

preferences and *system habit*. Categories of classification are : path related information (which are directly used for guidance), security related informations, and comfort informations (for instance, what building are around the user, smell informations, etc.).

4 Future Works

In a short term, we aim at integration of automation (using our user modeling and a CBR engine) in the prototype. Experiments (without the operator) will be conducted in July, 2002, dealing with non-sight deficient persons only.

In a mid term, the opportunity of adding plan recognition techniques to shorten the length of the computer-user dialog, by guessing his needs (e.g. its destination) will be evaluated, focusing on its integration with the UM/CBR engine.

A final (commercial) system will be ready in 2004.

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New Trends and Developments in Computer and Internet Technology for Visually Impaired People: A Survey and Usefulness in the Arab Sub-region

AbdulMalik S. Al-Salman

Computer Science Dept., KSU, Riyadh, Saudi Arabia
salman@ccis.ksu.edu.sa

Abstract. The wide spread application and rapid revolution of computers and Internet technology has made the use of them a must for many people including people with disabilities. This paper presents the new trends and developments in both computers and Internet technology aimed as aid to visually impaired people in general and the Arabic-speaking in particular. The developments include the various input and output devices used in conjunction with computers, the various software packages designed for the visually impaired, and the various ways through which they can communicate via the Internet.

1 Introduction

Before the spread of computers, the primary problem with visually impaired (blind and low vision) persons was accessing and retrieving written information without depending on other people. Usually, the visually impaired person (VIP) relies on a sighted person to read and describe information, use information recorded on tapes and cassettes, or use Braille written documents (usually written by Braille printing houses). Most of these processes are inconvenient for both the blind and the sighted.

After the spread of personal computers, these problems began to regress, and the new technology began to adapt itself to help this special group of people. New equipments and software emerged to assist VIP in accessing in convenient form without the help of others. Nowadays, the World Wide Web (WWW) has been the most widely used source of information and communication. Yet, to many VIPs over the world, the Internet remains inaccessible due to its visual nature (graphics, video, hyperlinks, etc.).

The use of computer-based Braille translation programs and embossers made the production of Braille easier and less expensive. This helped the dissemination of written information in Braille. Furthermore, individuals and small institutions became able to produce Braille documents in a reasonable time and cost. The computer revolution is not limited to ease the use of computer and Internet but tried also to change the Braille system to approximate the computer character representation. That means changing the number of dots in Braille cell from 6 to 8 to be identical to the internal representation of characters in computer (8 bits). The 8-dot system is still at its beginning and it is mostly used in scientific and mathematical writings especially in Europe rather than in USA. For the best of our knowledge, there is no study concerning this issue in the Arabic world.

It is important to note that VIPs in the Arabian World are still struggling with a 10-20 year technology gap. A minority, with proficiency in other languages especially

English, can use off the shelf technologies for reading, writing and communicating via regular computers, Braille note-takers and reading machines. The vast majority possesses only the basics – a cane, a Braille watch, basic Braille writing equipment and a cassette recorder. It should be also pointed out that the Arabic Braille is similar to the English Braille in direction (even though the Arabic text is written from right-to-left). The difference between the two is in the Braille cell interpretation. Moreover, Arabic Braille supports contraction, yet it is not standardized among Arab countries.

2 Computer Technologies

When personal computers first emerged, they were used to process text-oriented data only without any use of graphics or multimedia data. Even up, till now, text represents the mainstream form of representing data although they can be integrated with images and multimedia. The objective of most recent research in this area is to convert text into an accessible form (Braille system or reading data). Research also takes into account the ways in which the VIP can interact with computers (enter data into the computer and get data from it). Adaptive technology is the term used to describe the computer equipments and programs that are designed for or modified for the VIPs [1].

2.1 Adaptive Input and Output Technologies

The VIP may use a variety of equipments and programs that enable him/her to enter data into computers or retrieve it. Among these technologies are:

1. Voice Recognition (input). It is a technology that allows the user to use his/her voice as an input device. Voice may be used to dictate text into computer or to give commands to it. Most of these voice recognition programs need a period of training to be able to work properly. Among these programs are "Naturally Speaking" from Dragon Company [26], and "Via Voice" [27]. To the best of our knowledge, "Via Voice" is the only commercial software that supports Arabic. Yet, its price is relatively high and needs an extensive training. Very few Arabic-speaking VIPs are using it perhaps due to its high price and relatively low quality at the time being.
2. Optical Braille/Character Scanners (input). Scanners with optical Braille recognition (OBR) are able to scan a Braille document and convert it into normal text that can later be stored electronically on computers. This technology may be used to help the sighted user as well as the visually impaired user [28, 29, 30, 31]. Since the Braille system is an international system and the people differ only in the interpretation of the symbols according to their language code, this technology can be utilized by Arabic-speaking VIP in conjunction with Braille to Arabic text translators.
3. Braille Keyboards (input). Many VIPs use regular computer keyboards, however, some prefer using Braille keyboards. Braille keyboards usually have very limited number of keys compared with regular keyboards. Six of the keys are used to input Braille characters emulating -in the functionality- Perkins Brailier [22], in which a VIP presses up to six keys at the same time to form one Braille character [1, 14, 29]. In general, Braille keyboards are equipped with software driver (plus translation table) to translate Braille to text on computer screen. To the best of our

knowledge, there is no driver that supports translation of the Arabic language. From another point, Arabic-speaking VIPs may not be able to use regular keyboard for input, unless equipped with a sound feedback, due to the lack of standard character layout.

4. Screen Readers (output). They are one of the most widely available programs used by VIPs. A screen reader monitors all computer activities such as keyboard input, new text or graphics being written/drawn to the screen, mouse movement, the active window, the insertion point in a document, and many other activities. It sends text information to a speech Synthesizer and/or Braille display to provide a feedback about the running applications and operating system to the user. One of the famous screen reader programs is JAWS from Freedom Scientific Company. It supports many foreign languages (not including Arabic) beside the English language [1, 5]. Unfortunately, none of the international screen readers support Arabic.

In the Arabic world, there is a great effort being made by Sakhr Company to complete the implementation of an Arabic reading machine [51]. The reading machine is a software package that is composed of five programs: the documents reader, the net reader, the screen reader, the email reader, and the tutorial system. All these programs work under the Arabic MS-Windows. This effort is promising, even though the product price is relatively high. There is also a research in Arabic text-to-speech conducted by King AbdulAziz City for Science and Technology (KACST) [44], yet no commercial product was released.

5. Electronic Braille Display (output). An electronic Braille display is a tactile device that is usually placed under a conventional computer keyboard to enable the user to read the contents of the computer screen in Braille [24]. Braille display usually consists of 20, 40, or 80 Braille cells. Each cell has 6 or 8 pins made of metal or nylon, which are electronically controlled to move up and down to display a Braille version of the character that appears on the computer screen. Braille displays have buttons or bars to enable the user to move the Braille display around the computer screen [1, 24, 32]. The only Braille display that supports Arabic is VisioBraille note-taker, and it is very expensive for individuals [54]. It is claimed that some other Braille Displays support Arabic (such as Alpha Braille Display), yet the author could not find any documentations in this regard.
6. Braille Embossers (output). Braille embossers print Braille output from a computer by punching dots onto special paper [23]. However, before text can be embossed, it has to be converted to Braille and formatted accordingly by a "translation" program. Fortunately, Braille embossers can be directly utilized by Arabic Braille system (after translation from regular text).
7. Special Devices (input/output). There are many other devices with special multi-functionality that use computer technology to do the work. An example of these devices is Braille Note-Taker, similar in its functionality to Palm Pilots for the sighted user. A Braille Note-Taker consists of a Braille display and a Braille keyboard integrated with a speech Synthesizer [1, 2]. Arabic-speaking VIPs can partially utilize Braille Note-takers. They can enter notes in Arabic Braille and retrieve them in the same code. The only note-taker that supports Arabic is the VisioBraille [54].
8. Furthermore, there are some stand-alone systems known as *reading machines*, for example "The Reading Edge". They can scan text from books, newspapers, and magazines then speak it to the blind. They are supplied with a panel for controlling

its functions [21]. These machines are gradually been replaced by reading programs.

2.2 Braille Translation Software Packages

Braille translation software can help both sighted and VIP. It accepts text files and converts them into Braille. It may also convert Braille documents to an ordinary text. We will give a brief description of the most widely used Braille translation systems in both languages English and Arabic, and describe some of their features.

1. Duxbury Braille Translation (DBT) Software [4]. DBT is a window-based software that automates the process of conversion from text to Braille and vice versa. It provides translation and formatting facilities. It also provides editing facilities in the Braille mode where the user can treat the keyboard as Perkins Braille to enter Braille as well as using the software for ordinary word processing tasks. The software can translate Arabic text to Braille with special supplement. Using this supplement, one can create and edit natural Arabic text using Microsoft Word (Arabic version), and then import and translate the file into Arabic Braille using the DBT software. English text may also be intermixed, and both languages may be contracted. The translation of Arabic characters in DBT was not 100% equivalent to the Arabic character set supported by Windows 98/NT/2000, perhaps due to a mismatch in code pages. The software has only English interface (menus, messages, etc), and it does not support any type of sound, which is helpful for the blind to interact with computer.
2. WinBraille Software [30]. WinBraille is a free Braille editor program, developed for MS-Windows. It can handle most Windows compatible editors and browsers. Major features include: Braille key-in from the standard keyboard, interface to all Windows word processing programs, easy editing of a translated document, and support for Internet and e-mail. However, the Arabic language is not supported, and the software interface is English. Moreover, WinBraille does not support any type of sound, which is helpful for the blind to interact with computer.
3. Sensus Braille Software [45]. It was developed by Sensus ApS, Refsnæsskolen, and other Danish and International Braille authorities. It is a window-based software that automates the translation of English and Danish text into Braille (6 or 8 dots) and vice-versa. It, however, does not support the Arabic language.
4. The Arabic Braille Translator [50]. It is a window-based application, developed by Dar-Hosbat Al-Na's Al-Arabie, Jordan. The software is designed for the sighted users to translate Arabic text into Braille (one way translation) without contractions. It uses Arabic MS-Word Version 6 as its platform. The company no longer supports this product.
5. Printing System with Braille Software [52]. It was developed by the Kuwait Institute for Scientific Research. It is a window-based application that is oriented to sighted people to convert Arabic text to Braille (one way translation). The software supports multi-level contractions.
6. Arabic Braille Editor (ABE) [56]. ABE is a dedicated Arabic Braille environment for Arabic-speaking VIPs. It supports interactive and batch translation between Arabic text and Arabic Braille. The software has the ability to echo any pressed key. It does not support any type of contractions.

In addition, there are some efforts in progress done by the General Secretariat of Special Education and Prince Salman Center for Disability Research, Riyadh, Saudi Arabia to develop a complete Arabic Braille system.

2.3 Special Software Packages

There are many software packages that are designed and implemented specifically for VIPs; few of them can be utilized by Arabic-speaking VIPs.

1. Screen Magnifiers. Screen magnification software helps the VIPs to use computers by enlarging the picture on the screen by certain factor. Examples of screen magnifiers programs are Visionware and Sensus magnify [1,45]. This program is language independent, so it is an international program.
2. Scientific Braille Programs. It was not easy to represent many scientific notations with the basic Braille system [34]. Therefore, special codes were developed for mathematical and scientific notations. However, these codes were somehow cumbersome and rather difficult to learn and use, due to the six-dot limitation. New trends are being experimented with, such as DotPlus [35, 36, 48], Triangle [37], and ASTER [38]. None of these programs support Arabic.
3. Teaching Braille programs. Such programs teach VIP the Braille system itself [39,40]. Arabization of them would be useful to the blind institutes in the Arab world.
4. Accessing Graphical Information. Nowadays, most computers use Graphical User Interface (GUI). So, there is a need for advanced equipments and programs that enable the VIP to get the feel of graphics and colors [41, 42, 43]. There are mainly four ways to present graphical information for VIP (regardless of mother language).

Representing graphical information using special tones. Dr. Peter Meijer worked on a project called "The Voice Learning Edition". It is a video software that scans on image and converts it into sounds, by applying two simple rules. First, pixels situated "high" in the image are converted into high tones; those that are low are converted into low tones. The Second rule is the brighter the pixel, the louder the sound [9].

Representing graphical information using Graphical Braille Printers (GBP). GBP works as follows: solid ink is inserted as a block into the print head, where it melts and is then ejected through a row of nozzles. A language configurable voice output is integrated to announce the printer activities [10].

Representing graphical information using Special Equipment. A new mouse, developed by Immersion Corporation and Logitech, allows users to "feel" their onscreen actions [13, 19]. Another, a new mouse developed by Virtouch Corporation helps the visually impaired user to get the feeling of pictures, figures, maps, and scientific programs such as chemistry and math. It can also read regular text [20]. Touch Graphics Company have designed a different kind of input device, called the Talking Tactile Tablet, and an interface called the Tactile GUI [6, 18, 19].

Representing graphical information using Spoken Description. "The graph reader" is a program capable of describing business graphs (e.g., pie charts) [17]. Though, it uses English, it can be easily translated into Arabic because it has limited vocabulary.

3 Internet Technologies

Nowadays, the Internet has been one of the largest sources of information for many people. Since Internet is a mix of graphics, sound, video, animation and text, all designed to make sites more appealing to sighted users, there must be ways to ease the accessibility of Internet to the VIPs [46, 47]. There are many organizational efforts to enable disabled people to access the Internet. For instance, the WWW Consortium (W3C) developed common protocols that promote WWW evolution and ensure its interoperability [3, 16]. Unfortunately, most of the Arabic sites do not comply with these standards or even pay an attention to them. This is perhaps due to limitation of Internet usage by people, in general, and VIPs, in particular.

3.1 Voice Browsers

Voice Browser is a program that integrates the capabilities of ordinary web browsers and screen readers. Voice browsers read the content of Web Pages and differentiate between links and pictures. Among these browsers are Home Page Reader [25] and Sensus Browser [45]. At the Arabic level, Sakhr Company, through its Reading Machine, supports reading the Internet in both languages Arabic and English [51, 55].

3.2 Internet/E-mail Access via Phone

A new technology has emerged that allows an Internet user to request Web content via phone. This technology is called Voice Markup Language (VoxML). The new technology is similar to HTML and it is based on specifications released by W3C. VoxML is a technology from Motorola for creating a voice dialog with a Web site in which a user can call a Web site by phone and interact with it through speech recognition and Web site responses [7, 8, 11, 15]. Moreover, a new service is being developed by a British company, called INC Internet services, which allows anyone to hear his/her e-mail messages over the phone, without a need to switch on the computer. Therefore, the user can listen to his/her e-mails and even reply to them [12]. These features are not available in Arabic.

4 Conclusions

As new technologies emerge and as number of users grows, it is incumbent on technology developers to enhance their systems to help people with disabilities. One of the most important technologies in this respect is the computer and Internet.

There are many international worthwhile efforts to enhance the use of technology to people with special needs. Unfortunately, in the Arabic world these efforts are still in their infancy and moving slowly. As we have seen, most of the efforts were concentrated on translation between Arabic Braille and text. This survey shows that great efforts from technology developers are needed to help VIPs in Arab sub-region to reach the level of their peers in other sub-regions (specially Western countries). The efforts by the leading companies such as IBM [33], Microsoft [49], and Sakhr [53] suggest that there are sustained efforts to help all people, including the disabled.

In this paper, we presented an overview of the existing hardware/software technologies that improve VIPs' accessing computers and Internet. The review takes into account the various input and output systems that are used by visually impaired to interact with and facilitate the use of computers and their applicability for Arabic-speaking VIPs. In general, Arabic-speaking VIPs cannot utilize any software or hardware that is based on language processing or Braille/text translation.

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Auditory Emotional Access to Visual Information

Harald Schwende

Bavarian Research Center for Knowledge-Based Systems, Am Weichselgarten 9,
D-91058 Erlangen-Tennenlohe, Germany
Harald.Schwende@forwiss.de

Abstract. Seeing a picture and developing feelings for this is nearly impossible for blind persons. There isn't any system to reveal an emotional access to pictures for those persons. Surveys showed that it is very important for blind to transport emotions independently of the content especially for modern images. These emotions shall correlate with the feelings of seeing people. This sonification system enables an emotional access using the similarity of feeling by watching a picture or hearing music and transforming visual information in music compositions. Results of psychological, physiological and emotional acoustic researches, methods of image analysis and the rules of music composition are basis for this translation. After digitalization and image analysis, the presented system generates new data for the generation of synthetic music. The complete process takes the necessary aspects of the auditory and visual perception into account. A first version has already been developed and tested.

1 Introduction

Sonification can be described as use of non-language audio signals for transportation of information with acoustic parameters. The idea is used in some fields for a long time: a Geiger counter cracks the more, the stronger the measured radioactive radiation is and an iron begins to whistle if it overheats itself.

For blind persons, computer programs can read text or recognize simple picture information (e.g. geometric forms) with auditory output or using the sense of touch, like Braille equipment or graphic pin matrix systems. Only rough structures and nearly no color differences can be arranged. Even if there are procedures to interpret living beings, buildings or landscapes as such, it is not comparable with the emotions a seeing person would have during visual perception. This concerns particularly the modern pictures often not showing real objects. Surveys showed that there is a fundamental need for a system which tries to transport emotions for pictures.

Basic idea of the system is that music and pictures can produce similar emotions. This research project uses the correlation between the two senses, the psychological laws of picture- and music perception, emotional acoustics and the aspects of music composition as basis for a theoretical software model. In advance of the development of the sonification system a test software solution has been created as test system around every set of conceivable methods in the practice.

2 The Physiological and Psychological Base

Physiologically the visual and auditory sense have large frequency ranges and similar analyze processes by using a division of the visual scene into light frequencies and the auditory scene into partial vibrations. The specific sensitiveness, convergence and the equivalent processing in neural areas in brain are also very similar for both.

Important psychological aspects are the shape laws as descriptions of perception phenomena and as raw material for the sonification model. The change of a musical tone is interpreted as a change of the sound source. Quickly following tones are felt together and grouped such like tones sounding similar with pitch as relevant factor. Discovered concise figures get the advantage which is supported by clear delimitation and balances. Closed line color configurations are mostly interpreted as figures. Similar figures and near objects are perceived as group, different figures and far objects are separated by the observer.

The psychological effect of colors is dependent on individual experiences and on century old traditions. However, ideal typical assignments are possible. Beside this, bright picture elements seem easier and are looked at mostly longer. More frequent colors create the formal base and rare colors seem flashier. The psychological contrary colors are the color couples with the biggest contrast in psychological effect. During eye movements, points with higher attention are usually first seen.

Musical intervals are necessary for the psychological perception of music. The general impression is influenced by the choice of the scale, musical articulation, time and speed. The choice of the musical instruments is particularly important.

3 Sonification System

As first step important technical possibilities and theoretical models have been developed and tested with a special test software system. This system was also used to analyze the final requests for the sonification system.

Navigation with the mouse inside a picture can be done with a position transformation (frequency, amplitude) and color-content transformation. The generation of different musical instruments requires in addition a clear differentiability of place and color.

Music synthesis is more complex: After picture transformation an image analysis is done with regard to the psychologically relevant factors. The picture transformation is based on the HSB computer color model because of its similarity to perception. The psychological laws are the theoretical basis for the image analysis. After searching available figures and analyzing their main emphasis, positions, smallest distances, their representative color value, their order and orientation, the psychological contrary colors, the size, balance and similarity of figures and the brightness of foreground and background will be examined.

Sound synthesis is based on transformation and analysis results, the laws of emotional acoustics, shape psychology and color psychology and generates a specific note sequence for every picture element.

The pitch of tones is proportional to the HSB color system and it changes suddenly at the appearance or disappearance of figures. The emotional acoustic aspects like the minimal distance of the pitch and the frequency dissolving ability are taken into

account too. The sound varies according to the size of color areas and is limited by the musical time duration. Longer tones are generated for bright areas. The sound lengths are shortened between near figures so that these figures are felt as a group. The sound amplitude is dependent on the frequency of colors. The emotional acoustic laws like the dissolving ability of the volume and the influence of the pitch and clay length on the felt volume are taken into account. The musical instruments are arranged based on the color psychological knowledge and figure configurations.

For music generation the sound tones are joined together in special rings of independent musical voices. The start point of composition is the figure with most attention. The generated scale is related to the color composition and the arrangement of foreground and background. The order of similar figures determine the musical articulation and the combination of psychological contrary colors and figure arrangement are base for the musical time. A symmetric figure complex produces a harder rhythm and reverse. Instruments are arranged according to representative colors areas and the position of these areas. At the end the composition is then carried out with the help of the classic rules of composition theory.

4 Results and Conclusions

The first series of tests with the new system showed that an emotional correlation between the pictures and the produced music was often recognizable for the test participants. The navigation within the picture also could be done very well. Both the position of the mouse and the color surroundings of the mouse were assessable well.

The system offers a first modest possibility for an emotional auditory perception of pictures for blind people. By using the basic eye movement laws, shape laws, basic laws of color psychology and music psychology and the rules of emotional acoustics a practicable base for the sonification could be found.

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Auditory Sensation Aided Image Perception: Integration of Somesthetic Sense of Fingertip Position

Yoshihiko Nomura, Sayuri Nishihama, Tokuhiro Sugiura, Hirokazu Matsui,
and Norihiko Kato

School of Engineering, Mie University, Tsu, Mie 524-8507, Japan
nomura@mach.mie-u.ac.jp
<http://www.robot.mach.mie-u.ac.jp>

Abstract. A color image presentation system with sound via touch-panel interface was developed and some perceptual characteristics with the system were studied in this paper. Each subject actively operates his/her fingertip on the touch panel interface, and the system returns syllable sounds corresponding to the colors nearby the fingertip position. Without sight, he/she perceives images through the sound information together with the fingertip positional sense. The authors carried out some preliminary psychophysical experiments on the human perceptual characteristics in converting speech sounds into image patterns and on the fingertip positional sense. Based on the results of the preliminary experiments, the authors developed a color image presentation system. It was confirmed through experiments using the system that the subjects were able to perceive the shapes of simple closed polygonal figures within 2 or 3 minutes.

1 Introduction

Vision is the most important sense to be used for pattern information processing. Besides the vision, can't we process and recognize patterns in our brains through the information from other sense organs such as ear and skin (i.e., tactile)? This challenging target will also provide an interesting theme to a cognitive science world. Furthermore, ultimately, the technology might be used as a visual alternative of the blind persons and as a visual aid of lazy eye persons.

There have been reported many studies in this field such as those by audition [1], by tactile sensation [2], [3], and by both audition and tactile sensation [4][5]. Lately, there is even reported artificial vision connecting a television camera to a cerebral visual cortex [6]. Some studies have also reported for character input devices [7]. Regretfully, these have remained in character recognitions of low-resolution binary images. Yet, there might be little possibility for the methods to represent colors by changing strengths of vibrations in tactile or by changing frequencies of sounds. The authors have also begun work on a prototype for an interactive sound presentation system to aim at human's perceiving color image patterns. In the former work, a pen-tablet was used for an interface [8]. To improve image perception performance, the authors employed a touch panel interface, and some results are presented in this paper.

2 Experiments

2.1 Methodology

Experimental Method: The system works in an interactive style: a user points positions, where he/she wants to know, by touching his/her fingertip to touch panel display, and a system returns local color pattern information to the user in a verbal signal via stereo headphones as shown in Fig.1. The stereo headphones are used to help the user perceiving the sound source in the horizontal direction. An observation window of $160 \times 160 \text{ mm}^2$ (corresponds to $640 \times 640 \text{ pixel}^2$) is set on the touch panel display.

Matrix Representation: This system provides consecutive speech sounds, i.e., syllables that contain color information for matrix-configured pixels nearby the user-clicked pixel as in Fig.2. 1×1 , and 2×2 matrices were utilized. The total number of the syllables of 4 is corresponding to the fact that the limit of instantaneous remembrance is said to be 4~10. We might call the set of syllables as “*color pattern words*”. By virtue of utilizing syllables, users do not need much effort to remember the correspondences between the sounds and the colors. The correspondences are shown in Table 1. The initial syllables of color-meaning Japanese words were utilized as for the syllables, and were provided by the same rate of 150 ms as the colloquial speech in Japanese.



Fig. 1. Subject conducting an experiment

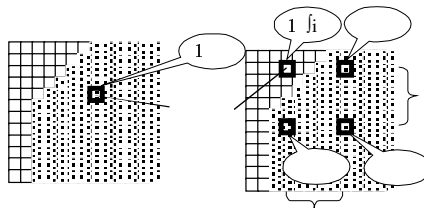


Fig. 2. Matrix-configured-pixels to be phonated

Table 1. Colors and syllables correspondence

<i>color</i>	<i>white</i>	<i>black</i>	<i>red</i>	<i>blue</i>	<i>green</i>	<i>yellow</i>	<i>light blue</i>	<i>violet</i>
<i>syllable</i>	ji	ku	a	o	mi	ki	zu	mu

2.2 Expt. 1 Effect of Learning on Instantaneous Image Recollection

To examine instantaneous image recollection ability, the following experiment was conducted for seven days with one subject: six sets a day, and 50 test patterns a set.

1. Closing her eyes, a subject hears four consecutive syllables randomly created with the eight colors, and perceives patterns in the brains.
2. Either correct pattern or wrong pattern is shown.
3. The subject answers either by pressing “Y” key when the shown pattern coinciding with the perceived pattern, or “N” key when not.

Fig. 3 shows the result of experiment that the recollection time decreases gradually from the initial value of 1600 ms to approximately 750 ms after 7 days of learning, keeping an achievement of over 80 % of correct perceptual rates. The subject reported after the experiment that she had acquired an ability of instantaneous image-pattern recollection with no conscious while learning.

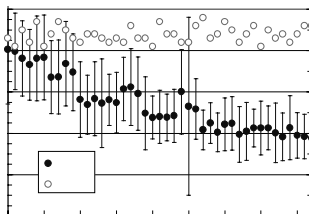


Fig. 3. Improvement of performance with learning

2.3 Expt. 2 Fingertip Position Perception Accuracy

When using the touch panel display interface, users should perceive positions of their fingertips. Therefore, the authors examine the accuracy of fingertip position perception by somesthetic sense such as the arm muscular expansion and contraction. The following experiments were conducted fifty times with two subjects.

1. Closing eyes, each subject touches his/her fingertip nearby the center of the circular frame.
2. The subject arbitrarily moves his/her fingertip in a centrifugal direction.

3. Upon touching the fringe of the circular frame, the subject returns his/her fingertip towards the very position where he/she touched in Step1. The system measures the deviation of the arrival position from the original position.

Accuracy of fingertip positional perception was obtained as follows: an average of a standard deviation of errors was 1.5 mm. On the other hand, one pixel corresponds to 0.25 mm on the display. Therefore, it is not efficient to express color information pixel by pixel. Thus, the authors set the intervals of sound presentation as 5.1 mm corresponding to approximately 3×1.5 mm.

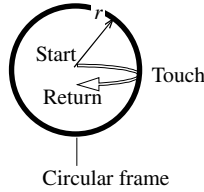


Fig. 4. Circular frame and motion of fingertip

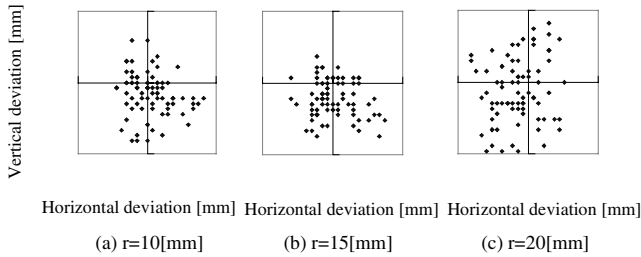


Fig. 5. Distribution of fingertip deviation

2.4 Expt. 3 Appropriate Matrix Configuration

To select an appropriate configuration from the two kinds of matrix configuration of 1x1 and 2x2 with the interval of 5.1 mm, an experiment was conducted with 4 novice

1. Closing eyes, and moving fingertips intentionally, the subject hears consecutive syllables and imagines matrix shaped local patterns, and, further, integrates the local patterns into figures in the brain.
2. The subject draws the perceived figures and colors on answer sheets.

Fig. 7 shows the experimental results that the 2x2 configuration is better than the other from the viewpoint of the evaluation value ($t=2.54 > t_c=1.687$, the critical value at a 0.05 level of significance) while there is no meaningful differences between the probing times ($t=0.008 < t_c$). It suggests that the 1x1 misinforms the subjects. The difference in the evaluation value is found to be significant by the test of hypotheses.

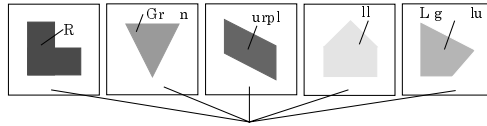


Fig. 6. Examples of closed figure images

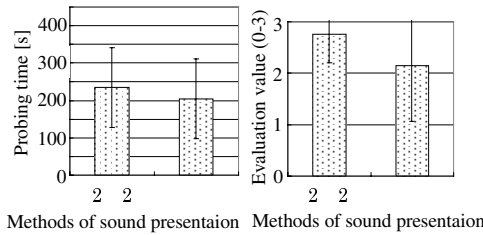


Fig. 7. Experimental results on figure image perception

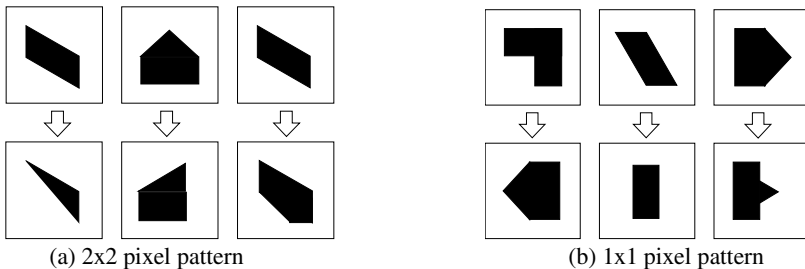


Fig. 8. Examples of misperceived image (top: true images, bottom: perceived images) We can see that the subjects missed single line when using 2x2 pixel pattern while they suffer fatal error when using 1x1 pixel pattern.

2.5 Experiments for Various Sizes of Figures

Some experiments using various sizes of figures were also conducted with 4 novice subjects using the simple figures as in Fig. 6. Other experimental conditions are the same that in Exp.3.

Fig. 9 shows that the probing time was improved to 2/3, i.e., less than 200ms after 4 sets although the evaluation value not. The probing times of the 1st time and the 4th time are different significantly since $t=2.336 > t_c=2.026$ (the critical value at a 0.05 level of significance) The results are considered to be reasonable because the subjects might have tried to continue probing until getting satisfaction with perception.

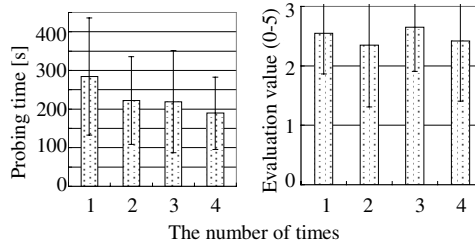


Fig. 9. The experimental results on learning

In addition to this, the authors found an interesting relationship of the probing time T with respect to the length of contour. Denoting the sum of slant line segments as l_s , and the number of corners as n_c we get

$$T = 0.000141 * l_s + 0.164 * n_c$$

Based on the variance analysis, the fitting was significant since $F=6.29 > F_c=3.28$ (the critical value at a 0.05 level of significance). Although the authors tried to model the time after adding the length of line segments of either vertical or horizontal as l_v , they could not find significance in l_v in the statistical sense.

3 Conclusion

This research aimed at human's perceiving color image patterns. The summary is

- (1) An interactive sound presentation system was developed.
- (2) Operators can interactively input positions of interest via touch panel interfaces.
- (3) The system presents local colored patterns by the form of concatenated syllables.
- (4) The 2x2 matrix configuration was better than 1x1.
- (5) It took about 3 minutes in practical experiments in the case of binary colored simple pattern figures.
- (6) After 7 days of learning, image recollection time for 4 pixels was decreased from 1600 to 750 ms.

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A Novel Application to Aid Low Vision Computer Users^{*}

Luciano Silva¹ and Olga Regina Pereira Bellon²

¹ Centro Federal de Educação Tecnológica do Paraná,
Programa de Pós-Graduação em Eng. Elétrica e Informática Industrial,
Av. Sete de Setembro, 3165, CEP 80230-901,
Curitiba-PR, Brazil

² Universidade Federal do Paraná,
Departamento de Informática,
Centro Politécnico, Caixa Postal 19092, CEP 81531-990,
Curitiba-PR, Brazil
{luciano,olga}@inf.ufpr.br

Abstract. This paper presents a novel application to help people with low vision disabilities and to allow the use of the computer. The application was initially designed to aid Web navigation, but it can also be useful to other computer applications. We describe the importance of the Web as source of information and knowledge and explain the main difficulties that disabled people have to access Web pages. We have chosen the most well-known accessibility tools of two different operating systems (Microsoft Windows and LINUX) to explain their features and limitations. Finally, the developed application tool, named MouseLupe, its characteristics and main contributions are presented in details.

1 Introduction

The World Wide Web became the largest source of information, knowledge and entertainment in the last years, mainly for the people involved with teaching activities, scientific research and electronic commerce. Originated in the academic world, it is considered an indispensable work tool for several researchers in most different areas.

All this readiness of subjects provided by the Web do not avoid that a simple search for specific information may be a quite difficult task. Frequently some precious time is wasted to find and to visualize the significant content of some Web pages. The problem may be worse than that and practically unbearable for people with visual disabilities.

Initially, Web pages had only texts and their evolution to complex pages with images, sounds, graphics, and animations provided great benefits for many users. However, they also created difficulties for people with disabilities and have

^{*} This research was performed in the IMAGO group (<http://www.inf.ufpr.br/imago>) and was supported by the Fundação Araucária grant.

become practically inaccessible for the disabled [1], [2]. Even with the complex and constant transformations of the Web organization, the number of disabled people using computers has surely been increasing [4].

The World Wide Web Consortium (W3C) [3], an organization interested in all aspects of the Web, sponsors the most extensive set of programs and initiatives devoted to the issue of Web accessibility for people with disabilities [7]. The W3C has created the Web Accessibility Initiative [5], that has published many documents and provided the single most comprehensive and useful set of resources for Web designers who wish to make their sites more accessible to people with disabilities.

There are four main categories of disabilities that affect a person's ability to use the Web: 1) Mobility, including inability to move, insufficient dexterity to operate a mouse or a keyboard, inability to control unwanted movement, and lack of limbs; 2) Hearing, ranging from inexact hearing, or diminished hearing, to no hearing at all; 3) Cognition and learning, including various difficulties in reading, understanding, staying focused, remembering, and writing [6]; 4) Vision, including blindness, low vision and color-blindness.

For people with mobility disabilities there are several hardware devices and software applications that provide Web navigation and make possible computer usage: mouth device to control the cursor movements, Web camera to capture the eyes or head movements to guide the cursor movements, speech recognition software to write words, execute commands, among others. Using these devices those people can access every Web page [12].

Sounds in Web pages are normally irrelevant in the page's context except when they are songs or speeches. People with hearing impairments usually have easy access to the Web because most of the Web pages do not contain sound information.

The cognition and learning problem is very complex and many researchers have been studying the relationship between the structured content of a Web page and people with these disabilities to propose efficient solutions and accessibility rules for designing Web pages. It is known that a page with a simple and intuitive interface, with clearly formulated text, and a consistent navigational scheme between pages can facilitate the access to those disabled people [4].

The vision disabilities are considered a permanent concern in the research and development of accessibility tools. Actually many research groups have been concentrating in this subject and proposing new alternative techniques to aid those people.

The screen-magnification software and high contrast displays are commonly used by people with low vision and help them to read the texts and interpret the images in web sites. Such software improves the readability of small text, but limits the visible area of a document. Enlarged graphics that contain text may be difficult to read. People who are blind do not use the screen display or mouse. Instead of reading Web pages or viewing images, they listen to the Web through softwares that acts as a screen reader. These screen readers convert text into synthesized speech and are unable to interpret the graphical content

of images. Because of that, some pages may be very difficult or impossible for a blind person to understand or navigate.

In the United States approximately 3.5% of the population has low vision and only 1% of them use a computer. If we consider this equivalent percentage for the whole world population, probably the percentage of people that uses computers will be probably very smaller [4].

Nowadays, the knowledge on the biological vision is extremely limited and some research groups in computer vision have been proposing systems using procedures similar to the human vision processes to explain its properties and to develop new computer vision applications [13], [14]. Projects are being developed to insert accessibility tools in many computer applications or in the usual computer operating systems as the Microsoft Windows and more recently in the LINUX distributions [21].

In this work we report the results of an exhaustive research on accessibility tools to aid people with low vision to access computer applications, mainly Web navigation ones [8]. We have also developed an accessibility tool, named MouseLupe, for people with low vision. This tool allows the user to access the Web in a more comfortable and pleasant way, stimulating the social inclusion and improving the access to information and, thus, the quality of life.

The Section 2 of this paper discusses the related works on accessibility tools for low vision disabilities. In Section 3 the developed tool is described and shown through the number of examples. Finally, the conclusion is presented in Section 4.

2 Related Works

There are many accessibility tools for each disability category. In this work we highlight and compare just those accessibility tools for people with low vision, not for blind people. For blind people we would have, for example, the IBM's software named, Home Page Reader, a text reader that uses the company's Via Voice Out loud text-to-speech synthesizer. A visually impaired user can use the software to speak text, image descriptions, and other fields of Web pages [15]. The accessibility tools for people with low vision are dedicated to help them people in visualizing the content of a computer display more easily, as well as, to aid in Web navigation.

Most of the accessibility applications for people with low vision make the zoom amplification of certain area of the computer display to facilitate the visualization of its content [9]. These applications are commonly named as screen magnification and generally the center of the amplification area is the mouse cursor position. The zoomed area is shown in a different window of the computer display, overlapping other application window. Whenever the user moves the mouse, the amplification screen is refreshed automatically.

Microsoft added in the most recent versions of its Windows operating system an application named, Magnifier [16], that divides horizontally the computer screen in two parts. The first, composed generally by 20% of the total screen

area and located in the superior part of the display, is used for the amplification and the other is used for the Windows desktop.

Because of the restriction on the amount of viewable area of the screen, a large, high resolution monitor is required by the screen magnification software to effectively increase the viewable area on the screen. The main problem of this application is that, besides the reduced display area, the user can be confused when moving the cursor in the application windows, while looking at the magnified part of the screen. That is due of the difficulty in the identifying relative mouse position in the amplification window and its relationship to the application window. This problem is worse when the application is a Web browser with which the user is reading the content of a Web page and moves the mouse to continue the reading. In this case, he may be disoriented and waste time to find the required position again.

In many applications, the option of changing the size of the text characters (font size) is considered an accessibility option. However, to enable this option, a disabled person initially needs the help of another person. In Microsoft Windows, there is an accessibility wizard [16], which guides the user through a series of Windows appearance options. These include adjustments for the font size, screen resolution, scroll bar size, icon size, color scheme, mouse cursor appearance and mouse cursor blink rate.

The Loupe [17], is a small utility that displays a magnified view of whatever is beneath the mouse cursor, much like a jeweler's or printer's loupe. The captured image can be pasted into any graphics program and most word processors. The Loupe also includes options to monitor a specific area of the desktop instead of normal mouse tracking. The BIGSHOT [18], is a screen magnification program that enables users working with large monitors and high screen resolutions to quickly magnify part or the whole screen to display in a more comfortable way small pictures, icons and texts.

The Lunar [19] is a software magnification system that magnifies the screen from 2 to 32 times, at any screen resolution and color depth. It allows horizontal and vertical magnification to be adjusted separately, and incorporates image smoothing, to make characters more readable particularly at higher levels of magnification. The ZoomText Xtra [20] software combines screen magnification software with a built-in document reader and is supplied in modular form, where level 1 provides magnification and level 2 adds speech output using any sound card. A speech synthesizer can also be used to provide the speech output.

Most of the available accessibility softwares are for Windows, although, there are some LINUX packages of accessibility tools for example, the gmag and xlupe [21]. The software for LINUX is in its greater part open source free software, which means no acquisition cost. The gmag is screen magnification software similar to the Magnifier of Microsoft Windows. The xlupe software is a simple application that has a window of variable size which shows the amplification image of the region where the mouse cursor is.

It is possible to enumerate the main limitations of these applications and their implications for the user as: 1) The amplification window limits the useful display

area; 2) The window overlapping may hides significant parts of an application; 3) The user attention is focused in a small region covered by the amplification window; 4) The user can be disoriented by just visualizing the relative position of the mouse cursor in the amplification window; 5) The user may not have perception of the global aspect of the application for being always visualizing the small amplification window whose location is fixed; 6) In most of the applications in which it is possible to change the font size, there is no way to change the font size of the toolbars or option menus. In this case the user needs to request the help from another person; 7) The change of the amplification level is a difficult task when this option is on amplification window.

Throughout this initial study about the current accessibility applications, it was possible to find their limitations and their virtues, and to develop a new and efficient accessibility tool.

3 Developed Accessibility Tool: MouseLupe

We had difficulties to obtain a specification of the Microsoft Windows window manager. Thus, we decided to develop the MouseLupe for the LINUX operating system. The LINUX distributions have no acquisition cost and the adoption of this operating system makes possible the development of accessibility applications at an insignificant cost.

Our objective was to develop an application like the traditional screen-magnification software, but not having a static window. The application needs to be fast and dynamic and show quickly whatever the user would like to enlarge. Then, we projected an application integrating the mouse cursor movement and the displacement of the amplification window. The result was the development of MouseLupe, see Fig. 1. The MouseLupe is an original tool that simulates perfectly a magnifying glass (Lupe) guided by the mouse movement and preserves the functions of the mouse buttons allowing a common Web navigation. It makes a great general purpose screen magnification utility for computer users with sight impairments.

The development guides of X Window System were used in this work [10], [11] and made it possible to consult all the sub-routines of the X window server, mainly the window and mouse events. The X controls the graphic interface of LINUX and a window manager is executed as a first X client application, for example the WindowMaker, KDE, IceWM, and so on.

When MouseLupe starts, it initially creates a transparent window, without borders, to contain the magnifying glass. The window borders of an application are attributions of the window manager. In order to create a window without its borders we needed to use the resource `OverrideRedirect` of X. This resource makes the application answer only to the X server commands and not to the window manager ones. This way, the window is directly controlled by the X events.

The mouse and window events, obtained by the `XQueryPointer` and `XMoveWindow` methods, were used to move the amplification window following

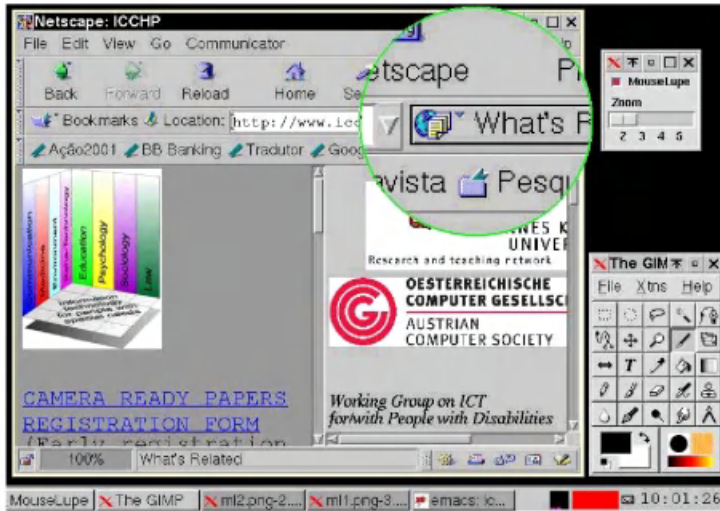


Fig. 1. Example of the MouseLupe application over a button of the Netscape browser. The figure shows a LINUX workspace with other window applications.

the mouse cursor position. The methods `XUnmapWindow` and `XMapWindow` were used to quickly remove the amplification window, copy the content of the display on the mouse position, and show the amplification window again. Doing that, a blink in the magnifying glass is noticed facilitating the MouseLupe identification on the screen.

A circle of 2 pixels (picture elements) width in the light green color was added in the border of MouseLupe to improve its limits identification in the screen. The MouseLupe content is refreshed every 5 seconds by default configuration, however the refreshing time may be decrease to allow the visualization of image animations shown in a Web browser. The size of the glass magnifying region is proportional to the amplification factor and its shape is a circle. To allow for mouse clicks to function, there is a 1-pixel hole in the center of MouseLupe circle. The mouse events are applied in the window below the MouseLupe.

The MouseLupe was tested by several users that checked its efficiency not only for people with visual impairments but also for people that need to magnify regions of its applications in a fast and dynamic way. The users' main comment was that finally they found an efficient screen magnification tool to be used in the most of computer applications. The developed application is very fast and simple and it does not require any resource of special hardware. In this first version, the only requirement is a computer with LINUX operating system.

The main advantages of the *MouseLupe* are: 1) It eliminates the window overlapping of traditional screen-magnifications software; 2) It eliminates the user confusion when the screen is splitted in 2 windows as it is shown in the Microsoft Magnifier application; 3) It allows the normal mouse functions, move

and buttons clicks; 4) It is possible to see a animating Web page because of the continuous refresh, even when the mouse cursor is not moving; 5) It is possible to move the mouse and quickly see a amplified region of the screen quickly; 6) The user can change the *MouseLupe* configurations using the own *MouseLupe* to see the configuration options enlarged (Fig. 2); 7) It is possible to configure the Mouselupe, to allow different shapes to the *MouseLupe*, like circle, box, rectangle and lupe.

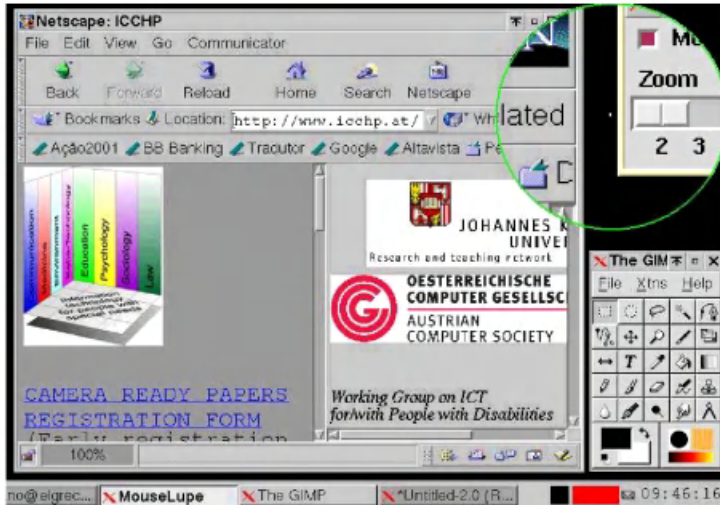


Fig. 2. Example of the MouseLupe application between the Mouselupe zoom options window and the Netscape browser window.

Other features that are being developed for *MouseLupe* are: 1) “Colors reduction mode”, to reduce the number of colors shown in the amplification window; 2) “High contrast view mode”, to show the amplification image in high contrast colors; 3) “Voice command recognition”, to allow changes on magnification level, or Lupe window shape, or to enable or disable the *MouseLupe*; 5) “Text mode”, the image on the amplification window has only white or black pixels; 6) “Image smoothing”, to make characters more readable particularly at higher levels of magnification;

4 Conclusion

In this work we report the results of an exhaustive research on accessibility tools to aid people with low vision to access computer applications, mainly Web navigation ones. We have also developed an accessibility tool, named MouseLupe, for people with low vision. This tool allows the user to access the Web in a more

comfortable and pleasant way, stimulating the social inclusion and improving the access to information and, thus, the quality of life.

The MouseLupe is an original tool that simulates a magnifying glass (Lupe) guided by the mouse movement and preserves the functions of the mouse buttons allowing a common Web navigation. It makes a great general purpose screen magnification utility for computer users with sight impairments. As future works we intend to finish the new features of MouseLupe and make it available for other operating systems platforms including the Microsoft Windows versions.

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Visually Impaired Persons Using Microsoft PowerPoint Presentations

Martin Jung and Erdmuthe Meyer zu Bexten

Center for Visually Impaired Students (BliZ)

University of Applied Sciences Giessen-Friedberg, Department of Mathematics,
Computer Science and Natural Sciences, Wiesenstrasse 14; D-35390 Giessen;
Germany

martin.jung@uni.fh-giessen.de

<http://www.fh-giessen.de/bliz>

Abstract. This paper deals with the experiences of the visually impaired students of computer science of our institute with Microsoft PowerPoint and how to improve the usability by customizing the screen reader JAWS. New opportunities and restrictions for visually handicapped persons will be discussed. Typical scenarios and some of the occurring problems to be solved will be shown.

1 Introduction

The University of Applied Sciences Giessen-Friedberg was founded 30 years ago with a main emphasize on technical disciplines. The present total world-wide number of blind persons is estimated to be roughly 40 million. In Germany about 155.000 people are considered blind and approximately 550.000 people suffer from visual impairments.

In 1998 Prof. Dr. rer. nat. Erdmuthe Meyer zu Bexten established the center for visually impaired students as a step towards equal opportunity. Among our 30 visually impaired students there are about 20 students of computer science. Part of our work is focussed on accessibility topics for visually impaired persons. This includes mathematical notations for the Visually Impaired [1], accessibility issues, ergonomical aspects with respect to visual impairment [3] or adaptive technology, like screen readers. Currently we started to increase the support for a special screen reader (JAWS by Freedom Scientific) within Microsoft PowerPoint. This screen reader's performance can be improved by scripts.

Visually impaired persons have access to computers via adaptive technology. They use special programs and additional hardware. A so-called screen reader program is employed to get the information of the screen and process it in a way to control a speech output or a Braille display.

Braille displays (see Fig. 1) use raised dots driven by piezo elements to provide a tactile output of Braille characters read by the fingertips of the user. There are some traditional job areas for visually impaired persons, but some of them have become obsolete due to new techniques or organizational changes in labor. On

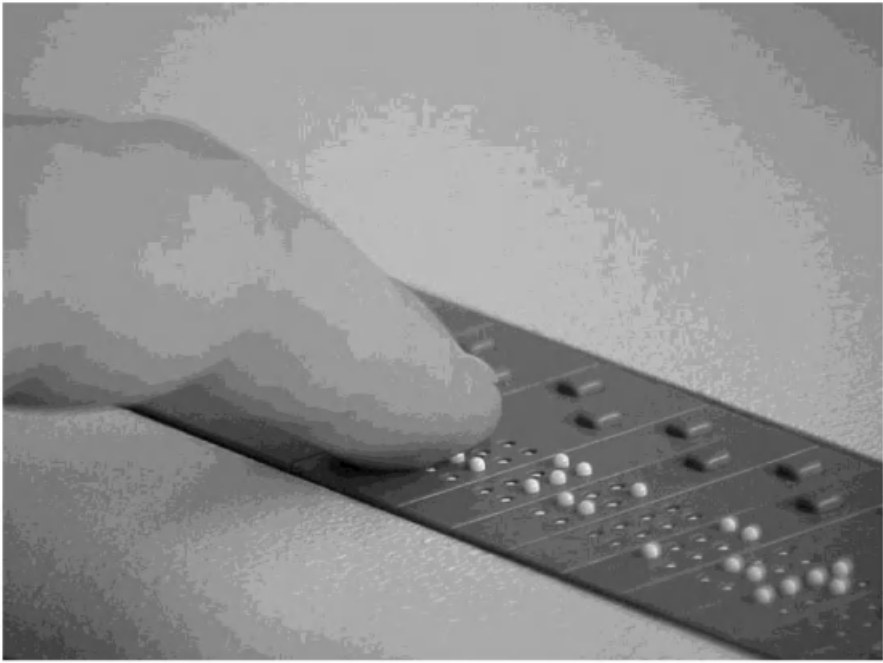


Fig. 1. Close up of a finger on a Braille display

the other hand the development of the refreshable Braille display created a whole new world for the visually impaired persons. Fast development of information and communication technologies of recent years lead to fundamental changes in our society.

New job areas opened up. Nowadays not only handling of plain texts is possible, even some multimedia applications are more or less accessible by recent developments of the adapted access devices, like screen reader programs and special web tools. Screen readers and related basic topics for graphical user interfaces have been discussed by Mynatt and Weber [2] and others. Still some more work in this area is needed since the evolution of new features and techniques put up some new questions.

An increasing number of tasks within the MS Office suite can be performed by a visually impaired person with the help of state-of-the-art screen readers like JAWS (Freedom Scientific, <http://www.freedomscientific.com>), but working with MS PowerPoint is limited. More exotic applications, like the SPSS statistical package, are even less supported by the designers of the screen reader software, though Dimigen et. al. [4] worked on this special objective.

People are not only expected to work successfully, the results of one's work also have to be presented in an appealing and up-to-date manner.

2 Look at Me – I’m Your Problem!

Visually impaired people should be given the possibility to make attractive presentations independently and have at least a basic access to presentations of other people. Devices like Braille displays or screen readers are mainly developed to manage textual contents and only allow for limited working with graphics or animations. Although they can catch, analyze and process the graphical characters of Windows, complex work based on pictures or graphics poses heavy problems. A screen reader software is hardly able to recognize written text in animations, such as rotating headlines.

2.1 Why Use the Screen Reader JAWS?

Checking the major screen reading solutions here in Germany, we found out, that JAWS gave some fairly good results, though being far from perfection. Since this is not only in Germany a widely used screen reader, we decided to choose JAWS. JAWS offers some basic functionality for MS PowerPoint. For some applications and scenarios there are scripts to control JAWS.

Depending on the tasks to perform, one will find out very soon about the restrictions and bugs of the existing scripts for MS PowerPoint. Currently this script is approximately 2000 lines and increases with every added support feature. Freedom Scientific provides a tool to customize these scripts called the script manager (see Fig. 2).

The shown code segment is an excerpt of the *KeyPressedEvent* function. On every keystroke the current conditions are tested. The second line calls for our added new function *ZeilenumbruchTest*. The user will be informed, if there is a line breaking.

3 Strategies—Approaches

Different solutions to enable visually impaired people to make presentations on their own by using Microsoft Power Point will be investigated.

The following strategies will be pursued:

- Developing a program to insert a text into a template which is transferred to a pre-built PowerPoint file. In this case it is necessary to find the places in a PowerPoint file containing plain text (ASCII). Opening a PowerPoint file with a simple ASCII-editor, manipulating one plain text area by replacing it with another text and finally writing back the file has failed. Control characters and/or escape sequences cannot be read and written correctly with an ASCII editor.
- Reading and writing the PowerPoint file in binary format will also be evaluated. Locating the right position of plain text among the binary code is crucial. The benefit of this solution is that PowerPoint need not to be installed. This procedure is quite complicated and only suitable for simple presentations, since users are restricted to employ predefined templates.

```

Void Function KeyPressedEvent (int nKey, string strKeyName, int nlsBrailleKey
ZeilenumbruchTest()); neue Funktion eingefügt
if UserBufferIsActive() then
  KeyPressedEvent(nKey, strKeyName, nlsBrailleKey, nlsScriptKey) ; default
return
endif
if NKey==spaceBarKeyCode then
  if not shouldItemSpeak(ot_item_state) then
    return
  endif
  if GetWindowSubTypeCode (GetFocus ())==wt_checkbox ||
  GetWindowSubTypeCode (GetFocus ())==wt_3State then
    Delay(3)
    SayFormattedMessage (ot_help, getObjectState())
    ElIf getWindowSubtypecode(globalFocusWindow) ==wt_ListBox then
      if GlobalRealWindowName==WN_AutoCorrect then
        : Office XP has listboxes which contain objects of type checkbox
        SetJcfOption(opt_Msaa_mode,2)
        if GetObjectTypecode()==wt_CheckBox then
          SayMessage(ot_no_disable,GetObjectTypecode())
        endif
      endif
    endif
  endif

```

Für Hilfe drücken Sie F1. Line: 1 Zeilen ges

Fig. 2. Screenshot of the script manager supplied by Freedom Scientific to configure JAWS for special purposes

- Creating a robot that operates with PowerPoint is a quite complex solution. It could use an ASCII file to control the robot, while the robot for his part uses the Windows Messaging System for operating with PowerPoint.
- Another approach is to use Braille display and screen reader within PowerPoint. Currently it is not working satisfactory. The screen reader software has to be adjusted for PowerPoint and best practice solutions have to be found. This method appears to be the most attractive, because visually impaired people could work directly within PowerPoint. Their working process would only be slightly different from that of a sighted colleague.

Efforts have been made to check possible solutions for the first three approaches, but did not lead to useful results until now. In discussions with visually impaired persons we had to learn, that there would be only little interest for this kind of solutions. In a recently started side-project alternative presenting techniques for visually impaired computer users will be investigated. Following the last approach might help visually impaired persons struggling for equal opportunities, especially in professional environment. As stated before, presenting the fruits of your labor has a growing importance and can promote your professional development a lot.

4 Adapting the Adapted Access

Examining the approach to customize the screen reader, the problem has to be divided into three different scenarios:

- creating PowerPoint presentations as a visually impaired person
- presenting these PowerPoint presentations as a visually impaired person
- accessing existing presentations created by other persons

While the main problem of the first scenario is the performance of the screen reading software within the program Microsoft PowerPoint, the second scenario seems to be easier to cope with: speaking or displaying the contents of the screen on a Braille display during presentation. The third scenario depends heavily on the usage of animations and graphically coded text in a given presentation. Improving the JAWS scripts is the main objective of our current work. Having dealt with this topic for some time, there are several facts to be taken into account:

1. version of the screen reader
2. version of the operation system, patch level
3. version of PowerPoint, service release level
4. properties of graphic display: resolution, color schemes

These are only the fundamental facts.

Currently we use Windows NT 4 (German) with service pack 5, Office 97 with service release 2 installed and JAWS version 3.70. Recently we started running some workstations under Windows 2000, but there is not to much experience with this platform with respect to the PowerPoint problem yet.

5 Conclusion

Presentations make for an excellent media to show scientific results or any other type of information. It has become some kind of de-facto standard in education at universities for lessons, in seminars and likewise in commercial reports.

Some of our visually impaired students have already made their own MS PowerPoint presentations even without the increased functionality supplied by our updated scripts for JAWS, but average users might be discouraged by the amount of work arounds needed. Basic tasks of the every-day-work already can be performed by visually impaired persons working with MS PowerPoint. We could manage to improve this functionality for several practical tasks, but still there are some restrictions and residual problems. Beyond a certain level of tasks, work arounds are the only way to succeed.

This results encourage us to carry on in increasing functionality in the near future. As a spin-off we were asked to publish some tips for the development of accessible MS PowerPoint presentations for users willing to do so.

Acknowledgements. Parts of this work have been carried out in cooperation with F. H. Papenmeier GmbH & Co. KG, Schwerte (Germany), <http://www.fh-papenmeier.de>, one of Germany's leading suppliers of adaptive technology for visually impaired persons.

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Using MS Office Features as Low Vision Accessibility Tools

Deborah Gilden

The Smith-Kettlewell Eye Research Institute
2318 Fillmore Street, San Francisco, California 94115, U.S.A.
debby@ski.org, <http://www.ski.org>

Abstract. Standard features in MS Office can be used to enhance the appearance of text and graphics images, and thereby provide visual screen access to people with low vision. Although not designed to be accessibility tools, these features can be more useful than Windows accessibility features. This easy, no-cost approach permitted a college student with extremely limited vision to switch from using the computer as a blind person, to accessing it well enough visually to be able to make schematic drawings by using a mouse.

1 Introduction

Two image enhancements that people with low vision generally find useful are increased magnification and high brightness contrast. Preferences for background and foreground colors, type font, line thickness, etc., are also common. These parameters, and other aspects of screen display, can be customized in MS Office applications.

2 Windows Accessibility Features – Merely “Windows Dressing”?

MS Windows has an Accessibility Wizard for those who “have difficulty seeing things on the screen.” It allows the user two size magnification options and a few color contrast options for the title bar, menus, buttons, scroll bars, and icons. Making these elements large, however, can be counter-productive as it reduces the size of the overall viewing/working area.

Windows also offers a magnifier that enlarges all or part of the screen. Unfortunately, this pixelizes the text and thereby makes it difficult to read.

A better strategy can be to make buttons and toolbars as *small* as possible in order to maximize the viewing/working area, and then use the tools found in applications to enhance images in the document, presentation, or spreadsheet. It is not necessary to see buttons or menus as they can be selected with keyboard commands that are either memorized or available from a large-print reminder list.

3 MS Office Features Allow for Fine Image Enhancement

In contrast to the restrictions of Windows accessibility features, MS Office applications provide the user with fine control of all text and graphics parameters.

3.1 MS Word

While black text on a white background is standard, people with reduced vision often prefer other color combinations. MS Word provides virtually unlimited color options for text and background.

Low vision users can also benefit from Word's options to alter text size via font size (in one-point increments), zoom (in one-percent increments), and bold.

3.2 MS PowerPoint

Generally thought of as presentation software, PowerPoint can also be used as a drawing program for generating flowcharts, schematic diagrams, etc. It addresses low vision needs by allowing for easy image enhancement via size, color, and outline, plus total control of the background appearance. In addition, objects can be grouped in meaningful ways to avoid visual clutter, as well as associated with sound and motion to direct visual attention. These features make PowerPoint an ideal graphics application for individuals with low vision.

3.3 MS Graph and Excel

Graphs can be made more visible by widening curves and making them and their backgrounds in high-contrast color combinations. Axis labels and values can also be enlarged, as well as highlighted by rectangles of contrasting colors.

4 Efficacy

We used the techniques described above with an engineering student whose vision was so poor that he believed visual screen access within Windows was impossible for him. We demonstrated that Word text could be made large enough for him to read, but he found it too slow to be practical. In contrast, PowerPoint gave him valuable access to graphics. Not only was he able to see graphics on the screen, but he also could create and edit graphics, such as schematic diagrams, with a mouse while visually monitoring his progress.

We believe that many others with extremely low vision will also find these easy, no-cost ways of enhancing screen images with MS Office, to be useful.

Access to Mathematics by Blind Students

Introduction to the Special Thematic Session

Arthur I. Karshmer and Chris Bledsoe

Information Technology Program
University of South Florida
Lakeland, FL USA

Abstract. Access to, and doing mathematics, is one of the biggest obstacles for blind students in school and at the university. Our special thematic session (STS) will present new approaches to offering blind students better access to mat, to provide new tools for doing math and offer support tools to math teachers to help them offer better instruction to blind students. In the remainder of this short paper, the basic problems and historical solutions to the problem are discussed as a means of laying the groundwork for our STS.

1 Introduction

Reading and writing mathematics is fundamentally different than reading and writing text. While Braille is adequate for the representation of text, it is not up to the task of representing mathematics. The two basic reasons for this are:

1.1 Linearity

Text is linear in nature while mathematical equations are two dimensional. What you have been reading in this text is a good example of this problem. In contrast, examine the following relatively simple equation.

$$a = \sqrt{\frac{x^2 - y}{z}}$$

Fig. 1. A relatively simple equation

One will immediately notice that the equation contains a superscript and a fraction – both being two dimensional in nature. The equation could have been written in a linear form, for example:

$$a = \text{sqrt}(((x \text{ super } 2) - y) / z)$$

For this relatively simple equation, a linear representation is adequate for reading to a blind user. But, with any increase in complexity it becomes apparent that linear representations are no longer useful.

1.2 Character Set

Text can be generally represented in a somewhat limited number of characters which normally include upper and lowercase letters, the 10 digits, various punctuation marks and a small set of special characters. Equations on the other hand can contain all of the normal text characters plus a large number of special characters.

Normal 6-dot Braille can intrinsically represent 64 unique characters. Through the use of special “escape” sequences Braille can support a much larger set of characters. But this comes at some cost. This means that the basic characters that can be represented in Braille can have different meaning in different contexts. While there is effectively no limit to the number of characters one can represent in the fashion, the reading and understanding of these special sequences becomes very involved. The more new characters one needs, the more escape sequences one requires. So, for example the letter “a” can have different meanings in different contexts. It could be an “a,” an “A,” a “1,” and so on. This makes for difficult reading and/or writing of mathematical equations in Braille.

Now, add to the mix the multi-dimensional nature of all but the simplest equations, and the escape sequences required to represent them. It becomes clear that Braille math representation is very difficult given the character set that can be represented in 6-dot Braille.

In spite of these limitations, numerous Braille mathematical notations have been developed over the years, primarily based on 6-dot Braille. In the United States the Braille math standard is named after its inventor, Dr. Abraham Nemeth. Other countries have their own standards and some countries have more than one. These representations use the tricks described above and are therefore not easy to learn.

Add to these problems the fact that the vast majority of mathematics teachers don’t know, and don’t care to learn math Braille notations and you can easily see the problems associated with learning math if you are severely visually impaired or blind.

Finally, while text can be recorded by sighted readers in the form of talking books, this technique does not work well with transmitting mathematical equations [5]. Having a human reader at your side does help, but is an impractical solution on several levels.

Other techniques have been tried to solve these basic problems, and these approaches will be presented in the remainder of this paper. While not an exhaustive review of other techniques, we present several examples of methods reported in the literature.

2 General Approaches

Most of the work reported in developing techniques to help visually impaired students deal with mathematics fall within the following general categories.

1. Tactile as in Braille and other raised representations.

2. Audio aids that read equations to the student with tools to help in the reading process.
3. Tonal representations of equations and graphs.
4. Haptic or forced feedback devices that represent shapes of objects and curves.
5. Integrated approaches.

While more exotic approaches have been postulated and are possible in the future, we will examine work that falls into the basic categories listed above.

3 Tactile Representations

We have already discussed the use of traditional 6-dot Braille and its limitations. Now we turn to other tactile methods. First and foremost amongst these other tactile methods is 8-dot Braille representation. By using 8 dots, we extend our basic character set from 64 to 256 characters. Additionally, most 8-dot systems attempt to have some sort of graphics associated with the dot pattern [4, 18].

In an effort to alleviate the problem of requiring teachers to learn Braille, there have been projects that allow a teacher to prepare instructional materials in familiar electronic ways and then have their work automatically translated into Braille. Three such projects are, 1) the ASTER project [14], 2) the LABRADOOR project [12] and 3) the MAVIS project [8]. Other markup languages have also been used to accomplish the same end as seen in the MATHS project which used SGML [2] and the MAVIS project which now uses XML [9]. By using standard markup languages, these projects offer teachers powerful tools to create instructional materials and make them usable by the blind. Another feature of many of these projects is their ability to generate refreshable Braille output.

Tactile output is also very helpful for the blind math student in other ways. For example, sighted students can easily examine the graphical output of a sine function, but for the blind this is not an easily achieved option. The ultimate goal here would be the development of a high resolution refreshable tactile device that could present images to be touched by the user. There are several industrial efforts to create such a device that would be inexpensive enough to be practical, but it hasn't been accomplished yet. In the meantime, there are other devices that can prepare the equivalent tactile sheet on paper or paper-like substances, One of the more promising of these devices is the Tiger Printer [4, 17].

4 Audio Aids

Audio has been one of the most popular and successful output media for the blind student over the years and is employed in a wide variety of computer-based device interfaces. Certainly, Jaws for Windows [3] is a necessary tool for any blind computer user. But this tool is primarily designed for the general user interface and is not well suited for more technical data interfaces.

The problems associated with the automated reading of equations have been the subject of several research projects over the years. Professor Abraham Nemeth not

only defined the U.S. standard for math Braille representation, but also developed a simple spoken structure for reading equations [13]. An interesting overview of the problem of reading math [7] offers an overview of techniques developed to that date. Finally, the MAVIS project carried out a series of psychological experiments to better understand the process and its inherent problems [5].

Two early projects in the delivery of technical information to the blind student through audio output were ASTER [14] and Talking Emacs [9, 19]. ASTER reads complex equations to the listener with special sonification to highlight parts of the equation while the Talking Emacs project reads C code to the user providing descriptive information about the code in addition to the basic program material. Given that the project was based on the Emacs editor work was planned to enhance the editor's base Lisp code to also read equations.

More sophisticated equation reading were key to both the MATHS and MAVIS projects. Additional features such as the use of prosody and highly flexible equation browsers to allow the user to navigate through complex equations. The MATHS system also uses non-speech sounds to give an overview of the equation. MAVIS (see Figure 2), on the other hand uses a hierarchical structure to group sub sections of an equation into meaningful "chunks," for browsing. Both MAVIS and MATHS also offer refreshable Braille output and specialized video output for low vision users.

5 Tonal Representations

Reading equations is not the whole problem associated with mathematics and blind students. The output of a function, for example, can also be a multi-dimensional structure. These forms of mathematical structure are even more difficult to describe in words than an equation.

Sonification of graphs has been the subject of several interesting research projects over the years [10, 11]. In these systems, musical tones are used to represent the shape of graphical object. Both two- and three-dimensional objects have been sonified with these techniques.

The use of strictly tonal representations have had limited success especially when used for complex graphs. Hearing alone seems to lack the information carrying capability to describe complex objects. While not a complete solution, sonification can be used with other non-visual output media to describe graphs.

6 Haptic Devices

The development of high resolution refreshable dot grids would be the best way to represent both text and non-text data. Unfortunately, such devices are still way beyond an affordable price. Other devices like the Tiger printer can produce relatively inexpensive raised dot paper output, but they are not dynamic in nature once they are embossed.

Another solution to this problem can be found in haptic or forced feedback devices. Such devices can work in either two- or three-dimensional space, and under computer control allow the user the "feel" shapes (Yu, et al. – 2000; Kennedy, et al., [16].

Again, high-quality haptic devices are reasonably expensive, but new less expensive devices are now coming on the market. Prices can range from US\$ 6,000 down to US\$ 100. Naturally, the less expensive devices don't offer the resolution of their more expensive counterparts.

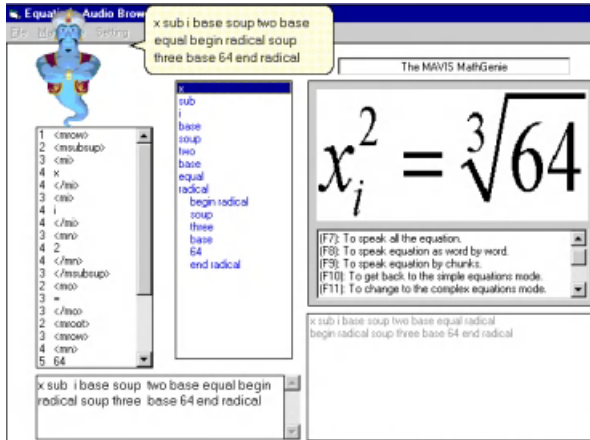


Fig. 2. The MAVIS MathGenie

7 Integrated Approaches

While all of the approaches to delivering math education to blind students have a great deal of merit, the truly successful ones offer a number of interface techniques. In the domain of reading equations, for example, the MATHS and MAVIS projects used multiple output media to accomplish their tasks. These included speech, sound, Braille and structured navigational techniques. In the case of MAVIS research from math reading experiments laid the groundwork for less ambiguous equation reading and the ability to speak equations into the system by the user.

Another example of integrated approaches is seen in the combination of haptic and sonic devices for describing graphical output [6, 15]. In these projects, forced feedback devices are coupled with sonification techniques to deliver a high quality rendering of the graphical output. An interesting project from the University of Bologna in Italy includes both haptic and sonic output to describe objects, but also incorporates vibrators to represent colors in the form of a tactile RGB display [1].

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Architecting an Auditory Browser for Navigating Mathematical Expressions

Arthur I. Karshmer¹, Gopal Gupta², and Doug Gillan³

¹ Department of Computer Science, University of S. Florida, and NSF

² Department of Computer Science, University of Texas at Dallas

³ Department of Psychology, New Mexico State University

arthur@csee.usf.edu, gupta@utdallas.edu, dgillan@nmsu.edu

Abstract. Understanding and internalizing complex mathematical expressions is a difficult task for visually impaired students. We present the design of an auditory browser, currently under development, for browsing complex mathematical expressions via audio. The architecture of the browser is influenced by experiments performed to study the perceptual and cognitive processes involved in reading mathematical expressions. The auditory browser is interactive and facilitates aural navigation of mathematical expressions. The characteristics of the browser along with its implementation are discussed in this paper.

1 Auditory Browsers

We consider the problem of communicating mathematical expressions to blind students through an audio browser. Communicating the structure of large mathematical expressions to blind students is a difficult problem that has received scant attention [3,1]. A linear reading of large expressions (e.g., coded in Nemeth Math or Marburg) can result in the “reader” getting lost in the details. It is a lot easier to understand a formula visually because the way the formula is written conveys its structure. Blind readers do not have access to the two dimensional display of Mathematics that the sighted users have that makes the visualization of mathematical expression easier. The linear encoding of a complex expression in \LaTeX , or Nemeth, or Marburg may be so long that by the time a user gets to the later part of the expression, they might have forgotten the earlier part.

In this paper we describe the architecture of an interactive auditory browser that allows blind users to “navigate” mathematical expressions in order to improve their understanding. The goal behind the development of the browser is to allow blind users to traverse the whole expression or parts of the expressions repeatedly so that they can “visualize” (i.e., internalize) the expression better. The browser will also support various strategies for conveying the structure of expressions to the blind user. This will be accomplished by presenting the *abstract* structure of the expression. The tool will also allow author or a third party to specify the best way of traversing an expression by providing default navigation strategies.

The navigation techniques supported in our browser are inspired by experiments that we did to understand how sighted humans read and understand mathematical equations. The results of these experiments and discussions with blind mathematicians/scientists/students are the primary inputs used in developing the design of the auditory browser. It should be noted that the browser is still under development; in this paper we report on the architecture of the browser.

2 Experimental Study of Equation Cognition

To investigate the design of computer-based aids for equation reading (auditory browser) by persons with visual impairments, we decided that first we should understand how people read equations. Our research, thus far, has focused on understanding the perceptual and cognitive processes used by sighted people as they read equations, primarily because no research had previously been done on this very basic topic. However, we clearly recognize the need to follow-up with studies on equation reading by blind people, to determine differences and similarities with sighted people. We began by observing 15 students as they read equations; we asked them to think aloud as they read the equations. The 14 equations that they read varied in the types and number of operators and in the overall complexity of the equation. The verbal protocols of the participants' thinking aloud were analyzed to determine their cognitive and perceptual processes as they read and solved equations. The analysis suggested the following features of equation reading: (1) reading proceeds largely in a left-to-right direction reading one element at a time, much like reading text (for an example of text reading, see [6]); (2) however, unlike text reading, equation reading frequently involved an initial scan to determine the structure of the problem (on approximately half of the problems that we observed); (3) most of the problems required backtracking of previously read elements of the equation; (4) readers chunked together elements of the equation (usually within parentheses) and solved those subexpressions as separate modules; and (5) as a consequence of chunking, readers solved the equation hierarchically.

Because verbal protocol data may, under some conditions, reflect the participants' expectations concerning their cognitive processes, rather than the actual processes, conclusions drawn from them should be tested by means of true experiments. Accordingly, we conducted a series of experiments to examine the features described above. In Experiment 1, we had participants read an equation during a 1, 2, or 4 second presentation, then we asked them to recall the equation. Participants showed the best recall for the leftmost items in the equation. Given the common primacy effects in memory in which the first items read are the best remembered, this last finding supports the hypothesis that equation reading is left to right. In addition, participants' recall improved the longer the equation was presented; and in all presentation conditions, participants tended to make more recall errors for the parentheses than for numbers or operators. This finding suggests that parentheses are not processed in the same way as

numbers or operators, in that they serve a structural, not a semantic, role. That is to say, parentheses help the reader navigate through the equation and identify how to organize it, but don't provide meaning in and of themselves. As a consequence, they appear to be easier to forget.

In a second experiment, we also used a memory procedure to examine the chunking process that we had observed in the protocol study. In this experiment, we gave participants an equation to solve, then after they had solved it, we gave them an intervening task (counting backwards from a randomly-selected number by three for an average of 15 seconds). Each equation consisted of a one operation within parentheses and a few operations outside of the parentheses. Then, we presented a recognition probe – on half of the trials the probe was an equation that was identical to the target equation that they had solved, and on half of the trials the probe differed in systematic ways from the target. Participants indicated if the probe was the equation that they had solved or not and rated their confidence in their answer on a 4-point scale from 1 (not at all confident) to 4 (very confident). Thus, we could convert their responses into a scale from -4 (not the same, very confident) to +4 (the same, very confident). The probe equations that differed from the target, differed according to either the numbers within the parentheses or those outside: (1) a change of one number within the parentheses [e.g., $(5+2)$ in the target might be $(5+4)$ in the recall probe], (2) a change of two numbers within the parentheses, with the outcome differing from the target [e.g., $(5+2)$ in the target might be $(6+4)$ in the recall probe], (3) a change of two numbers within the parentheses, with the outcome the same as the target [e.g., $(5+2)$ in the target might be $(3+4)$ in the recall probe], (4) a change of one number outside of the parentheses, (5) a change of two numbers outside the parentheses, with the outcome differing from the target, and (6) a change of two numbers outside of the parentheses, with the outcome the same as the target. The results showed good recall and high confidence for the trials in which the recall probe was identical to the target (a mean recall score of +2.83), and usually good rejection of the different probes (recall scores ranging from -1.45 to -2.21). The one probe which departed from this pattern was the one in which the numbers in the parentheses were different between the target and recall probe, but the outcome was the same. The mean recall score, +.38, was significantly higher than the other different probes. This finding supports the hypothesis that equation readers simplify subexpressions first and replace them with the result.

In our third experiment, we investigated the function of an initial scan. Prior to giving participants an equation to solve, we presented them with a preview of some or all of the information in the equation. The preview involved showing them, for two seconds, either (1) the whole equation, (2) the numbers from the equation in the appropriate spatial positions for the equation but without operators or parentheses, or (3) the structure and operators of the equation in the appropriate spatial positions for the equation but without the numbers. In addition, on one-fourth of the trials, participants received no preview prior to the equation. Immediately following the preview, participants received the equation

to solve. Thus, the preview served the function of an initial scan of an equation. Although based on the protocol study, we hypothesized that the structure and operator preview would give equation readers the most helpful information, that preview resulted in increased time to solve the equation when the equation was complex. In fact, previewing the numbers from the equation was slightly more helpful than previewing the whole equation. Thus, these findings suggest that the purpose of the initial scan may be to process the numbers rather than to set up a framework for the equation.

Our findings from the research on the perceptual and cognitive processes in equation reading lead to the following suggestions for the design of an equation browser (of course, given the caveat that the same processes need to be observed in visually impaired equation readers):

1. the browser should proceed from left-to-right, element-by-element, but should permit the user to backtrack and reread the equation repeatedly,
2. the browser should allow the user to select subexpressions for separate evaluation (and ideally, to replace the subexpression with the outcome),
3. the browser should not interfere with a user's need to hierarchically solve the equation.

3 Auditory Navigation of Expressions

The design of the auditory browser hinges on the inferences we drew from our experiments described above. The input to the browser is the *parse tree* of the expression to be browsed. The parse tree is produced by a parser developed separately. The browser is thus independent of the Math markup language in which the mathematical expression is written, and thus can work for \LaTeX , MathML, Nemeth Braille Math, Marburg, etc. The output of the browser is audio rendering of the expression with options to interactively move around various parts of the expression and hear them again and in different ways. The browser has the following features:

1. It reads the expressions out from left to right by default, in accordance with the observation that readers read mathematical equations from left to right, element by element.
2. It allows the user to hear the expression hierarchically, that is, the expression can be read out abstractly with details of some of the subexpressions omitted.
3. It allows the users to evaluate subexpression with the result of evaluation replacing the subexpression in the main expression.
4. It allows the users to aurally "navigate" the parse tree through commands and to hear different subexpressions repeatedly.
5. It allows the user to provide input through keystrokes as well as via speech.
6. It allows the user to "voicemark" [2,3] certain subexpressions and to return to them later for browsing.

The last two features are made possible because the audiobrowser is being implemented using the VoiceXML technology. Next we illustrate these points further with an example. Consider the expression:

$$a_i = \int_{\sqrt{\frac{a-b}{2}}}^{\sqrt{\frac{a+b}{2}}} x^2 dx$$

The understanding of this expression can be greatly facilitated by repeating the structures and substructures of the expression using speech output. Thus, for this expression by default the auditory browser will speak the expression out as:

```
a subscript-begin i subscript-end
equals
limit-integral with lower-limit
  squareroot-begin numerator-begin
    a minus b numerator-end over
    denominator-begin 2 denominator-end
  squareroot-end
and upper-limit
  squareroot-begin numerator-begin
    a plus b numerator-end over
    denominator-begin 2 denominator-end
  squareroot-end
expression x exponent-begin 2 exponent-end d x
```

Given the complexity of this expression, hearing it only once may not be enough. One can argue that outputting this expression as auditory speech while making sure that it is understood unambiguously (by outputting `squareroot-begin squareroot-close`, etc.) makes this expression more complex and harder to understand in the spoken form. This is because, the signs for the various operators in mathematics have been designed to convey the scope of the operator in a visual manner (e.g., `squareroot`), while in auditory/speech output the scope information has to be explicitly stated. To compensate for this extra complexity introduced in audio rendering, the user should have the option to hear the whole expression as well as its sub-expressions interactively again and again. This is in accordance to the observation in [3] that during reading of material displayed visually by sighted individuals, the reader is active while the visual rendering is passive (e.g., the reader may glance through a page skimming parts of it, while pausing to read important segments in detail). In non-interactive audio rendering, the active-passive roles are reversed, the text is read out (i.e., rendered in audio) actively, while the non sighted reader just becomes a passive listener. Giving the listener the ability to interact with the audio renderer thus is important since it makes the reader play an active role in understanding the expression.

The speech output can be made more economical by recognizing those instances where the keywords introduced for indicating the scope can be removed, for example, the `subscript-begin` and `subscript-end` sounds can

be removed without introducing any ambiguity in the example above. Similarly, `x exponent-begin 2 exponent-end dx` can be stated as `x squared dx` without losing any information. Whether a sound is superfluous or not depends on the context. In some other context it may not be possible to omit the `subscript-begin`, `subscript-end` grouping without introducing ambiguity, e.g., if the subscript was a more complex expression, or the `exponent-begin`, `exponent-end` grouping, e.g., if the expression to be integrated was $(x + 2)^2$.

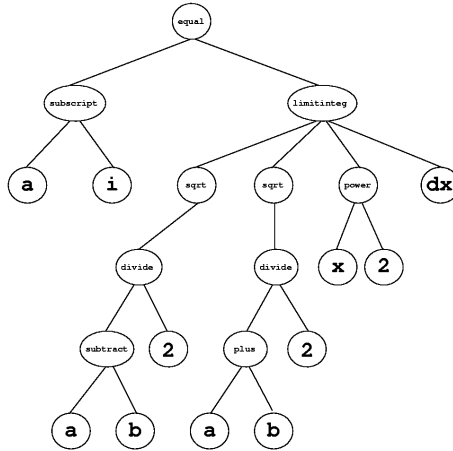


Fig. 1. An Example Expression Tree

The auditory browsing of an expression described above can be viewed as interactive navigation of the expression (see Figure 1). Abstractly, it can be viewed as navigation of the expression tree that corresponds to the expression. The auditory browser is based on traversing the expression tree upwards, downwards, or sideways, depending on what the user tells it to do. The user will be able to move up or down, or left or right, using the arrow keys. If the user hits the space bar, the expression rooted at the current node of the expression tree will be repeatedly read out using speech output, with pauses in between each reading to give the user time to press the option keys (or give spoken commands).

3.1 Abstract Navigation of Expressions

The passive nature of listening also inhibits “abstract” or “birds eye” view of the expression, since linear reading of an expression prevents the reader from developing a high-level, abstract view first and then examining parts of the expression in detail later to develop a better understanding. Thus it is highly desirable that any browser designed for rendering equations in audio permit the

listener to hear the expression in an *abstract* form so he/she can understand the structure of expressions in a hierarchical manner.

Thus, to understand the structure of an expression, it may be not enough to hear the expression repeatedly. For example, the expression above that involves an integral may be hard to internalize when heard in its entirety. It may be better if instead of reading out the whole expression, the auditory browser first presents the expression in an abstract way. For example, for the expression above, we might just want to convey that there is an equation whose left hand side has a subscripted variable while the right hand side is an expression involving integration with limits that contains a squareroot. The subexpressions omitted are replaced by the speech word “**something**”. Thus, in order to present the expression in an abstract way, the speech audio will output:

```
a sub subscript-begin i subscript-end equals
limit-integral with lower-limit
  squareroot-begin something squareroot-end
and upper-limit
squareroot-begin something squareroot-end
expression something d x
```

Note that expressions can be abstractly read out quite conveniently using their parse trees, for instance, reading the contents of the nodes only up to a certain depth. For example, given the parse tree shown in figure 1 for the expression under consideration we read the contents of the node up to a depth of 3 to yield the output above. Content of nodes below the depth of three is replaced by the speech word “**something**”.

There may be other ways of abstracting the expression apart from depth, for example, just reading out a specific branch (e.g., the leftmost or rightmost branch) of the expression tree. Or, the reader might wish to hear only the parenthesized subexpressions up to a certain depth while everything else has to be read out in its entirety. For example, given the expression $x + (a^2 + b^2) \times (a^2 - c^2) + y$, its structure can be conveyed by reading out: **x plus something times something plus y**. Multiple abstractions may be applied simultaneously, e.g., reading the leftmost branch until a certain depth. Design of suitable abstract navigation strategies is a topic of ongoing research.

A number of issues arise when we consider reading out the tree abstractly. For example, the principal issue is that the depth to which we need to read the parse tree out abstractly depends on the type of the operators used. For each operator we need to determine how it is to be abstracted. Also, the user should have the ability to hear the abstract structure of any subtree in the parse tree during navigation. This functionality, for example, can be built into the backspace key in the auditory browser, so that while navigating the parse-tree using the arrow keys, if the visually impaired user is at some node of the expression-tree, and presses the backspace, key then the sub-expression rooted at that node will be read out with the depth abstraction applied.

3.2 Expression Evaluation

Our goal is to also provide expression evaluation capabilities as part of the audio browser. While browsing a subexpression the user will have the option of pressing the enter key causing that subexpression to be simplified. The subexpression will be replaced by the result of the simplification, and the expression tree will be permanently changed. The result of the simplification may be provided by the user (expressed in Nemeth Math, for example) or it may be automatically calculated. In the latter case, the audio browser will need to interface with a software module, such as Mathematica [4], that can simplify and evaluate expressions.

Providing the ability to simplify and evaluate expressions will make a browser considerably more useful, as users can browse an expression and simplify it at the same time in an interactive fashion.

3.3 Voicemarking of Expressions

The audio browser should also provide the facility to remember (or bookmark) certain subexpressions. These subexpressions may be browsed again later. Subexpressions can be bookmarked by pressing a specified key when that subexpression is being read out. The bookmark can also be entered through voice by uttering a phrase that will serve as an identifier of that subexpression (such a voice-based bookmark is termed voicemark in [2]).

Bookmarking subexpressions can be quite useful in understanding and internalizing expressions. The user can understand the various subexpressions piecemeal. Those (s)he does not understand are bookmarked at first, and then browsed later once a better understanding of the rest of the expression has been developed. Bookmarking can also be used to develop customized abstractions of the expression by the user. For example in the expression involving integration above, the upper and the lower limit may be bookmarked using speech voicemarks “high” and “low” respectively. The marked subexpressions then may be abstracted away. Thus, in abstract rendering this expression will be read out as: `a sub i equals limit-integral with lower-limit low and upper-limit high x squared dx`. The user can then return later to the voicemarks “high” and “low” and understand them separately.

3.4 Implementation of the Audio Browser

We plan to implement the audio browser using the VoiceXML technology [5]. The *Voice eXtensible Markup Language* (VoiceXML) is an XML-based markup language designed for rapid development and deployment of speech enabled software applications. It is a scripting language for distributed voice applications, much as HTML is a language for distributed visual applications. Through VoiceXML, application developers can create audio dialogs featuring synthesized speech, digitized audio, recognition of spoken and DTMF key input, etc. The goal is to provide voice access and interactive voice response to information and services on Web sites, call center databases, etc., through telephones, PDAs and desktops.

To implement the audiobrowser using VoiceXML, the nodes of the expression tree will have to be translated into suitable VoiceXML *dialogs* [5]. These dialogs will then be woven together based on the navigation strategy used by the user to produce a VoiceXML document. This VoiceXML document will then be incrementally rendered in audio in a dynamic fashion using one of the publicly available Voicebrowser (e.g., Open VXI, a portable open source library for interpreting VoiceXML.) Using VoiceXML as a vehicle for implementing the browser considerably simplifies the implementation task, while also allowing it to accept voice input.

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REMathEx – Reader and Editor of the Mathematical Expressions for Blind Students

Pavel Gaura

Faculty of Informatics, Masaryk University
Brno, Czech Republic
gazi@informatics.muni.cz

Abstract. The project REMathEx is developed at the Faculty of Informatics, Masaryk University, Brno as a support for blind students allowing them to study complex mathematical expressions. The system uses the combination of the braille display and the speech synthesis outputs to provide the user with all the information concerning studied mathematical expressions. The basic principles of the system and its use are described in the paper.

1 Introduction

Large amount of the technically oriented textbooks contain structures almost inaccessible for visually impaired people. In the AUDIS project (see [1], [3]) we tried to find the solutions and advancements for accessing the electronic-form studying materials comfortably by the visually impaired. We helped them to study structured texts, tables or lists quickly; we also provided them with a tool for reading the mathematics (see [2]).

Although the system was able to read the mathematical expressions and to parse its parts in several levels (see [2]), it has shown its usability for a limited set of expressions only. Therefore, we decided to analyze the achieved system properties and implement a new module for reading mathematical expressions. The module will also be available as a standalone application for studying, evaluating and editing mathematical expressions.

2 How Can Blind People Study Mathematics?

Many blind students that are able to study mathematics read the mathematical expressions using the national versions of the Nemeth Code (mathematics and scientific notation of braille). The expressions can be printed on the paper, stored in the braille display equipped computer or vocally recorded. The paper version can be written in more rows to display the spatial arrangement of the expression parts; the computer

version can be simply modified. The recorded version is comfortable to listen, but very hard to parse and understand.

All mentioned methods suffer from the limited view of the whole expression structure and limit the speed of the study. None of them can be effectively used for the expression evaluation, because these methods are not convenient for editing.

3 Syntactical Tree of the Mathematical Expression

The method used in the REMathEx system for displaying the mathematical expression is based on parsing the syntactical tree of the expression. Basically, the tree contains *operators, variables* or *numbers*. The Fig. 1 displays the representation of the expressions (1) and (2); the nodes with the same color represent the separate layers.

$$\frac{a + \sqrt{b} + \sqrt{e}}{x^3} \tag{1}$$

$$(e^x)^x = e^{x^x} \tag{2}$$

The user of the system has to know nothing about the tree structure, because it is not necessary for the navigation between individual parts. It can only help him to understand the spatial collocation of the printed mathematical expressions.

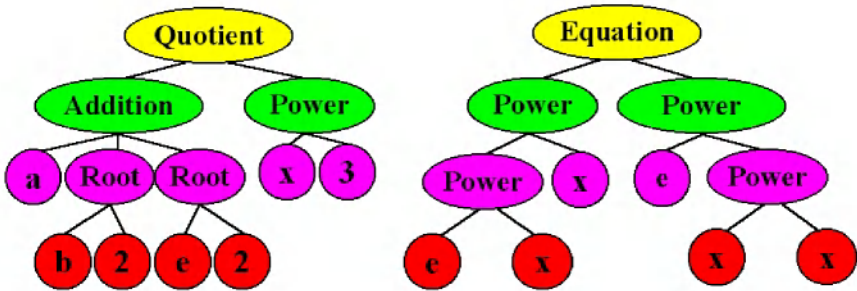


Fig. 1. The examples of the mathematical expression syntactical tree

4 Reading the Mathematical Expression

Reading the technical texts has its specifics, because it carries not only the semantic information, but also the structural information (e.g. the complex mathematical expressions). In this case, the text complexity does not depend only on the length and

content amount, but also on the level of the logical branching (see [5]). The branching of logical parts influences our short-term memory. Therefore, we forget content of already read expression parts and have to return back in spite of understanding it before.

To prevent this, we use some kind of expression overview. Reading visually, we can glance at the whole expression to obtain the main logical structure and then we study individual parts sequentially. In ASTER system the substitution mechanism is used to figure the main expression structure and to separate logical entities (see [8], [9]). We suggest using improved “reading by levels” method described in [2] for the same purpose. Some rules for properly using the method are discussed in section 5.5.

5 The System Overview

The system uses the MathML (see [7]) format to store the mathematical expressions, internally represented in a tree structure. The tree structure is not presented directly to the user; it only serves as a container for the information about the expression.

For studying the complicated mathematical expression, the REMathEx system offers the combination of several types of view. The user is always positioned at one node from the *current layer* (V1) of the syntactic tree (V2). This node is called the *current node* (V3). The subtree beneath the current node contains the subexpression (V4) called the *current part* of the whole expression. The situation is demonstrated in Fig. 2.

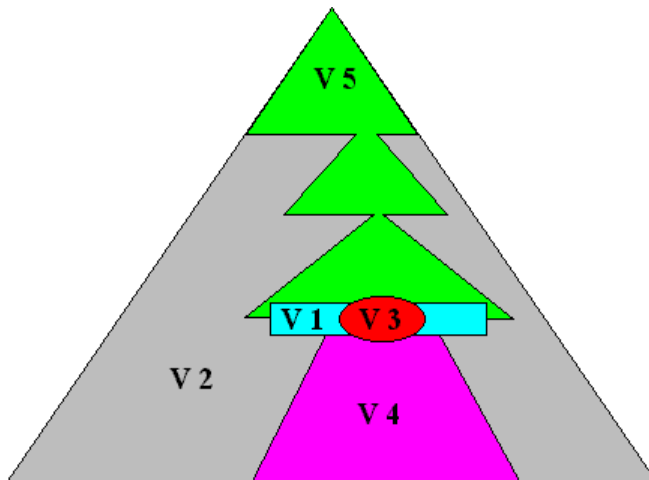


Fig. 2. The types of view available in the system

5.1 Preview of the Expression

When starting to study a new expression, the system tells the *whole expression preview*. This type of preview is derived from the whole expression tree structure and is read using the speech synthesis. The user can select the complexity of the preview by setting the value of tree depth to be processed (in following text we will call it *depth level* or *level*). The nodes below the depth level are not included in the resulting preview and the nodes above the depth level are expanded using the translation table (e.g. the “*fraction*” node is expanded into “*divided by*”, for details see section 5.3 and chapter 7). The nodes at the depth level remain unchanged (collapsed) and serve as a substitute for their subtree structure. The starting expression preview (*level* is 1) of the expression (1) will be “*Fraction*”. The same preview for level set to 2 will be “*Addition | divided by | Power*”.

Every individual part of the preview is virtually connected to a tree node and the user can navigate through these parts, making the visited part the current. In the last example the user can move between the nodes ‘Addition’, ‘divided by’ and ‘Power’. When selecting the ‘Addition’ node, it becomes the current node.

5.2 Display of the Current Expression Part

The *current part* of the expression is constantly displayed on the braille display using the mathematical notation of braille code (e.g. Nemeth Code or its localized versions). It means the braille display shows always the subexpression contained in the subtree of the current node. In case the braille representation of the current part is longer than the width of the braille display, the system divides it into more rows and the user can switch between them. Usually, it is not needed, because the user can descend into the lower layers of expression to study sequentially the shorter parts.

5.3 Preview of the Current Expression Part

In addition to the braille representation of the current expression part, the system provides the user with *current expression part preview*. It is the same as *whole expression preview*, except the current node subtree is processed only. As it shows partially the same as braille display, the current expression part preview serves mainly as a brief view to the expression structure and as the navigational structure for directly accessing the expression subparts instead of scanning the whole braille notation sequence.

The preview for the node ‘Addition’ and level 2 of expression (1) will look like “a plus root plus root” and the user can navigate between the nodes ‘a’, ‘plus’, ‘root’, ‘plus’ and ‘root’. Then, selecting the ‘Root’ node, the preview will look like “square root of b”.

5.4 Preview of the Expression with Regard to the Current Node

The user can request the *whole expression preview with regard to current node* (V5 in Fig. 1). It compounds the supreme layer of the whole expression tree with the current layer (the part the user is currently in). In the upper part of the processed tree only the nodes situated on the path from the tree root to the current node are expanded.

The preview is read using the speech synthesis and the current node is emphasized (e.g. pronounced louder). It provides the user with the brief information about the basic expression structure and about the relative position of the current part.

For the expression (1) with the current node ‘Power’, this type of preview will look like “Addition | divided by | *Power*” and the current part (braille display) will contain only x^3 . The *Power* expression will be emphasized, ‘|’ is a kind of mark that divides the expression parts. The start and the end of the expression part describe the operator extent (e.g. by opening and closing earcons, voice prosody or pauses between parts).

5.5 Using TTS for Reading the Mathematical Expression

Reading the expression vocally (e.g. using TTS) we need the mechanism for separating the logical parts and its levels in the utterance. We use the timing computed from the expression structure (e.g. “*a plus b* <pause> *minus c*” or “<sound start>*a plus b* <sound end> *minus c*”). There is also a possibility to use the beginning and the ending earcons or background sounds that can be faster for a large set of expressions, but it can be unpleasant for some users.

As described above we use some form of subexpression substitution (e.g. “*Fraction*” for “*a divided by b*”) for reading the preview of the expression. The application of substitution mechanism depends on the tree structure of expression and on the depth level the user has chosen.

We define a *weight* for every node type in the tree (for MathML it is defined for every tag type) to be able to count the *weighting function*. Using the weighting function we are able to determine the exact *complexity level of expression subtree* (e.g. recursively counting the sum of weights for all descendants). The complexity level can be used to prevent the substitution application on simple subexpression (e.g. *a*, should not be read like “*a* with subscript”) or for automatically setting the best starting depth level for each expression.

5.6 The System Structure

The REMathEx has been designed as an object oriented system to be easily integrated into the Audis hypertext system (see [1], [2]). The simplified structure of the system is outlined in Fig. 3.

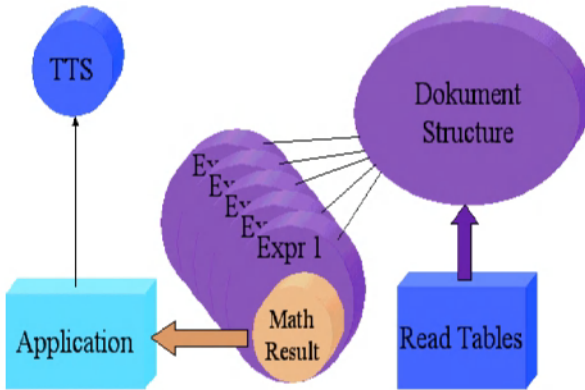


Fig. 3. The simplified structure of the REMathEx system. The arrows show the dataflow when the system generates the preview and the braille form of the mathematical expression

6 Expression Editing and Evaluation Support

The current part of the expression can be substituted by the new expression. The system validates the correctness of the replaced part and then also the correctness of the resulting expression. The whole expression or its parts can be duplicated to create the expression evaluation sequence.

The exact rules for replacing subexpression have to be defined to prevent the insertion of nonequivalent operators (e.g. in integral expression, the lower limit cannot be substituted by a product). Such mistake reveals also during the subexpression validation using the grammar, but the validation is performed only after finishing the subexpression modifications and the user should be informed immediately. A powerful way to help the user with expression editing is to navigate him using the dialogue access (see [4]). This access can prevent the user to enter wrong values. The modified grammar used originally for validating the expression can be used for generating the dialogue (as used in AudiC programming environment – see [10] and [11]). The system provides the user with the list of the entities available in the tree context. The user recursively selects from such structured groups of entities (e.g. container | relation | operator | qualifier | other) and the system navigates the user to fill the whole subexpression tree. The names of grammar entities can be translated to the language of the user so that the dialogue can be as close to the natural language as possible.

7 User Modeling

There are some specifics related to the design of our system that can be solved using the model of the user. First of all, the braille code and the definition of the mathematical braille are completely different in each country. Therefore the system has to be adaptable to the appropriate braille standard. The system is also able to switch between 6 dots braille used especially for mathematics and 8 dots braille used for texts studied using computer.

Usually, there are more possibilities how to read the same mathematical expression vocally. The system has the matrix and predefined values for every operator to know how to synthesize the pronounced expression. The user can modify the values to adapt the system to his needs. The table for operators has the structure outlined in Table 1.

Table 1. The example of the table used for rendering the expression to voice and to Braille

OP	W	List	1 descendant	2 descendants	N descendants
Eq	2	equation	%ERROR	%1 equals %2	%1 equals %2 (and it equals %N)
		0,2356	%ERROR	(%1)0,2356(%2)	(%1)(0,2356,%N)

The weight W defined for each operator OP is used for determining the expression complexity. The ‘List’ column defines the way of reading for the collapsed (not expanded) part of tree. It is usually applied on nodes at the edge of the depth level (see section 5.1). Last three columns designate the way of reading for expanded tree nodes with adequate number of descendants. The numbers represent the braille characters, the 0 character is a space - an empty braille symbol. These fields contain wild-card sequences starting with % character. Each sequence expands according to an expression tree content.

The most important wild-cards follows: %1 and %2 are replaced by its first and second descendant’s content (possibly recursively processed), %N processes all descendants that have not been processed yet, %LAST processes the rightmost descendant, %tag (e.g. %bvar) processes all descendants of type ‘tag’. There are also some minor wild-cards that allow a fine adjustment of the resulting utterance: %ERROR indicates a tree logical structure error (e.g. equation cannot have only one descendant), %DESC returns the number of descendants (e.g. for previewing a table or matrix). Empty field is processed as %N, therefore we can use %EMPTY instead.

The parentheses declare the range for the wild-card sequence (e.g. “text %N” results into “text %1 %2 %...” while “(text %N” results into “text %1 text %2 text ...”).

We have to take into account the dispositions of the user. The redundant spatial information can help to imagine the whole expression to the student that has become blind later and already studied mathematics visually. The born-blind students are usually not able to understand the spatial collocations of the expression parts. Therefore, the system can skip this kind of information to speed up the communication.

For reading the constant symbols and presentational tags we use the translation table similar to the one described above (see Table 1). The translation table defines the

way of reading the symbol by voice and writing the symbol on the braille display (e.g. $> | 0,345$).

For an expression processed by the system there exists the current node (see section 5.1). When reading the preview by voice, the current node can be highlighted for better orientation. The system supports several combinations (and the user can select from them) to emphasize the node: inserting the defined pause, saying the node content using another voice or changing the voice properties (pitch, volume).

8 Conclusions

The implementation of the system's first version is not completely finished yet, but we have tested prototype and the algorithms using the Wizard of Oz method with a group of blind students. The results compared to other methods of reading mathematics by blind showed us the usability of such system, especially related to the speed of study. Blind users can use the REMathEx system to read mathematical expressions through the braille display. However, the system brings the possibilities for better navigation and faster orientation inside the expression. Additionally, the design of the system allows not only to read but also to modify the expression.

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Speaking Technical Documents: Using Prosody to Convey Textual and Mathematical Material

D. Fitzpatrick

School of Computer Applications, Dublin City University, Glasnevin, Dublin 9,
Ireland

dfitzpat@computing.dcu.ie,
<http://www.compapp.dcu.ie/~dfitzpat>

Abstract. Though Braille is the most common means whereby blind people can access information of any kind, it is rapidly being superseded by spoken versions of the same material. Owing to the bulky nature of Braille, the ability to transport a small portable computer, rather than multiple volumes of a book has far greater appeal.

However, to date the monotonous nature of synthetic speech has meant that both highly technical information, and the more visually oriented presentational styles (such as mathematics) have been largely inaccessible to blind people. While the ability to approximate human prosody is apparent in some synthesisers, these features are not utilised by the developers of screen-access software. Consequently, the ability to present anything other than purely textual material is distinctly lacking in this type of software. This lack ensures that blind students and professionals working in the scientific or technical arena are to a great extent prevented from reading large amounts of relevant material.

This paper describes a model of verbalising mathematics using spoken audio. The language of written mathematics can be translated in to an English representation based on the grammatical structures inherent in the language. The model discussed here encapsulates the structure of an equation in the most intuitive form of communication available; natural speech, while the content is enhanced by the use of alterations in the prosody (inflection) of the voice. It concludes with a discussion of some current areas of investigation. These include the application of certain acoustic affects to the speech signal to convey auditorily, those visual cues so readily apparent from the spatially oriented layout of mathematical content.

1 Introduction to Prosody

The prosodic component of speech is that set of features which lasts longer than a single speech sound. The term *prosody* can be traced back to ancient Greek where it was used to “refer to features of speech which were not indicated in orthography, specifically to the tone or melodic accent which characterised full words in ancient Greek” [2]. Prosody is defined as “. . . those auditory components of an utterance which remain, once segmental as well as non-linguistic

as well as paralinguistic vocal effects have been removed” or “sets of mutually defining phonological features which have an essentially variable relationship to the words selected” [2]. Acoustically, *speech* can be decomposed into three primary components; frequency, amplitude and time. “Frequency is the term used to describe the vibration of air molecules caused by a vibrating object, . . . which are set in motion by an egressive flow of air during phonation.” [2] The unit of measure used in the frequency domain is the Hertz (Hz). Speech is not as simple as other acoustic sounds, as it can contain many elements vibrating at different frequencies. The frequency of repetition of the complex pattern is referred to as the *fundamental frequency*, and it is this frequency which is primarily responsible for the perception of pitch.

Amplitude, (measured in decibels) is the acoustic component which gives the perception of loudness. A common definition is “the maximal displacement of a particle from its place of rest” [2]. The duration of a signal is the third component in the acoustic view. This is simply the measurement, along the time-line of the speech signal. If one considers the prosodic component of speech, then it can be reduced to a series of frequencies, a succession of intensity levels and a sequence of durations. It is these components which yield our understanding of pitch modulation, relative loudness and/or the relative duration of syllables, words or phrases.

The use of *stress* is a key prosodic feature of the English language. What is perceived to be stress, is the increased prominence which is often added to a word or syllable. This increased prominence seems to confer a degree of emphasis on the utterance, and is akin to the addition of visual emphasis in the written material. Stress has been given a number of different definitions. Some definitions relate stress to the force with which a speaker utters certain syllables, thereby relating it to a greater articulatory effort. Other definitions equate the addition of stress to the perceptible loudness observed by the listener; “loudness being a perceptual dimension” [2].

A feature of English prosody of extreme importance to TechRead is that of *intonation*. There are several definitions of this phenomenon:

1. the suprasegmental level of pitch, stress and pausing
2. the non-lexical manifestations of melody in speech
3. the gradient contrast due to pitch

From an auditory perspective, intonation is intrinsically related to pitch. It should be remembered however, that a perception of a pitch change does not occur at every alteration in the fundamental frequency. At an acoustic level, intonation can be seen as a succession of fundamental frequency curves in time. Alternatively, on a phonetic level, intonation can be viewed as a succession of perceivable pitch events. At a phonological level, pitch events are grouped together into meaningful categories. In the British tradition, the analysis of intonation related the pitch and stress of an utterance. Only the pitch of the stressed syllable is considered relevant for the characterisation of intonation patterns. An alternative approach to the analysis of intonation is to use a so-called “features” approach. Several prosodic features are used in this model: tone, pitch range,

loudness, rhythmicity and pausing. This leads to a discussion of intonation in its broadest setting.

In the prosodic model used in TechRead, intonational features are used to convey structural and visual aspects of any document. The model is based on the phonetic model developed by Ladd and Monaghan [6,9] and the phonological model outlined in [8]. For further discussion of the role of prosody in conveying information, see [7,2].

2 Speaking Mathematical Expressions

The paradigm on which the spoken mathematical presentation is based, [8] is that of converting a sequence of juxtaposed symbols, delimited by both white space and other visual cues (such as parentheses) into a serially transmitted linguistic approximation. In order to achieve this, a parallel was drawn between the structure found in mathematical expressions and the inherent composition of English sentences.

There is often a nesting, and grouping to be found in English language; whether spoken or written. This can be seen in the sentence, “the goal, which was scored in the last minute, won the match”. The clause “which was scored in the last minute” could be omitted without a loss in intelligibility in the sentence. However, its inclusion endows a more descriptive appearance to the sentence, and conveys more information to the reader (or listener) than would otherwise be the case.

This clausal break-down of a sentence structure is done automatically when the utterance is being spoken by a native-speaker of a language, and coupled with the inflection of the voice (that is, the use of pitch, amplitude and other prosodic features) it can convey a variety of meaning, depending on what timbre the speaker imparts to it. For example, the sentence “the goal which was scored in the last minute,” when said with a falling pitch at the end of the utterance, can convey to the listener that a statement is being made, whereas “the goal which was scored in the last minute?” implies that the speaker is asking a question.

The nesting of clauses within sentence structures, therefore can be seen as a means to impart more descriptive semantics to the information being spoken. The subtle use of pauses and changes in prosody assist the listener in interpreting what the speaker is trying to convey. Coupled with the localised nesting of clauses within sentences, is the combination of unrelated, though logically sequenced sentences to form passages of spoken material. Each sentence forms a unique entity, which contains both verb and noun phrases, thereby enabling its understanding. However, when placed in the context of surrounding material, the semantics of an individual sentence can be altered radically.

If we extend this to the written form of presentation, then the sequence of sentence structures can be brought together into paragraph units, which themselves contain an underlying message, of which each individual sentence forms a part. The nesting, therefore, can be seen as the overall paragraph unit, which contains sentence structures, which contains words, which themselves contain

characters, both alphabetic and punctuational. By inference, therefore, it can be said that the atom of the paragraph is the character, as it is the smallest unit into which the complex structures of English can be reduced.¹

It is not just the characters in and of themselves which facilitate the understanding of the written, or spoken information; rather it is the means in which they are concatenated to form the superstructures defined above. Imagine the set of characters “thankyouforreadingthisdocument”. This is merely the concatenation of character symbols, to form the words of an utterance, which are all syntactically legal, but the lack of delimiters (in this instance white space) can render their meaning ambiguous. The addition of such delimiters turns the above sequence of character symbols into the intelligible sentence “thank you for reading this document”. This is an extremely important fact to be born in mind when an analogy is drawn between the presentation of English, and the transformation of the visually oriented mathematical notation into a linear, transitory speech signal. Just as the visual cues which form an implicit part of the parsing of mathematics, so also does the addition of pausing, and other prosodic features assist greatly in the disambiguation of the syntactically complex mathematical material.

The function of clausal grouping was illustrated above. In a system where not only the horizontal juxtaposition of characters, delimiters and white space is permissible, the sub-grouping of component parts of the whole becomes more important. Unlike the methods used in English, mathematics uses vertical offsets, coupled with the horizontal arrangement of symbols and white space to infer different meanings to material. Consider the two trivial examples; x^{y+z} and $x^y + z$, where exactly the same symbols are used. In the first representation, the three symbols $y + z$ form a superscript to the x , while in the second, only the y is part of the superscript.

The use of such visual cues, as can be perceived from the preceding two examples, is one form of grouping found in printed mathematics. Others involve the use of parentheses, brackets and white space to assist the reader to parse the material and to gain an understanding of the underlying meaning. It is this form of ambiguity which must be removed from the spoken rendering of this syntactically rich data.

3 Conveying Mathematical Grouping

It is beyond the scope of this brief document to outline in detail how the prosodic model caters for each individual construct found in mathematical material. It should be noted, however, that their depiction in isolation is vastly different from, and may be heavily influenced by, adjacent symbols. Accordingly, a strategy was needed to cater for the diverse combinations permissible in mathematical presentation. Unlike previous systems [10,11], TechRead does not employ any non-

¹ Linguists have developed smaller units, such as phonemes into which languages can be decomposed. For the purposes of our discussion, the atom of the sentence is perceived as the character, as it is the smallest unit into which we need descend.

speech audio to convey the material; rather it relies on the vocal representation only to impart the information. Therefore, it proved necessary to examine the grouping of the material, to deduce a method whereby it could be delivered in as unambiguous manner as possible. Another stipulation was that the utterance be maintained at a length which would not impair the listener's ability to apprehend the material. Coupled with this, was the knowledge that the interface to TechRead [3,4] would provide the functionality to enable the user to peruse the material in detail, thus alleviating some of the problems encountered with the flow of information past the passive listener. It should be stated at this juncture that the prosodic model used in TechRead is described here in the context of the DEC-Talk [5,1] Speech Synthesiser. In future versions of the system, it is envisaged that an alternative synthesiser will be used, however DEC-Talk was chosen as it is a commonly-used device.

Previously, it was discussed how the prosodic model used in TechRead is based on an application of those paradigms found in the decomposition of English; namely clauses. If one assumes, that a mathematical expression is a structure in and of itself, and that it can contain an arbitrary degree of nested sub-expressions, then it can be resolved into either a sentence structure which contains various clauses, or a paragraph (i.e., a set of sentences which may themselves be unrelated, but which when logically combined make up a superstructure). This being the case, the need was perceived to examine the \LaTeX mark-up in an attempt to deduce the points at which the delimiters could be interpreted as the equivalents of clause boundaries in English. This proved to be successful, as it emerged that, in order to produce well-formatted equations, it is necessary to mark documents up using unambiguous syntactic representations. Using this as a basis, it could be inferred that, should these delimiters be present in the mark-up, it should prove possible to equate them with clause boundaries in an English verbalisation of the material.

As a consequence of this examination, it emerged that it would be possible to construct three levels of nesting.² Using DEC-Talk, it is extremely difficult to accurately control the length, and placement of pausing. For example, one observable phenomenon is that when the characteristics of the voice are altered by the inclusion of a control sequence in a string of text, an indeterminate pause is introduced into the utterance. Also, above certain speaking rates (240 words per minute, approximately) certain minor pauses are ignored by DEC-Talk, as they would not be perceptible to the listener. Ideally, the pausing would be set at predetermined values, from which the same relative changes made to the other prosodic features of the speech could be applied to the pausing, thus maintaining compatibility between this element and the remainder of the voice contour.

The two methods used in TechRead to imply the grouping of terms into sub-expressions, (and by extension of sub-expressions into the whole formulae) is to insert pausing, and alter the speaking rate at strategic points within the

² This can be extended. However, for the purposes of our investigation, the number of levels of indentation was kept to three, as it was consistent with the paradigm of paragraph, sentence and clause boundaries observable in English.

presentation. This is not an arbitrary process, as the subsequent paragraphs will reveal, but is based on both the mathematical components preceding and following the point at which the pause is needed. For example, the expression $a + b + c$ is a simple, linear concatenation of three quantities, separated by two relational operators, irrespective of whether the material is being read visually or auditorily. However, the expression $\frac{a}{b} + c$ is non-linear in the print medium, but linear in the audio environment.

Accordingly, something must be introduced to indicate to the listener that the fractional component of the expression merely encompasses the first two elements, and that the final one is not contained therein. The method whereby this is achieved, is to speak the expression as follows: “a over b, plus c”. Using this method, it can be clearly seen that the distinction between the fractional component of the expression and the remaining relational operator and quantity is evidenced. If one also adds a slight quickening of the speaking rate of the utterance of the fraction, then the distinction becomes even more apparent to the listener.

The example of the previous paragraph is an extremely simple demonstration of the capabilities of the methods used in the system to produce spoken output from mathematical material. This method works equally well, when complex entities are included in the expressions. As an example of such a more complex example consider the following equation:

$$\sum_{i=1}^{n-1} a^i + \frac{i+1}{i-1} \quad (1)$$

This example is more complex than the preceding expression, as it contains several operators in combination to produce a formula which could prove quite difficult to read. Using unadorned text strings, it would not be discernible where the scope of the various superscripts ended, or which items were contained in the fractional component of the formula. Also, there could be confusion as to whether the summation encompassed the entire scope of the remaining elements or whether it was merely confined to that component which immediately followed it. Using the prosodic enhancements, it is possible to produce an audio rendering which can clearly and intelligibly inform the user of the means whereby this formula can be decomposed.

The first aspect in producing any meaningful output from mathematical material is to determine the degree of nesting in the formula. Once this has been established, the levels, and indeed lengths of pausing required to speak the content can be determined. In the preceding example, the summation encompasses the entire gamut of the remaining material, thereby yielding one level of nesting. The material itself consists of one superscripted element, followed by a fractional component. However, the fractional component itself comprises three complex terms, as the numerator consists of $i + 1$, while the denominator consists of $i - 1$. Accordingly, there are several degrees of nesting observable in this expression. There must be a lengthy pause to indicate that the entire formula is contained within the scope of the summation, followed by various pauses to indicate to the

listener to the scope of the superscripts, and sub-expressions of the fractional element.

The approximate verbal rendering of this equation would be as follows. For simplicity, the symbol “..” has been used to indicate a longer pause, more akin to that found between paragraphs.

“sum from i equals 1 to n minus 1 of.. a to the i plus 1 plus. i plus 1 over, i minus 1.”

The pausing in this example illustrates an approximation of the nesting used in TechRead to indicate the scope of various operators. Combined with increases, and decreases in the speaking rate between the various clause boundaries, it has proved possible to use this mode of presentation to determine the scope of operators in expressions even as complex as this. Moreover, the use of pausing *after* operators is a useful aid in assimilating the fact that the operator is itself followed by a complex term.

In the quoted passage above, the reader can observe the pause after the lexical operator “over”. Once the listener has become familiar with the system, this pausing strategy can be used to anticipate the fact that a complex term is about to be spoken. Conversely, in a simple equation, the pausing would not be placed after the operator but before. This indicates the scope of operators (such as fractions), and also informs the user, without the addition of extra lexical information, that the term they are about to hear is a simple one.

The alterations in the speaking rate have been carefully calibrated to ensure that, even at the deepest level of nesting, the utterance is not delivered too rapidly. With this in mind, a value of 6% has been chosen to assist in informing the listener of the subtleties of the grouping which are so easily observable to the visual reader. The reason that an increase of 10% were not chosen, is that if three or more levels of nesting were encountered in an expression, then the ultimate speaking rate would be too fast, and as a consequence, the listener would be unable to ascertain what was being spoken.

The alterations in the speaking rate, and the pausing which is introduced into the verbal presentation, is always relative to the starting rate from which the alterations are made. This caused many problems when experimenting with various DEC-Talk-specific settings, as this particular synthesiser uses internal rules to calibrate the pausing and pitch contour of the voice. Consequently, there are occasions when the utterance can be stilted in its delivery. This fact does not impair the intelligibility of the utterance: however it proves quite frustrating to any developer who wishes to produce a standardised approach to rate and pausing changes.

4 Conclusion

Though the inclusion of prosodic alterations in the utterance of mathematical equations alleviates the problem of apprehending the material, it is not a solution of itself. Just as the written language of printed mathematics is a form of

presentation, so also is prosodically enhanced synthetic speech. It is *imperative* that an intuitive interface be placed on top of this presentational modality [11,3] to facilitate rapid and easy perusal of the material. We also believe that further enhancements can be made to the actual “spoken language of mathematics”. As was stated previously, the inherently spatial layout of printed mathematics presents readily understandable presentational cues to the visual reader. We propose the development of “spatial speech”; a system which, through the application of various acoustic effects, moves the speech signal to replicate the horizontal and vertical off-sets of the printed presentation.

This discussion has briefly described a model for representing mathematical equations using synthetic speech. It is only to be hoped that the emergence of mark-up schemas such as MathML will lead to an increased accessibility to mathematical material for those who cannot rely on the standard written notation.

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Access by Blind Students and Professionals to Mainstream Math and Science

John A. Gardner

Oregon State University

Corvallis, OR 97331

USA

John.Gardner@orst.edu

Abstract. The Oregon State University Science Access Project has developed computer technologies providing access to math and science information for people with print disabilities. The Accessible Graphing Calculator (AGC) is a Windows application that can display graphs through an audio tone plot. The Tiger Tactile Graphics and Braille Embosser is a true WYSIWYG Windows "printer for the blind" that embosses graphics as variable height gray-scale images and can emboss text as braille. The WinTriangle self-voicing RTF scientific word processor is under development but already used to create information readable by blind people and sighted scientists. The new Scalable Vector Graphics (SVG) web graphics language is ideal for creating extremely accessible graphics of great complexity. These are viewed by blind people with the Accessible SVG Viewer and a tactile copy. The Tiger, WinTriangle, and the ASVG Viewer are becoming user interfaces to HTML/mathML,SVG – a monumental breakthrough to truly equal access.

1 Introduction

People with print disabilities who become competent computer users can have good access to words in most electronic documents and applications. The Oregon State University Science Access Project (SAP)[1]has been devoted to expanding access to include math and scientific formulas, complex tables, charts, diagrams, and other graphical information.

Two SAP developments are already commercially available – the Tiger Tactile Graphics and Braille Embosser[2] and the Accessible Graphing Calculator[2]. Two others, the WinTriangle self-voicing scientific word processor[3] and the Accessible Scalable Vector Graphics Viewer[4,5], are under development but already usable. We describe these products briefly and compare their capabilities with other methods for achieving similar access. Finally we describe the potential of using Tiger and WinTriangle to interface to the mainstream web languages HTML[6] and mathML[7]. The ASVG Viewer is a universal interface to the new SVG[8] web graphics language, so the combination provides access by blind people to essentially all important static web information that has been properly-authored. The Accessible Graphing Calculator and ASVG Viewer are also useful for most people with other print

disabilities, but complete math/science information access by people who have other than visual print disabilities still awaits further technology developments.

2 Tiger Tactile Graphics and Braille Embosser

The Tiger Tactile Graphics and Braille Embosser[2] is a WYSIWYG Windows printer that embosses text and graphics instead of printing in ink. A major enhancement in graphics embossing capability, the ability to emboss variable dot heights, was announced earlier in 2002[2]. Tiger now embosses graphics in gray scale. Dark intense colors emboss as high dots. Light faint colors emboss as low dots. Many graphic illustrations and much graphically-presented information can simply be embossed with no special modifications by sighted transcribers – except for addition of labels that emboss as braille. Adding labels in text boxes takes only a few seconds per label, so "transformation" of graphics can be done very quickly by any competent sighted computer user. At some future time when graphics are presented as properly-created Scalable Vector Graphic (SVG) files, graphical information will be usable by people with print disabilities without any assistance by a sighted person.

The Tiger printer driver can detect ViewPlus® and Duxbury screen fonts and replace them by internally-defined dot patterns before embossing. One can translate text to braille with the bundled ViewPlus® Braille Translator, but standard braille has serious deficiencies for scientific information. We strongly recommend using Tiger screen fonts that emboss as DotsPlus® Braille[9].

DotsPlus® is an extension to braille that that any person who knows braille in a Roman alphabet-based language can learn in a few minutes. Scientific symbols can be embossed if Tiger versions of the Windows symbol screen font and other math/science fonts are used. In effect virtually any literary or scientific character that can be entered into a computer will emboss as a unique DotsPlus® Braille symbol. Apart from letters and numbers, most DotsPlus® symbols are tactile images of the ink symbol - eg plus, equals, slash, brackets... DotsPlus® Braille is winning very high praise from students who have been given the opportunity to use it for math and science[10]. Fig. 1 shows a familiar example – the quadratic equation and its solution in standard visual form created in MS Word with the MathType 5 math editor using a standard environment. Fig. 2 is made by changing MathType to the Tiger environment in that same file and printing on Tiger.

$$ax^2 + bx + c = 0$$
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Fig. 1. The quadratic equation and its solution written in standard visual form



Fig. 2. The quadratic equation and its solution as embossed on the Tiger.

$$ax^2 + bx + c = 0$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Fig. 3. The quadratic equation and its solution as written in WinTriangle linear form. Spaces in equations are optional.

The only other technology useful for creating tactile graphics from computers is "capsule paper"[11]. Capsule paper (called Swell paper or Flexi-paper by some manufacturers) is expensive chemically-coated paper that is heat-treated after an image is printed or copied onto it. Black areas swell and white areas do not, producing a tactile image. With great care one can use greys to produce variable heights, but it is difficult and usually requires several attempts to get it right. The tactile quality of graphics is acceptable, but capsule paper braille is difficult to read. The major advantage of capsule paper is that the initial cost for the heat treatment device is smaller than the cost of a Tiger.

There are a number of braille embossers on the market, but none can print all information directly from standard Windows applications. None have the high (20 dpi) resolution of Tiger, and none can print text in any form except braille. Tiger is not merely a braille embosser or a way to make excellent graphics. It is the Information Equalizer.

3 The Accessible Graphing Calculator (AGC)

AGC[2] is a Windows application that has the usual features of a good scientific graphing calculator. Graphs can be computed and viewed on screen. They may also be displayed as an audio tone plot where high frequencies are large y values and low frequencies are more negative y values. Users can play the entire graph or move point

by point or by portions between maxima and minima. As one moves, one hears the tones, but one can also hear the x and y values spoken by using hot keys. Various enhancements permit very good real-time access. For example an optional white noise component below a certain y value (default is zero) indicates values above/below the transition value.

One can print to any Windows printer, including Tiger and printers for capsule paper to obtain tactile images. However, experienced users seldom need to make tactile copy, because information is usually quite accessible audibly.

There are other ways to create tactile graphs, including swell paper with any graph-creation program. One can also buy special graph creation programs for some braille embossers operating in "graphics" mode – so they cannot print any labels on axes or anywhere else. There are no other graphing calculators that give "real-time" access to graphs usable by blind students in classrooms or blind professionals on the job.

4 The WinTriangle Scientific Word Processor

WinTriangle[3] is a Windows version of the DOS Triangle[12] editor that permitted blind users to access a number of special markup and math/science symbols. WinTriangle uses the RTF file format, so files may be read and written in any graphics word processor. Standard word processors do not give easy access to special symbols, and screen readers do not read these symbols well if at all. WinTriangle permits one to insert characters from several standard Windows fonts used by scientists as well as the special Triangle.ttf font created by the SAP. It voices these special characters as well as indicating bold, italic, superscripts, subscripts, etc. The Triangle.ttf screen font has markup characters permitting one to write any scientific or math expression in a linear form. Scientific syntax is modeled on the popular LaTeX layout language, so essentially any scientific expression can be composed in "Triangle notation". Fig. 3 shows the quadratic equation and its solution in WinTriangle notation.

WinTriangle is available now in a beta form and is accessed with speech only in "novice mode" where each character is spoken. Refinements are planned that will include more compact voicing options and braille access.

Braille readers have other options for reading and writing math and scientific expressions – the best being use of some modern notetakers to create scientific information in math braille or computer braille. Information in this form can only be prepared by braille experts and can only be read by braille experts. Communication with teachers, parents, or peers who are not braille experts requires an intermediary.

Whether or not they read braille adequately, a blind person can do math by laboriously writing out expressions in words. Even if one uses abbreviations and compact conventions for markup indicators, "plain text" notation is extremely tedious at best. WinTriangle notation is much more compact and much faster to read and write. WinTriangle has the great advantage that any sighted scientist needs only a small sheet of symbol definitions to read WinTriangle notation in any word processor. Faculty members in several US universities accept written work in this form and some even write it for their blind students[10].

5 Accessible Scalable Vector Graphics (ASVG) Viewer

SVG is a new powerful compact web language permitting outstanding graphics quality. ASVG is SVG in which the objects in the SVG file are sensibly defined and have their label properties filled out to identify them. Description properties may also be used to provide an arbitrarily long description of the object(s).

SVG files can be created with most graphics authoring tools, but the SVG file is not automatically accessible. For example, object structure may consist of lines and shapes having no individual meaning, and object labels are usually empty. However some graphics authoring programs, if carefully used, can produce excellently accessible ASVG object structure. However these objects still need to be labeled. We have created an editing program that can re-arrange objects and permit their label and description properties to be filled in. After this object editing, the SVG file is visually identical, but it is now accessible.

A sighted user of the ASVG Viewer can select an option that permits one to click open dialog boxes with labels and descriptions of objects. Blind users can do the same thing by making a tactile copy, with swell paper or Tiger, and placing it on a digitizing pad that acts as a mouse. The user feels an object, activates the mouse click, and hears (or reads with on-line braille) the label and/or description. Viewers may also choose an option that speaks an object label whenever the mouse moves from one object to another.

The ASVG viewer and editor should become available in beta form later in 2002. To our knowledge there is no other method for making general mainstream graphics that can be automatically accessible to blind readers.

6 Non-visual Access to Mainstream Markup Languages

Tiger and WinTriangle are developed to be useful as stand-alone products, but both can also be web interfaces. With proper style files, Tiger can print web documents for blind people as easily as a standard ink printer can print for sighted people. WinTriangle's display can be used for viewing HTML/mathML using a "converter" application currently under development. We hope eventually to create a HTML/mathML compiler so that blind authors can use WinTriangle as a scientific authoring tool for mainstream web documents. The combination of text/math access with Tiger or WinTriangle and the graphics access by use of the ASVG viewer and Tiger embosser give truly equal information access to blind people.

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L^AT_EX at the University of Applied Sciences Giessen-Friedberg – Experiences at the Institute for Visually Impaired Students

Erdmthe Meyer zu Bexten and Martin Jung

University of Applied Sciences Giessen-Friedberg, Department of Mathematics,
Computer Science and Natural Sciences, Wiesenstr: 14; D-35390 Giessen; Germany
erdmthe.meyer-zu-bexten@mi.fh-giessen.de
<http://www.fh-giessen.de/bliz>

Abstract. This paper deals with our approach to use L^AT_EX as a mathematical notation for our visually impaired students of computer science at our university. The way we use L^AT_EX, how it is taught to the students, possibilities and limitations will be discussed.

1 Introduction

The University of Applied Sciences Giessen-Friedberg was founded 30 years ago with a main emphasize on technical disciplines. In 1998 Prof. Dr. rer. nat. Erdmthe Meyer zu Bexten established the center for visually impaired students. Among our 30 visually impaired students there are about 20 students of computer science. Visually impaired persons studying nature sciences are confronted with a lot of Mathematics. In fact it is one of the greatest obstacles they have to overcome during their studies. A major part of the problem is the handling of mathematical expressions for tests or in homework and the communication with sighted persons. Visually impaired persons use Braille print, i. e. raised dots embossed by a special printer or typewriter, for writings. However, conversion of mathematical terms into Braille and handling this terms is not easy.

2 L^AT_EX as a Mathematical Notation for the Visually Impaired

Until now there is no standardized mathematical notation for Braille users [1], so we decided to use L^AT_EX [2]. While there are some other mathematical notations common in Germany, L^AT_EX is the only one to be used by sighted persons, too. Originally developed as a typesetting system by D. E. Knuth thirty years ago, it also makes for a convenient tool to be used as a mathematical notation for visually impaired persons. Training materials for several topics in L^AT_EX are available through the internet. Using L^AT_EX as a mathematical notation for visually impaired persons is not a new trick. Other approaches like Raman's AsTeR or the HrT_EX [3] developed in Linz, Austria, also employ T_EX or L^AT_EX for the same purpose.

3 Teaching and Using L^AT_EX

In cooperation with the German Institute for the Blind, Marburg (Deutsche Blindenstudienanstalt e. V.) we created a modular training concept starting with simple tasks, preceding to more complex functions and enabling users to help themselves. The objectives of our lessons include the installation of the L^AT_EX system, the documentation and customization, structure of documents and choice of L^AT_EX commands. Students of computer science have three semesters mathematical lectures with written tests and homework. Some of the professors and lecturers at our university are familiar with L^AT_EX. If the lecturer has his own script in L^AT_EX, it will be made available for our students. Some lecturers have no script or use inaccessible formats. In this case we supply a kind of a standard script in L^AT_EX. Students take notes during lectures in a mixture of ASCII and L^AT_EX and complete it at home during revision. If lecturers offer tests in L^AT_EX, the visually impaired student reads the tests, works on it and codes the results in L^AT_EX. After compilation and printing the printout is given back to the lecturer. Same is with homework. Lecturers not familiar with L^AT_EX benefit from our translation services. Known problems: L^AT_EX takes some time to learn and some practice to be a useful tool. Hand written corrections on the returned tests are not accessible for the visually handicapped user and sighted assistance is needed.

4 Conclusion

L^AT_EX is currently the right tool for our purposes, since there is still a considerable amount of L^AT_EX users without vision impairments and no better solution for visually impaired persons as a mathematical notation.

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Experience with Access to Mathematics for Blind Students in Slovakia

Martina Kobolkova and Peter Lecky

Comenius University, Support Centre for Visually Impaired Students¹
kobolkova@fmph.uniba.sk, lecky@cezap.i.i.fmph.uniba.sk

1 Introduction

After entering the school, children have to learn how to receive, manipulate with and transfer information in a certain way. Here we can see a beginning of unified symbolic language at school, which is developed systematically on the way to university.

2 Mathematics for Blind Students

Overview 1: Learning aids used by children at special elementary school for the blind.

- rules for writing Slovak code of Braille alphabet (last version from July 1996)
- audio books and Braille books with tactile pictures (prepared in National Library²)
- mechanical Braille type-writers for calculations (e.g. Tatrapoint³)
- rubber sheet with films of plastic and set of drawing instruments, 3D & 2D models
- talking calculators, electronic note-takers for blind people (e.g. Aria⁴) are used only as calculators or simple text note-takers

While blind young people had only opportunity to prepare for their university study at a *secondary grammar school with special class for the blind* (teachers without qualification in teaching children with SEN), they didn't meet so many obstacles in everyday school-time. A teacher in special class tried to adapt curriculum and working methods to students' needs. In more complicated situations, they considerably reduced their requirements and contents of curriculum. This fact caused that students were not prepared for university study of subjects, relative to mathematics.

A teacher in *mainstream education (at regular school)* is in a quite different situation. He/she has own system of work during lessons - explaining new topics, examination, etc. Teacher is confronted with new demands in his/her work. A blind student faces new challenges likewise - he/she wants to do everything like his/her peers do. When we look at the class with integrated blind child as one unit and perceive diversity of it's individuals as normal, we will find rich resource for all children. As an example, this new situation could stimulate teacher's decision to shift from hand

¹ Support Centre for Visually Impaired Students - <http://cezap-www.fmph.uniba.sk/>

² The Slovak Library of Matej Hrebenda for VI in Levoca - <http://www.skn.sk/anglicky.htm>

³ won National Prize for Design in 1999 - http://www.sdc.sk/english/zlta/ncd_1999_e.htm

⁴ Aria Braille Palmtop Computer - <http://www.robotron.net.au/aria.htm>

written or printed texts to structured electronic documents (e.g. HTML), from calculators to CAL Systems - Computer Algebra Systems (e.g. MuPAD for Linux⁵), etc.

Overview 2: Teaching and learning aids used by blind students in mainstream education - at secondary grammar school (changes comparing to primary school).

a) lack of books and study material:

- audio books – difficult and slow navigation (National Library, Support Centre)
- Braille books (no official service available, few pieces printed in Support Centre)

b) following aids are new or used in different way:

- mechanical Braille type-writers (noisy, but useful 2D space, complex calculations)
- (portable) computer with Braille line for mathematics (expensive and rare solution)
- first steps from Braille notation of mathematical symbols to ASCII representation (mostly own systems, similar to programming languages or CAL Systems)
- tactile pictures (mostly quick sketches on films of plastic or paper)
- students are preparing own materials with support of family and friends (OCR - Optical Character Recognition, recording on audio tapes or to digital audio files)

Our experience with *mathematics for the blind at university* overcame two years history. We were confronted with fact, that first blind student in Slovakia would like to study Computer Science at Faculty of Mathematics, Physics and Informatics. It started as a project "Informatics for the Blind" - 3 years bachelor study.

There were some technical issues to be solved in a short time, primarily preparing of study literature. Fundamental decision was to choose, if we will: 1. *complement existing system of Braille notation of mathematical symbols*, 2. *select one of existing ASCII representations*. With respect to completeness, language independence, common features with program code and requirements for adaptation of those system, we decided to use AMS - ASCII mathematical script, developed by the SZS at Universität Karlsruhe⁶. Besides we tested system HrTeX, developed by i3s3 at Johannes Kepler Universität Linz⁷.

Overview 3: Teaching and learning aids used by blind students at university:

- (portable) computer with Braille line for mathematics
- ASCII representation of mathematical notation (AMS)
- tactile pictures (printed on microcapsule paper, simple dotted schemes printed on Braille printer, quick sketches on films of plastic or paper)
- CAL Systems for calculations (MuPAD for Linux is accessible for blind users)

3 Conclusion

If we already had developed the full system of Braille mathematical notation, we could be satisfied for a while. Whereas we doesn't have it, we are forced to look for further ways of accessing mathematics for blind students. We should try to turn these conditions to good account and monitor new trends and projects in this area.

⁵ MuPAD, Computer Algebra System – <http://www.sciface.com/newspro.shtml>

⁶ SZS, Study Centre for VI Students – <http://szswww.szs.uni-karlsruhe.de/en/index.html>

⁷ i3s3, Johannes Kepler Universität Linz – <http://www.integriert-studieren.jku.at/index.html>

Infty Alpha Test Site

Kanahori Toshihiro¹ and Suzuki Masakazu²

¹ Tsukuba College of Technology, 4-12 Kasuga, Tsukuba-si, Ibaraki 305-0821, Japan
kanahori@k.tsukuba-tech.ac.jp

² Faculty of Mathematics, Kyushu University 36, Fukuoka, 812-8581 Japan
suzuki@math.kyushu-u.ac.jp

Abstract. This paper introduces a new experimental system on the web. This system provides some functions of our document reader system of scientific documents including mathematical formulae, named Infty [1], via the Internet. The system recognizes page images of clearly printed mathematical documents uploaded by a user, and outputs the recognition results in \LaTeX and HTML. The user can download them from the site. The system will be able to output them in Unified Braille Code and AMS (ASCII Mathematik Schrift) in the near future.

The recent development of the OCR technology made possible its practical use in various applications. However, there is no commercial OCR software which can recognize mathematical formulae today. This limitation of the applicability of OCR reduces largely the effectiveness of its use in scientific fields. To solve this problem, we developed a document reader system of scientific documents including mathematical formulae, named Infty, and reported it at the ICCHP 2000 [1]. The Infty system recognizes scanned page images of scientific documents including mathematical expressions. It is developed in view of its application, for example, to the retro-digitization of mathematical journals, as well as to the automatic transcription of scientific documents into Braille codes. After the ICCHP 2000, the Infty system has been improved [2].

In this paper, we shall introduce our new experimental system on our site, named Alpha Tester Page, providing some functions of the Infty system via the Internet. In the site, after the user registration, users can upload scanned binary page image files (TIFF Grade-3, black and white), and get the recognition results by the Infty system in the form of HTML file or \LaTeX source file. It assumes that the uploaded images are scanned carefully, in either 400 DPI or 600 DPI, and original source page is clearly printed. (300 DPI images are not recommended but can be recognized.) The recognition results in the form of HTML file can be browse by a HTML browser on Microsoft Windows installing our original fonts for special mathematical symbols which are released on the site (see Fig. 1).

We are implementing a function to output recognition results in Unified Braille Code and AMS (ASCII Mathematik Schrift defined in Karlsruhe University). By the function, visually handicapped people who can use the Internet will be able to read scientific documents transcribed into Braille codes easily by themselves.

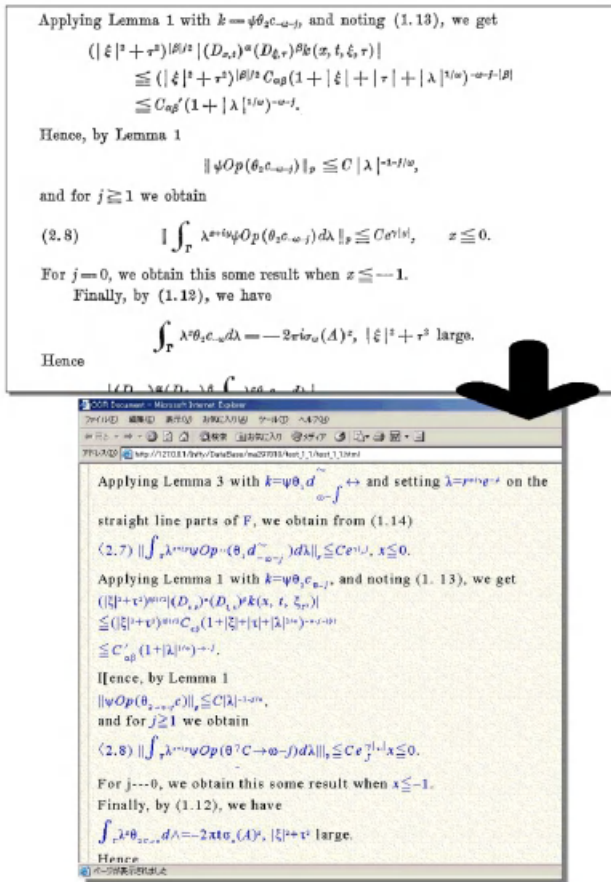


Fig. 1. Example for the transcription of page images into the HTML

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Designing an AutoMouse to Promote Computer Accessibility for People with Severe Physical Impairments

Ming Chung Chen¹, Tien Yu Li², Chi Nung Chu³, Ling Fu Meng⁴,
Chien-Huey Sophie Chang², Arr Mien Chou², Tony Yang², Chih Chen Hui²,
Ai Chiao Ku², and Yun Lung Lin²

¹ Department of Special Education, National Chiayi University, 300, Shiuefu Rd.,
Chiayi, 600 Taiwan, R. O. C.

ming@chen.twmail.cc

² Department of Information and Computer Education, National Taiwan Normal University,
162, Sec. 1, Heping East Rd., 106 Taipei, R. O. C.

³ Department of Information Management, Chung Kuo Institute of Technology, 56, Sec. 3,
Shinglung Rd., 116 Taipei, R. O. C.

⁴ Department of Occupational Therapist, Chung Gung University, 259, Weng Hwa 1st Rd.,
Kwei Shan, 333 Tao Yuan, Taiwan, R. O. C.

Abstract. Accessing computers is a difficult task for people with severe physical disabilities, even though they are equipped with an alternate mouse. The purpose of this study was to design an AutoMouse for the clients with severely physical impairments including those who are with amyotrophic lateral sclerosis (ALS), cervical spinal cord injury (SCI), and muscular dystrophy (MD). Through the use of AutoMouse, a click free operation environment was provided to the users. The results indicated that the client, when using the AutoMouse, had easier access to computers.

1 Introduction

Computer accessibility has been a focus of governments and researchers in the recent years. Through the researchers' efforts, there are various alternative input devices available in the market. Unfortunately, some people with severe physical impairments still experience difficulties in clicking the target icon when they used an alternate mouse such as trackballs, joysticks, and electronic point devices.

To solve the problems mentioned above, The Program for Improving the Working Interfaces and Increasing the Work Competencies of People with Severe Physical Disabilities was established. The purpose of this study was to design a software that could simulate the functions of the mouse click and to exam its effectiveness.

2 Features of the AutoMouse

2.1 The Principles of the Design

Researchers adopted three principles to develop a small but useful mouse-click simulated software program.

Windows-Compatible. The mouse-click simulation software should be windows-compatible since windows operation system is popular in Taiwan. And it should be compatible to Microsoft Office and IE programs. Besides, the simulation software would not need to be installed in advance.

Chinese Interface. The interface of the software should be in Chinese, and the Chinese description of each icon will be displayed when a mouse is moved onto it.

Click Free. The operation should be click free once the software is executed because the target users of this software are people with severe physical impairments who may have very limited stamina to do the clicking. Users should be able to move the cursor on the targeted icon without clicking, and the software should select it automatically.

2.2 The Functions of AutoMouse

Based on the principles mentioned above, the researchers on our team developed an auto-click software named AutoMouse, created with the Delphi Language. Once the program has been executed, a graphic interface window will show on the desktop (see Fig. 1). As presented in Fig. 1, the AutoMouse includes three parts. The first one is mouse-click simulation, the second one is options setting, and the third one is program exiting. The function of every icon would be activated if the mouse cursor moved and stayed on it for a moment. The first two functions were described below.

Mouse-Click Simulation. Four types of mouse-click simulation were developed: left-side double click, left-side click & lock, right-side click, and right-side click & lock. The program will click automatically when the timing bar fills up.

Options Setting. Users could reset the sensitivity of a mouse movement and the wait time for click. When a dialog box pops up on the desktop, the icon for options setting is activated. For those who could not keep the mouse cursor stable in a smaller area, they could reduce the sensitivity of mouse movement and thus allow the mouse cursor to move in a larger area. Still, the AutoMouse will detect the cursor on static situation and will wait for click. For those who could move the cursor quickly, they could adjust the wait time for click in order to prevent the AutoMouse from purposelessly clicking.

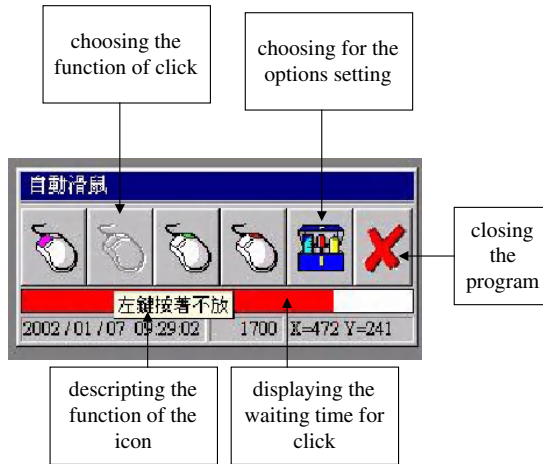


Fig. 1. The graphic interface of the AutoMouse. This shows the functions of the different parts of the AutoMouse

3 Results

Three clients in our project used the AutoMouse combined with other adaptive input devices. The results of their application are described as follows.

Client A is a retired computer engineer with amyotrophic lateral sclerosis (ALS) who stays at home currently. He does not have enough motor and muscle strength to keyboard or click when using mouse. Our service team provided him with a trackball and with the AutoMouse software. With this adaptation, the client is able to operate the computer without difficulty and communicate with friends by E-mail.

Client B is a freshman with muscular dystrophy (MD) who had trouble accessing a computer even though he had already used a small trackball and a switch. Our team provided an infrared mouse with the AutoMouse for him to do the clicking. Then, the client is able to log onto Internet and work on his assignments using these two adapted devices.

Client C, who is with cervical spinal cord injury (SCI), lives in a residential facility for people with disabilities. She could use a trackball with a switch with her right hand only. She couldn't do clicking or dragging simultaneously. After our team equipped her with the AutoMouse, she is able to operate the computer effectively and easily, and she begins to learn drawing with a software as a part of her rehabilitation plan.

Besides to the positive feedback mentioned above, the clients complained that the program clicked automatically when they just stayed the cursor on an icon for a moment. The researchers decide to add an icon that could enable/disable the function of automatic click that can be controlled by the user when this version is updated.

Evaluation of Long Descriptions of Statistical Graphics for Blind and Low Vision Web Users

H.K. Ault¹, J.W. Deloge², R.W. Lapp³, M.J. Morgan³, and J.R. Barnett⁴

¹Mechanical Engineering Department, Worcester Polytechnic Institute, 100 Institute Road, Worcester, Massachusetts USA 01609-2280
hkault@wpi.edu <http://www.me.wpi.edu/Ault/>
<http://www.wpi.edu/~atrc>

²Department of Electrical and Computer Engineering, Worcester Polytechnic Institute, 100 Institute Road, Worcester, Massachusetts USA 01609-2280

³Computer Science Department, Worcester Polytechnic Institute, 100 Institute Road, Worcester, Massachusetts USA 01609-2280

⁴Department of Fire Protection Engineering, Worcester Polytechnic Institute, 100 Institute Road, Worcester, Massachusetts USA 01609-2280
jrbarnett@wpi.edu <http://www.wpi.edu/~jrbarnett>

Abstract. The objective of this research was to maximize not only accessibility but also user comprehension of web pages, particularly those containing tabular and graphical information. Based on literature and interviews with blind and low vision students and their teachers, the research team developed guidelines for web developers to describe charts and graphs commonly used in statistical applications. A usability study was then performed to evaluate the effectiveness of these new guidelines. Accessibility and comprehension for both blind and low vision users were increased when web pages were developed following the new guidelines.

1 Introduction

People in the modern world depend on computer-based technologies in order to function in their everyday lives. All sectors of society use the Internet, including low income, youth and elderly, ethnic groups and persons with disabilities. The Internet provides a variety of services including e-commerce, education, information retrieval, communication and entertainment. A 1998 user survey indicated that 3.5% of Internet users have a visual impairment [1]. Blind and low vision users have been able to access the Internet since the introduction of screen readers, but with strictly text-only web pages. Newer web elements such as images, tables, graphs and multimedia have placed limitations on accessibility for the blind and low vision users in recent years. These barriers inhibit blind and low vision persons from using online resources such as e-commerce and web-based education. The goals of this research were to develop methods to describe graphs and tables to blind and low vision users and to perform a usability study to measure the success of these methods.

2 Background

The World Wide Web Consortium (W3C) was formed in 1994 to promote interoperability and encourage an open forum for discussion of issues related to use and development of the Internet. It is composed of over 400 member organizations. The W3C serves as the primary Internet standards organization. One of W3C's major long-term goals is to promote universal access by promoting technologies that take into account differences in culture, education, ability, material resources, and physical limitations of all users. Due to lack of awareness about accessibility issues, many web sites have technological barriers that prevent persons with disabilities from accessing all or parts of the site. Graphics are particularly problematic for users that rely on screen readers. The W3C's Web Accessibility Initiative (WAI) provides products and guidelines to enable companies and organizations to design and evaluate their own web sites for accessibility [2].

2.1 Describing Graphical Elements

According to Blenkhorn and Evans [3], graphical information can be classified as one of five types: real world images, maps, schematic diagrams, charts, and graphical user interfaces. When making graphics accessible, two important aspects must be taken into account: the physical representation, *what the graphic looks like* and the implied meaning, *what the graphic means*. For blind or low vision users, written descriptions are currently the most common means available through screen readers. Graphs or charts may be used to display the information contained in tables. Graphs help to make sense of lists of numbers displayed in tables and are a more effective way of visually explaining what the information means.

Complexity is a characteristic inherent within many graphs and tables used in the field of statistics. Descriptions that provide a comprehensible understanding of the material are of particular importance when addressing the issue of accessibility. Graphics can be used to display large amounts of data in a very compact and concise manner. The viewer has access to not only individual data points, but also gains a more holistic view of the information. For large amounts of statistical data, graphical representations enable the viewer to identify trends and make comparisons more easily [4].

There are several techniques that can be used to allow blind and low vision users of a web site to access and understand the information given in graphs. Rothberg and Wlodkowski [5] recommend that the web content developers provide either a complete description in text for static graphs or an audio equivalent to graphs. Sound-representations of graphs are an excellent way to allow blind or low vision users a means to visualize the shape of a curve [6]. Hard copy output in the form of raised images has also been used to create tactile representations of graphics [7]. Haptic or force-feedback devices allow the user to trace shapes that appear on screen [8]. All of these methods, however, require expensive hardware and/or specialized software which are not currently available to most users.

2.2 Current Web-Based Approaches

The current approach taken by web developers is to supply a text-based description of the graphic in one or more of three forms: alt-text, captions or long descriptions. The key to conveying the meaning of difficult concepts is by using elaborate verbal descriptions, explanations, and instructions [9]. However, just because an image has alternate text does not mean the intended meaning will be conveyed. CAST recommends a balance between brevity and complete information [10].

Alt-text Method. The common way to deal with a graphic image is through the *alt-text* coding method, which provides a brief text output to the screen reader when graphics are encountered. Instead of a user hearing or reading the filename of the image, they will be given a short description or title of the graphic. This makes all graphics easier to understand because the *alt-text* descriptions provide meaningful identifiers of the graphics rather than the source paths to the image files.

Captions. Captions are also meaningful identifiers of graphics when properly used. The methods concerning text must be taken into account when creating captions for graphics as well as some extra guidelines that specifically apply to the use of captioning in accessibility design.

Long Descriptions. A *long description* is embedded on the web page in the form of a longdesc tag within the HTML element [11]. WGBH, a public television station in Boston, Massachusetts USA, instituted the practice of placing a capital "D" text link next to graphics to provide a link to a long description [12]. The W3C accessibility guidelines require web content developers to provide *long descriptions* of complicated graphs and tables, but do not provide enough guidance to create meaningful descriptions. Many sources make recommendations regarding the design of accessible web sites, however most refer to the W3C guidelines and provide only general methods regarding text labels for graphical elements; a few show simple examples. None of the sources reviewed provided general methods or strategies for writing verbal descriptions of specific types of graphical elements [11,13].

2.3 Sponsor Background

The Australian Bureau of Statistics, National Education Services Unit (ABS, NESU) has an extensive web-based education system online. Government regulations require the ABS to make its content accessible to users with disabilities. The ABS Australia Now curriculums are a set of lesson plans that meet national and state curriculum guidelines. The plans are designed to have students complete activities that require research into published ABS statistical reports throughout the ABS site. The majority of the ABS curriculums are designed for use by lower and upper secondary schools. One primary purpose of Australia Now lesson plans is to give students real data to apply to problems [14].

3 Methodology

The study included four phases. The first phase involved developing a set of guidelines to describe the types of graphs typically used to display statistical data. The second phase was the creation of a set of web pages using the new guidelines in conjunction with the current ABS web content guidelines and lesson plans developed by ABS. For the third stage, usability testing of this content was conducted with blind and low vision users. The fourth phase was to instruct web content developers at the sponsor's site to use the new guidelines and to provide documentation for future work. The focus of this paper is on the results of the usability study. The entire project is described in [15].

3.1 Graph Descriptions

Methods for describing various graphical elements were developed based on information gained from a literature review [3,16,17,21] and interviews with blind adults and secondary students, and educators of visually impaired students. Little has been published in this area, however work has been started by the Center for Advanced Educational Services at MIT [18] and WGBH [12]. The goals of these programs are to provide guidelines for math and science applications, aimed at making this form of content more accessible to individuals with vision and hearing disabilities. These guidelines will provide information on writing descriptions to make graphs and tables accessible, which the W3C guidelines do not specifically cover.

Just because a web page is accessible, it is not guaranteed to provide meaningful information. The ABS web site contains many graphs and large tables of data. This information must be correctly described textually in order for blind and low vision users to comprehend the information contained in the graph or table. In order to do this a short handbook was created that details how to best describe line graphs, pie charts, bar graphs, scatter plots, geographical maps, and tables. By describing a graph or table correctly a student will understand not only what the graph or table contains, but also be able to make his or her own conclusions of what the data actually mean. General guidelines and a sample line graph description are provided below; additional information on graph descriptions can be found in [14, 19]. Images must always have an *alt-text* description as well, which should say enough about the image for the user to decide whether or not he or she wants to read the long description.

Guidelines for Line Graphs. State that it is a line graph. Describe axes, horizontal then vertical, with labels and units. Include the range of numbers for each axis. To describe the line, state the starting point, then direction and pitch to next point (e.g. rises slightly, declines moderately), then state the coordinates and repeat until the end of the line is reached. If the line is curved, state so in the description. For example, "curves slightly upward" or "curves moderately downward".

If there are no points on the line, estimate points that are near major tick-marks, and describe trends in between. For multiple lines on one set of axes, describe each line individually, but if the lines cross at any points, state so in the description.

Example description of Figure 1. The horizontal axis represents the temperature in degrees Celsius; from left to right, the axis ranges from 0° Celsius to 40° Celsius. The vertical axis represents the cumulative percentage, and from bottom to top, ranges from 0 to 100 percent. The data points are as follows: Line begins at 0% at 5°, then rises slightly to 4% at 10°, then rises slightly to 12% at 15°, then rises moderately to 28% at 20°, then rises moderately to 48% at 25°, then rises sharply to 80% at 30°, then rises moderately to 96% at 35°, then rises slightly to end at 100% at 40°.

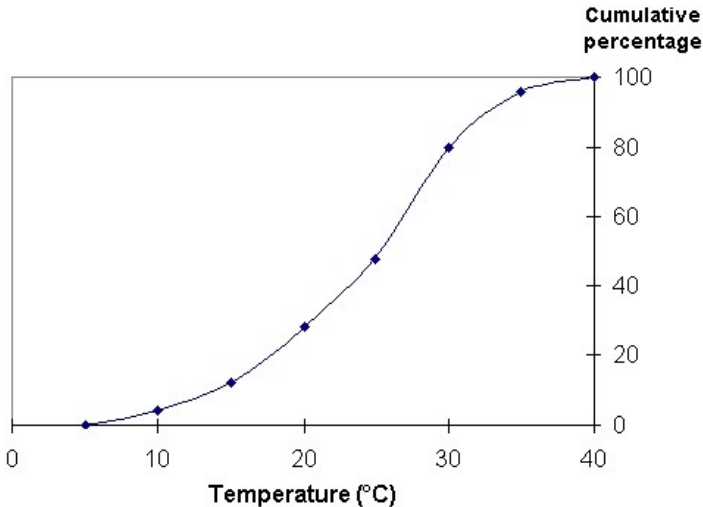


Fig. 1. Sample of line graph with long description

3.2 Sample Web Page Content Development

Three sets of sample web pages were created. The first set consisted of original web pages from the ABS site using no accessibility features. The second set included alt-text descriptions as recommended by the W3C single A guidelines [20]. The third set added W3C double A compliant guidelines with long descriptions based on the newly developed methods. The test web pages were based on “Statistics: A Powerful Edge (SPE)” content. The SPE web pages and lesson plans are used to teach statistics and contain combinations of graphs, tables, and written text. The established lesson plans allowed the research team to test whether the educational value of a web page increased with use of accessibility guidelines and different graph descriptions.

The objective of the test was to compare accessibility of sample web pages not only for navigability, but more importantly to determine whether the blind and low vision users could extract useful information and perform content-related tasks based on information extracted from the long descriptions of the graphical web elements. In some cases the information required by the user could be obtained from more than

one source on the web page (table or graph), and the study also examined the source used by the students to answer content-related questions.

Five questions were used to test whether the subject grasped the concepts presented on the web page and could formulate answers to questions based on the lesson plans and statistical data presented. The questions dealt with interpreting the data as a whole and making decisions on their meaning. The web page contains a title bar at the top, then a section of text with two images, a stem and leaf table, line graph, bar graph, pie chart, then a navigation bar at the bottom. In order to test the different levels of accessibility and comprehension the research team used distinct versions of the content developed using each set of guidelines, yet still keep the same basic format. The web pages had the same layout for each set of content, but different data values and a slightly different statistical concept each time. The original page was chosen because it uses a wide variety of graphs, tables, and images that are all interrelated.

3.3 Usability Study

A usability study was performed to compare existing inaccessible web pages to accessible web pages created with the new guidelines. Thirteen secondary students with prior Internet experience tested the web pages. Seven partially sighted students, aged 12-15, grades 7-9, used high contrast and screen magnification strategies. The remaining six subjects were totally blind, aged 17-21, grades 10-14, used a screen reader to access the web pages. Content sets 1 and 2 were tested on the same day (morning and afternoon sessions) at school; content set 3 was tested approximately two weeks later in the students' homes.

Actual web pages from the sponsoring agency were selected for the test content as described above. The activities were administered by a member of the research team acting as a mediator, and consisted of five multiple-choice questions. The students were given four possible answers to choose from. If a student could not answer a question because the information was inaccessible they were given the option of a fifth answer, Unable to Determine (UTD). The first question asked for information that could be most easily obtained from the table. The next three questions prompted for information that could be found with the least difficulty by using information from the line graph, the bar graph, and the pie chart, respectively. In order to find the requested information, a student had to review the graph or its textual description, understand its meaning, then answer the question. The final question required either a calculation or a prediction based on the information.

Accessibility was determined by the number of activities a student could not complete due to inaccessible elements on the web page, be it a graph or image without a description, a poorly formatted table, or anything else that prompted the UTD response. The questions were designed to determine not only whether the sample content was accessible, but also if the intended meaning was conveyed clearly and understood. The questions focused on themes and concepts that were manifest in the included lesson plan. If the sample content was accessible *and* aptly described, then these questions were answered correctly.

4 Results

The results indicate that the modified web pages provided improved accessibility as well as understanding of the content. Figure 2 shows the comprehension results for low vision and blind users. Low vision students were not able to answer 9% of the questions based on the original pages, but answered all questions on the revised pages. The percent of activities completed correctly by low vision participants actually decreased throughout the three sets of content. For low vision users, there was very little difference between the accessibility content of 1 and 2. The majority of accessibility elements were added to content set 3. The fact that none of the questions in set 3 were inaccessible demonstrates that the accessibility additions were useful.

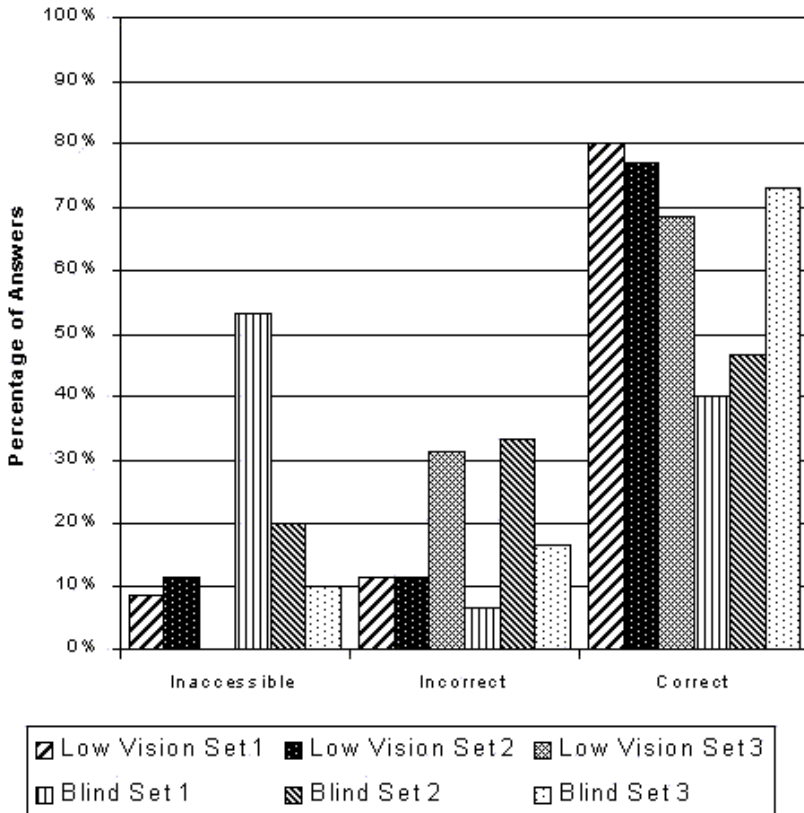


Fig. 2. Accessibility and comprehension scores for low vision and blind users for web pages with statistical graphics

Blind students were unable to answer 53% of the questions in the original web pages due to accessibility issues, but that dropped to 10% in the modified web pages. Blind students were able to correctly answer 73% of the content-related questions on the improved web pages, as compared to only 40% on the original web pages. Answers to content-related questions were more likely to be derived from the graph

descriptions rather than the tables when compared to the original web pages. Fourteen out of twenty-seven sources used for answers in content set 3 were from the graph descriptions rather than the table.

Access times were also reduced significantly, as seen in Figure 3. Compared to the original web pages, blind students took only two-thirds the time and low vision students took only one-third the time to complete the modified web pages.

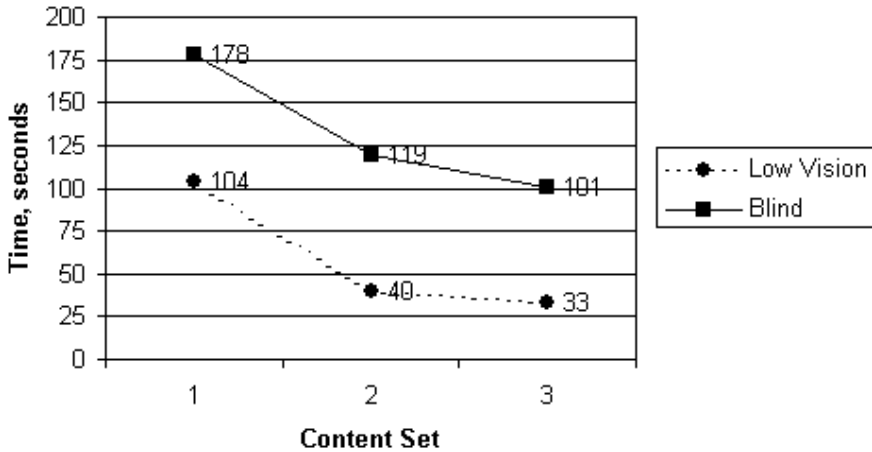


Fig. 3. Time to complete comprehension activities for blind and low vision users

5 Discussion

The test results show good improvement in accessibility and comprehension of the modified web pages.

5.1 Low Vision Results

The greatest percentage of questions answered in the usability study was in content set 1. Many accessibility features were added to content set 3, but the participants noticed few of these, resulting in a slight decrease in overall comprehension scores. A number of factors may have influenced the results. First, the small sample size (six students) would allow for some variation in success rate even if the students simply guessed at the answers. This is not unlikely, as the low vision users were less mature and at a lower educational level than the blind test subjects. Secondly, the testing of the third content set occurred in the students' homes, due to the schedule of testing during school vacation. The researchers noted that the younger low vision students seemed to be distracted by the home environment and were not focused on the lesson plans as during the in-school testing of the previous sets. Since most of the information in the first two content sets was accessible in some way to the low vision

users (less than 10% UTD answers), there was not as much room for improvement as for the blind users.

5.2 Blind Results

For the blind audience, the research team's guidelines both proved to be extremely useful tools in increasing the accessibility and educational value of the web content. There were a greater number of correctly answered questions, and the number of UTD questions decreased for each set of content. Although the response times of participants did not continue to decrease between content sets 2 and 3, the number of accessible elements and correct responses increased. From this it can be concluded that the changes made to content set 3 were effective.

6 Conclusions

This study shows that incorporating accessibility features such as carefully worded long descriptions of graphical information into web content greatly increases the ease of navigation, the amount of information on a page that can be accessed, and the educational value. Incorporating accessibility features into web content greatly increases the amount of information that can be accessed and the educational value of a web page. A simple reference for creating accessible web content provides a uniform, standard, and effective way to describe graphical data. These techniques are of value to every web developer on the Internet. The improvement shown when applying these guidelines and techniques is substantial, and may convince web content developers to implement these guidelines in their own web sites.

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A Tactile Display System Equipped with a Pointing Device – MIMIZU

Makoto Kobayashi¹ and Tetsuya Watanabe²

¹ Department of Computer Science, Tsukuba College of Technology,
Kasuga 4-12-7, Tsukuba City, Ibaraki, Japan
koba@cs.k.tsukuba-tech.ac.jp
<http://www.cs.k.tsukuba-tech.ac.jp/labo/koba>

² National Institute of Special Education,
Nobi 5-1-1, Yokosuka City, Kanagawa, Japan
twatanab@nise.go.jp
<http://www.nise.go.jp/research/kogaku/twatanab/indexEn.html>

Abstract. A tactile display system equipped with a pointing device has been developed. The system, named MIMIZU, has a stylus pen and a body containing tactile display units. The stylus pen and the body are connected with three links and three angular sensors. Using the system, visually impaired users can draw and erase tactile images. It is effective not only for tactile drawing, but also as an interactive multimedia displaying method. If the user points to arbitrary positions over the tactile image, the system can feedback to the user a kind of tactile or acoustic reactions like vibrating pins, changing the tactile image, playing a sound, and so on. It means that MIMIZU has good possibility to give effective educational materials and enjoyable entertainment to visually impaired people.

1 Introduction

The idea we first had was very simple. Connecting a stylus pen to tactile display units with multi links would realize a tactile display system with a pointing device.

In general, totally visually impaired persons use raised line drawing kits to make tactile drawings. However, those kits do not allow the users to erase the lines once drawn. Therefore, they have to make drawings without any mistakes and that is not easy for them. Though an experimental system called Tdraw [1] that utilizes swell-paper and a digitizer enables recording the drawing electronically, these tools do not allow users to erase raised tactile drawings. So the main purpose of our project was to develop a tactile drawing system that enables rewriting or redrawing. The first idea to accomplish the purpose was to use tactile display device units like a refreshable Braille display instead of swell paper. Since the device units display tactile images flexibly, a system that allows users to erase tactile lines easily might be realized by using them. But we found it was difficult to track the motion of a pointing tool like a pen tip over the tactile display units because of its mechanism. A tablet board can't be mounted under the units because there are some kinds of actuators or motors in the

units. Mounting the board over them has a problem for users. This design disturbs their touching the tactile images. Image sensing to detect the pen tip using an overhead mounted camera is also difficult by the reason that visually impaired users tend to use both of their hands to make drawings. It means that the user may hide the pen tip. We tried to apply a magnetic sensor, but the sensor couldn't work correctly by fluctuations of magnetic field that arose from actuator motion.

Our solution to this problem was very simple, as mentioned above. We connected the stylus pen and the tactile display units with three links and three angular sensors. By using the detected angular data and the length of the links, a computer calculates the position of the pen tip and controls the raising or lowering the tactile pins under the pen tip. Although this method has some disadvantages of restricting the stylus movement, it was considered the best way to realize a pointing device over the tactile display. We named the tactile display system MIMIZU, which means a kind of worm in Japanese, for the motion of the tactile display. Actually, the stylus move is similar to the motion of worms.

2 Hardware Description

MIMIZU is composed of a stylus pen device connected with links, a computer equipped with an LCD tablet, tactile display units, shown in Fig.1. The tactile display units are tiled and contained in the box made of acrylic board and aluminum angles. The box also contains a power supply and an electrical circuit board to drive the display units. In this section, details of those components are described.

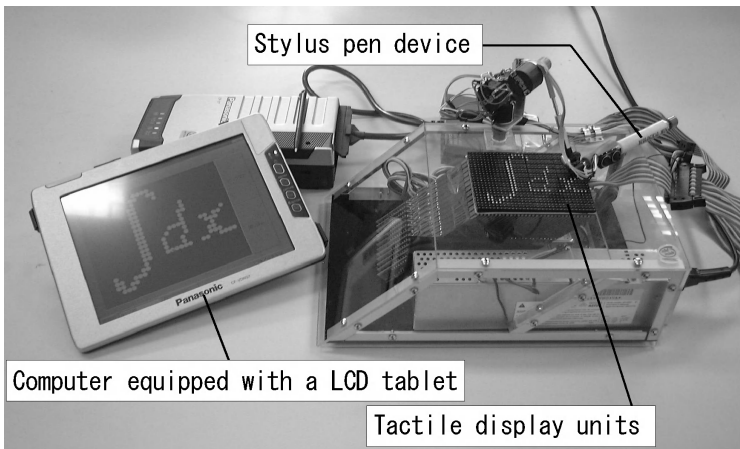


Fig. 1. This figure shows an overview of the proposed tactile display system. It is composed of stylus pen device, computer equipped with LCD tablet, and tactile display units tiled as matrix.

2.1 Stylus Pen Device

The stylus pen device is connected to the base of the system with three links and three angular sensors, as mentioned above. Fig.2 shows a detailed illustration of the device. Angular sensors are potentiometers (CONTELEC, 2303N, 20kOhm) whose shafts rotate 1080 degrees and are energized twenty volts. The top of the link and the tip of the stylus pen are connected with a ball joint and users can move the angle of the stylus freely.

The stylus pen has three buttons. Two of them are on the middle of the pen body and the other is at the end of the pen. Each button is energized five volts and connected to digital input ports on the Universal Pulse Processing (UPP) card inserted to the computer. The roles of the buttons are not strictly decided and depend on software running on the computer.

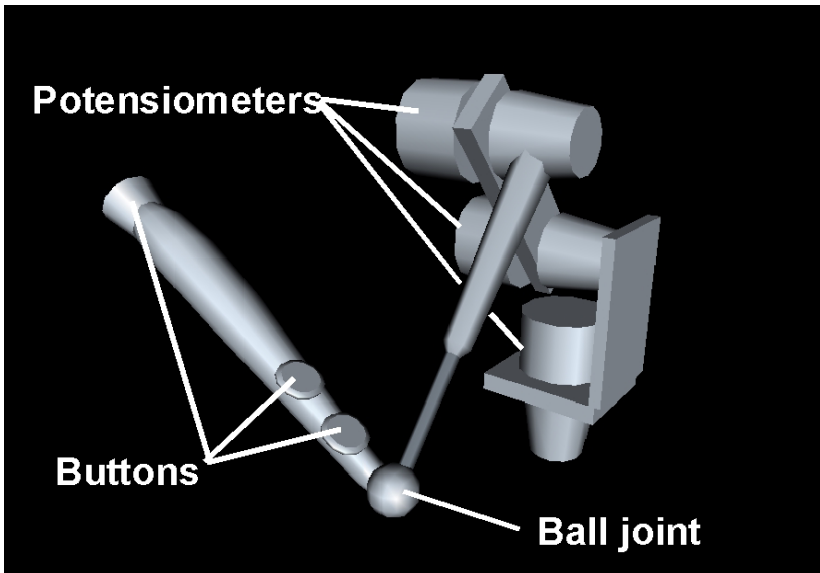


Fig. 2. A detailed illustration of stylus pen device: a stylus pen is connected to the base with three links and three angular sensors. The connection between the pen tip and the top of the link is a ball joint. The stylus pen has three buttons.

2.2 Computer Equipped with LCD Tablet

The computer calculates the positions of the pen tip and controls the tactile display units. It is equipped with the LCD tablet, so that sighted users can point an arbitrary position or make a drawing intuitively using the tablet and the pointing stylus. We chose FMV-MC series by Fujitsu, Japan and CF-07, shown in Fig.1 by Panasonic,

Japan. It should be noticed that the LCD tablet of CF-07 is separated from the computer itself and communicates without wires. Therefore, in the case of lessons in the classroom, the sighted teacher can move freely in the room carrying only the LCD tablet unit.

The computer is also equipped with a UPP card (REX5059, Ratoc system, Japan) inserted to the PCMCIA slot. The card has AD-Converter ports that converts from analog input signals to digital ones, and has Input/Output ports that input and output digital signals. The AD-Converter ports connect to the angular sensors on the stylus pen device, the Input ports are connected to the buttons on the stylus, and the Output ports are connected to the control terminal of the tactile display units through wires. The resolution of the AD-Converter is ten bits and its range of voltage is from zero to five volts.

2.3 Tactile Display Units

MIMIZU has twelve tactile display units (SC-5 by KGS, Japan) laid out in three by four. Each unit has 64 tactile pins arranged in 8 pins by 8 pins with inter-pin spaces of 3 mm. Therefore, the total number of pins is 768, arranged in a matrix of 32 columns and 24 rows, and its surface measures 96 mm by 72 mm. The diameter of the pin is 1.3 mm and its stroke length is 0.7 mm driven by piezoelectric ceramic actuator. All pins can be set within 1msec by control signals from the computer.

Another feature of the display unit is that an angle between the piezoelectric actuator and the pin is set at 45 degrees. Because of the alignment, developers can extend the surface of the tactile display as large as they want.

3 Application Software

At the time our project started, though the purpose of the project was to develop a system of drawing tactile images, we were aware of the possibility that the system would be a multimedia terminal for the visually impaired. Therefore, in addition to drawing software, several software programs are tentatively made for applying MIMIZU. In this section, the programs are explained.

3.1 Electric Raise Writer

The electric raise writer software program realizes the simple function of drawing/erasing tactile images and filing them to the hard disk drive.

When this program starts, the computer calculates the position of the pen tip from the value of angular sensors and the length of links using trigonometric functions. If the user pushes the button on the stylus pen near the pen tip, the computer sends to the tactile display units a signal to raise a pin under the pen tip. When the user pushes the other button, raised pins under the pen tip will be lowered. Using such simple algorithms, the user can draw a line and erase an arbitrary part of the drawing by moving

the stylus with the button pushed. While the user is making a drawing or erasing it, the computer plays a certain sound file that depends on which action is being done. It helps the visually impaired user to judge which action they are doing at that moment. Also, when the user pushes the button at the end of the stylus pen, all raised pins are lowered, i.e., the surface of the tactile display is cleared. To help to confirm it, another sound file will be played when this action is done.

On the other hand, for sighted teachers in schools for the blind, an operating method by the LCD tablet is prepared. If the sighted user makes drawings with the stylus onto the LCD, the drawing image on the LCD is immediately reflected to the tactile display units. Moreover, line drawings made by the user can be saved to the hard disk on the computer. Of course, the saved data will be opened and displayed at any time the user wants.

The program also has an animation mode. In the animation mode, arbitrary pins will be vibrated or moved right or left and the other arbitrary pins will be stable. Using this mode, for example, the system can display moving sine waves on the stable axis. Moreover, the program prepares a communication mode in which tactile images can be sent to the other MIMIZU through a network cable.

3.2 Ping-Pong Game

The ping-pong game program presents a kind of tactile game. A player has to pursue a ball expressed by four tactile pins and to strike it back by a racket expressed as a short tactile line.

The player controls a position of the racket using the stylus pen. The ball moves straight but bounces off the walls of the top, bottom, and left side. The racket is set at the right side, and is allowed to move upward and downward. When the ball bounces at the wall or the racket, a knock sound is played. This game is very simple and very easy to play when you see the LCD. It is, however, difficult to play only with the tactile sense.

3.3 Learning Chinese Characters

A program for learning Chinese characters gives the visually impaired an effective learning method to understand components of the character.

Most Chinese characters are composed of several components. Basically, each component has its own pronunciation and meaning individually. The combination of the meaning of each component makes a whole meaning. It is a significantly different point from alphabetical letters. For example, a Chinese character of “totally visually impaired” is made of two components (see Fig.3). The upper component has a meaning of “lost” and the lower one expresses an “eye”. On the other hand, it is very difficult to select correct Chinese characters for the visually impaired even if they use a screen reader program when they write letters. Because there are so many Chinese characters that have the same pronunciation but different meanings. In that case, knowledge of components helps them to select a correct character. Therefore, it is very helpful when they write, though it is said that the knowledge of components is

not always necessary for visually impaired persons when they communicate with other persons orally. Of course, it is very important from the viewpoint of cultural sophistication.

Ordinarily, visually impaired students use tactile sheets on which Chinese characters are embossed in order to learn their shapes and meanings. However, it is hard for the students to distinguish each component on the sheet because of difficulty in detecting the borders of the components only from tactile information. The Fig.3 shows that the border between the upper component and the lower one is not clear only from tactile information.

Based on such a background, the program is designed to learn not only the shapes of complete Chinese characters but also the meanings of each component. When the program starts, tactile pins display the whole image first. If the user moves the stylus to the area of a component, a cluster of the pins that express the component vibrate at a low frequency. Then, if the user pushes a button near the pen tip, the pronunciation of the component is spoken. Through these operations, the user recognizes shape and pronunciation of each component. Finally, they can understand how the whole meaning of the character is composed.

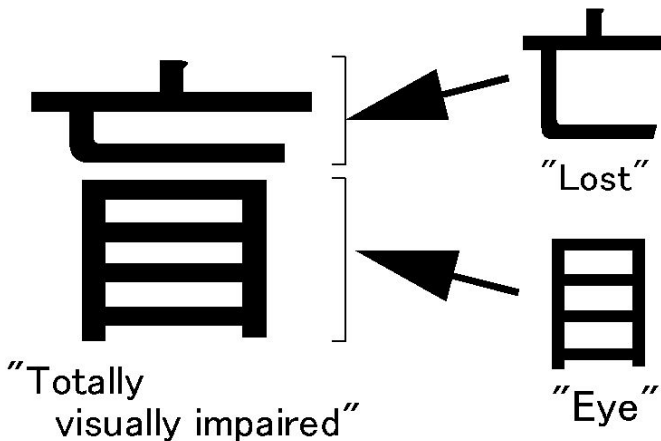


Fig. 3. This figure shows a Chinese character (left) and its components (right). The whole character means a “totally visually impaired”. And the upper component means “lost”, and the lower means “eye”. On the MIMIZU, each component is vibrated when the stylus is on the component and its pronunciation is spoken when the user pushes a button.

4 Evaluations

We brought MIMIZU to several schools for the blind in Japan, seeking the evaluation and comments by students, staff, and teachers.

The results obtained are as follows: First, when they tried to use an electric raise writer program, it seemed to be basically fun to make drawings by the system. They highly evaluated our trial to realize an erasable raise writer system, and they said that the function of erasing and that of giving sound information are important for visually impaired users. About animation modes, they commented that the method of moving to right or left is not always suitable on the tactile display, but vibration is good for the visually impaired to notify certain areas. On the other hand, a general complaint is that the resolution of tactile display is not enough. For instance, when they touch lined pins, it is difficult to distinguish whether the pins represent a line or separated dots. Especially in the case of aslope line, it is difficult to understand what the pins are displaying. To solve the problem, we must develop a new style actuator because the specification of inter-pin space between those pins depends on the drive mechanism. Other complaints are poor precision of pen tip detection and difficulty in recognizing where the pen tip is. We think that the main reason of the detection problem is fluctuation of values from the angular sensors. It will be solved if the sensors are replaced by a kind of encoder instead of the potentiometer by which it is now equipped. With respect to the recognition of the position of the pen tip, the fact that the pen tip is made of a ball joint is considered as the main reason. Therefore, if a connection point between the stylus and link is moved from the tip to the end of the stylus, the feeling will be improved.

Next, when they tried to play the ping-pong game program, it seemed that the program gave a good impression, especially to the students. They wanted to play other tactile games and proposed a kind of shooting game. They said that they always play computer games using only sound information and it is not good enough to enjoy playing, so they want to know spatial information using the system. We have to say that it is difficult to apply MIMIZU to the existing computer games, but it will be valuable to make other tactile amusement programs using it.

Finally, the program for learning Chinese characters was highly evaluated by the teachers and students in high grades. They seemed to recognize the importance of learning Chinese characters from the viewpoint of each component and its meanings. Though they use Chinese characters with screen reader programs on the computer in daily life, they have trouble understanding its shapes and components, they commented.

5 Summary and Future Research

The tactile display equipped with the pen stylus was tentatively developed and was evaluated. We can conclude that there are still several factors to improve, however, the system is very valuable if effective software programs are implemented to it. It was clear that an effective educational system could be realized with a pointing device over the tactile display, even if its resolution is not enough.

Finally, we will introduce one of the software programs that has been developed. The program is named “interactive tactile map”. The idea was proposed from some teachers who evaluated MIMIZU. The interactive tactile map program basically dis-

plays tactile maps, but the tactile maps on the display can be changed by the actions from the user and the program also gives some sound information. For instance, an overview of a floor map in a building is displayed first. When the user points to a certain room with the stylus and pushes the button, the system replies the detail of the room, such as room number, the purpose of the room, and so on, by playing sound files. When the user pushes another button, the map changes to a detailed map of the pointed room. If the user points to a position of the stairs and pushes the button, the map changes to another floor map. The program can also display the current position of the user by vibrating the tactile pins. By using this method, the visually impaired user can easily detect the current position, which is hard to search in an ordinary static tactile map. In this manner, we think MIMIZU has various prospects of being a multimedia terminal for the visually impaired.

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Preparing Tactile Graphics for Traditional Braille Printers with *BrlGraphEditor*

Mario Batusic and Franz Urban

i³s³ University of Linz
Altenbergerstr. 69, A-4040 Linz (AUSTRIA)
Mario.Batusic@jku.at
<http://www.integriert-studieren.jku.at>

Abstract. This poster presents a new *WYSIWYG editor* for tactile graphics developed by Franz Urban in the framework of his diploma theses in computer sciences at the institute *i³s³*, Johannes Kepler University of Linz, Austria.

The editor is designed as a research tool for investigating an appropriate production technique for the paper printed tactile graphics.

1 Tactile Graphics with Traditional Braille Printers

Graphical methods of representation and graphic depiction get ever more importance in our age of multimedia access to the real and virtual worlds. Primarily in the education the graphics play an important role and are indispensable in the area of mathematics and sciences.

Due to modern OCR- and speech-Synthesis technology, access to text can be provided to a large extent. Graphical data, which often carries an important part of the information contained in the document, is ignored by all OCR-packages currently available.[2]

After ten years of experience in preparing tactile graphics as part of the scientific/studying literature in the area of mathematics and computer science the following main problems showed up:

- There is no elaborated method for drawing good perceptible tactile graphics.
- There is no algorithm developed to automatically simplifying and optimizing regular graphics into tactile ones.
- The most traditional Braille printers dispose of a graphic mode but the producers don't offer a good graphic editor to help producing the proper tactile graphics. So the only alternative is the use of thermoform foils, which, however, is more expensive.

We developed *BrlGraphEditor* in first place to support the traditional Braille print production of simple 2D graphics like graphs and diagrams in the area of mathematics/sciences. It should also be used for preparing test materials in the field of tactile perception research.

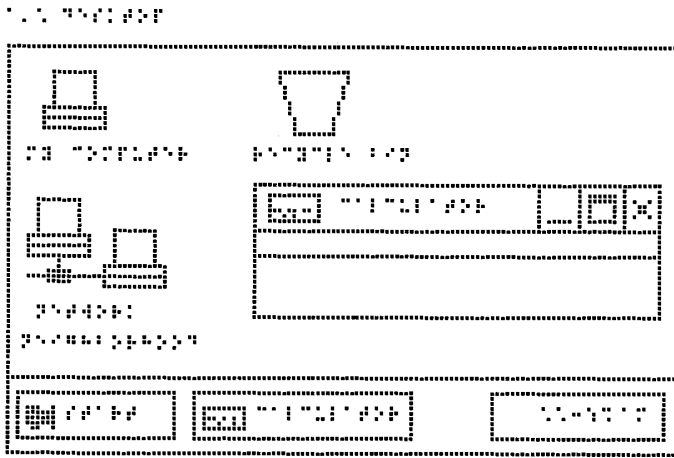


Fig. 1. A Tactile Graphic of the Windows Desktop drawn with the *BrlGraphEditor*

2 About *BrlGraphEditor*

BrlGraphEditor is a very simple drawing tool. It is designed exclusively for making tactile graphics to be printed on traditional Braille printers. To allow the full control over the results, the editor displays the graphics in the exact resolution of the selected Braille printer.

Here are the main features of the *BrlGraphEditor*:

- German and English version of the user interface
- support for many different character tables and/or for Unicode
- modular architecture allowing extensibility towards other printers with new features
- offers two different views of text elements:
 1. fix font view appropriate for use during the editing/error correction
 2. native Braille view to give the composer the proper idea of dot positions on the graphic.

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TeDUB: A System for Presenting and Exploring Technical Drawings for Blind People

Helen Petrie¹, Christoph Schlieder², Paul Blenkhorn³, Gareth Evans³, Alasdair King³, Anne-Marie O'Neill¹, George T. Ioannidis², Blaithin Gallagher⁴, David Crombie⁵, Rolf Mager⁶, and Maurizio Alafaci⁷

¹ Centre for Human-Computer Interaction Design, City University, Northampton Square, London EC1V 0HB, U.K.

h.l.petrie@city.ac.uk

² TZI, University of Bremen, Universitätsallee 21 –23, D-28359, Bremen, Germany

gtis@tzi.org

³ Department of Computation, UMIST, Sackville St, Manchester M60 1QD, U.K.

plb@co.umist.ac.uk

⁴ National Council for the Blind, 45A Whitworth Road, Drumcondra, Dublin 9, Ireland

blaithingallagher@eircom.net

⁵ Federatie van Nederlandse Blindenbibliotheken, Molenpad 2, Amsterdam, 1016 GM, the Netherlands

⁶ Rolf Mager, F.H. Papenmeier GmbH & Co. KG, Talweg 2, D-1620 Schwerte, Germany

⁷ Unione Italiana Ciechi, Sezione Provinciale di Verona, via Trainotti 1, 37122 Verona, Italy
uicvr@uiciechi.it

Abstract. Blind people can access and use textual information effectively in a variety of ways – through Braille, audiotape or computer-based systems. Access and use of graphic information is much more problematic, with tactile versions both time-consuming and difficult to make and textual descriptions failing to provide independent access to the material. The TeDUB Project is developing a system which will automatically generate descriptions of certain classes of graphics (electronic circuit diagrams, UML diagrams and architectural plans) and allow blind people to explore them independently. This system has great potential in work, education and leisure domains to open up independent access to graphic materials for blind people.

1 Introduction

One of the most difficult problems of being blind is accessing and using information. Good solutions exist for textual information – it can be transcribed into Braille or read onto audio-tape and text can be accessed on a computer using a text-to-speech program or a Braille display. However, much information used by sighted people is graphic in nature – photographs, pictures, drawings, and diagrams of many varieties. Access and use of graphic information for blind people is much more problematic. Tactile versions of the graphics can be produced, but this is time-consuming, expensive and requires particular design skills to produce a graphic which works as well in a tactile form as it does in a visual form. A cheaper and easier solution is to produce a textual description of the graphic. However, this solution denies blind

people an extremely important component of access to graphics – the ability to explore them from different perspectives, answer one’s own questions and build up one’s own mental model of the material represented. For these purposes one needs an interactive system.

The EU-funded TeDUB Project is investigating ways in which systems can be developed that allow blind people to interact with graphics and thus be able to use them much more effectively. Within the project, the system will be demonstrated with a number of types of technical drawings (specifically electronic circuit diagrams, UML diagrams and architectural plans), but as the technology improves, the same system has the potential to give blind people access to other classes of graphics.

2 The TeDUB System

The heart of the system is the image processing system. The image analysis process will comprise two steps: first, the classification of the type of the diagram to be analysed, and second the extraction of the relevant diagram content. For both steps, knowledge-based approaches that combine descriptive and formal ontologies will be used. This ensures that the image processing system can be easily extended for other types of graphics, not studied in the TeDUB project. Primitives such as line segments, junctions and arcs will be extracted using image processing methods. The additional use of domain knowledge, which is quite well defined in the types of diagrams that will be analysed in the TeDUB Project, will support the symbol extraction process.

3 The Interface for the TeDUB System

To allow blind people to use the information provided by the technical drawings effectively, an interface is required that provides the appropriate interactive capabilities and yet is sufficiently easy for users to learn and use, so that it does not distract them from the tasks which they wish to undertake with the graphic. The TeDUB Project will explore the use of a range of interaction modalities for such an interface – synthetic speech, non-speech sounds, the three dimensional presentation of the speech and sound, commercial forcefeedback devices and the use of a touch tablet with graphic overlays.

The interface will need to be able to deal with a wide range of graphics that may differ greatly in their nature and structure. To develop an appropriate interface for a completely novel application area will require considerable development effort. To facilitate this process we are using a “Wizard of Oz” prototyping technique. A Wizard of Oz prototype is one where the real functionality of the system is not present (usually because it has not yet been developed), but is somehow simulated to allow the interface to the system to be designed and evaluated. For the TeDUB system, we have produced a set of the types of data structures that might eventually be produced by the image processing system. This is allowing us to design a number of prototype interfaces and allow visually impaired people to try them out and experience the potential of this system. Some of the issues being explored are how to present an overview of the graphic, what level of granularity at which to present the information

in the graphic, and how to structure the information so that it can easily be navigated. It will also allow us to test the appropriateness of different data structures for the image processing output. We anticipate that this will be a much more effective means of developing the user requirements for the interface and the functionality of the system than simply asking people about their requirements.

4 Conclusions

The TeDUB system has great potential in work, education and leisure domains to open up independent access to graphic materials for blind people. Considerable effort will be required to develop an image processing system robust enough to produce adequate descriptions of even a narrow range of graphics and an interface flexible enough to allow blind people to explore that range of graphics. However, that effort is clearly worthwhile, as the increase in information access and use for blind people will be equally considerable.

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Improvement of User Interface for Blind PC Users

Yutaka Shimizu¹, Masami Shinohara², Hideji Nagaoka³, and Yasushige Yonezawa³

¹ University of Electro-Communications, Chofu, Tokyo, Japan
shimizu@se.uec.ac.jp

² National Institute of Advanced Industrial Science & Technology, Tsukuba, Ibaraki, Japan
m-shinohara@aist.go.jp

³ Tsukuba College of Technology, Tsukuba, Ibaraki, Japan
{Nagaoka, Yonezawa}@cs.k.tsukuba-tech.ac.jp

Abstract. An application by which blind users can operate two tactile devices by themselves was developed. Laboratory assessment showed the possibility to transmit certain kinds of non-textual information.

1 Introduction

Building a multi-modal interface is a promising way to improve access to information equipment for the blind. As previously reported, we developed two tactile devices, a tactile mouse and a tactile graphic display. We then developed an application by which blind users can operate the devices by themselves. Here we outlined the application and show the results of assessment using three set tasks.

2 List of Hot-Keys

Users can perform all operations to control the devices by keyboard. The key-commands are grouped into three categories, namely display control, parameter input, and mouse pointer control. Table 1 shows the key assignment.

3 Laboratory Assessment

A schematic illustration of the experimental system is shown in Figure 1.

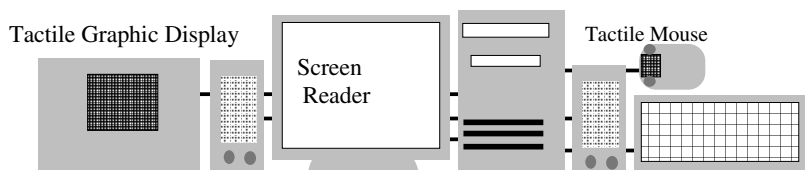


Fig. 1. Schematic illustration of the experimental system. The tactile device driver converts a bitmap image into a binary form, and sends it to the tactile devices via USB ports.

Table 1. List of hotkeys for operating the tactile devices

Command	Key operation	
	Tactile mouse	Tactile graphic display
<i>Display control:</i>		
Application off	[Ctrl]+[.]	[Alt]+[.]
Capture & display on/off	[Ctrl]+[0]	[Alt]+[0]
Display MousePos		
whole screen	[Ctrl]+[*]	[Alt]+[*]
current window	[Ctrl]+[/]	[Alt]+[/]
<i>Mouse pointer control:</i>		
Store current position		[Ctrl]+[Alt]+[+]
Return to the stored position		[Ctrl]+[Alt]+[-]
Move by pixel		
in 8 directions		[Alt]+[1 - 4, 6 - 9]
Jump to		
the top of whole screen		[Ctrl]+[Alt]+[7]
current window		[Ctrl]+[Alt]+[8]
the bottom of whole screen		[Ctrl]+[Alt]+[3]
current window		[Ctrl]+[Alt]+[2]
the left end of current window		[Ctrl]+[Alt]+[4]
the right end of current window		[Ctrl]+[Alt]+[6]
<i>Parameter input:</i>		
Setup mode on/off	[Ctrl]+[+]	[Alt]+[+]
Return to the default		[Ctrl]+[Alt]+[d]
Setup window open/close		[Ctrl]+[Alt]+[m]
Cancel the set parameter		[Ctrl]+[Alt]+[5]
Set capture size	[Ctrl]+[Alt]+[s]_[25,50,75, or 100]_	[Enter]
Select capture mode		[Ctrl]+[Alt]+[c]
Mouse mode		_[m]_
Fixed mode		_[f]_[x1-y1-x2-y2]
Set color levels	[Ctrl]+[Alt]+[l]_[r, g, b, or bw]_	["number"]_
Reverse image on/off		[Ctrl]+[Alt]+[i]
Select test mode		[Ctrl]+[Alt]+[t]_[ab, aw, l, r, b, or t]

3.1 Training

After receiving verbal instructions on how to operate the devices, the subjects repeated practice operations with the aid of an experimenter. The training was finished when individuals could smoothly perform correct action to any instruction by the experimenter. All events in PC were recorded using *Winwhatwhere Investigator*.

3.2 Task 1: Mouse Pointer Control

A mouse is a difficult device for blind users to handle. To assess the functions to help blind users to control the mouse, the subjects were given the following task.

Start; Get current pos.; Jump to the top; Move directly below to near the center; Move horizontally to near the center; Go up 8 pixels; Move left 4 pixels; Store current pos.; Jump to the right end; Return to the stored pos.; End

3.3 Task 2: Pattern Recognition

Five pictures, as shown in Figure 2-a, were given and each subject was asked to reply what each picture was like. The subjects had to change the capture size and reverse the image to perform this task. They were free to use either the keyboard or mouse to move the mouse pointer.

3.4 Task 3: Compound (Exploratory and Cognitive) Task

The subjects were asked to find out where the target picture, as shown in Figure 2-b, was in a window which also contained text, using the tactile devices and the screen reader. They were free to operate any device.

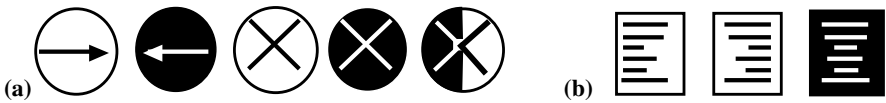


Fig. 2. Two stimuli given to the subjects. (a) Five pictures for pattern recognition task and (b) three target icons in a window containing also text.

4 Conclusion and Future Works

Table 2 shows a part of the performance data obtained in the three tasks. It indicates that cooperative work by both auditory and tactile modalities may succeed in transmitting visual information to some extent. We can be fairly certain that tactile devices having a high frequency response, high spatial resolution, and wide display area is advantageous to transmitting a broader range of visual information. On the other hand, it may be desirable to optimize the interface with compact tactile devices from the viewpoint of cost for personal use. Thus the following efforts must be done.

- Development of a tactile unit having a high frequency response and spatial resolution
- Improvement of the interface to help explore a screen
- Reconsideration of the information structure to convert visual into audio-tactile information
- Construction of a cognitive model for task analysis and evaluation

Table 2. Performance data obtained through Task 1, Task 2, and Task 3

Task & Measure	Subject A	Subject B	Subject C
Task 1: Necessary time (sec)	1.58	1.33	2.23
Success rate	0.3	0.8	0.9
Task 2: Response time (sec)	2.17	1.57	1.05
Correct ID rate	0.8	0.8	1.0
Task 3: Necessary time (sec)	16.08	6.26	5.29
Correct rate	0.0	0.3	0.3

Haptic Perception of 2D Pictures and 3D Objects: Accurate Mental Representation as a Function of Visual Status

Helen Graupp¹, Keith Gladstone¹, and Leanne Thompson²

¹ iSys department, 105 Judd Street, London, WC1H 9NE, UK
hgraupp@rnib.org.uk kgladstone@rnib.org.uk

² Psychology Department, Lancaster University, Bailrigg, Lancaster, LA1 4YW, UK
l.thompson@lancaster.ac.uk

Abstract. In two experiments, participants of varying visual status explored tactile diagrams and 3D objects. Congenitally blind participants were poorer at identifying tactile diagrams haptically than adventitiously blind and blindfolded sighted people. Tactile picture recognition benefits from visual knowledge, experience and imagery. In another study blind and blindfolded sighted participants explored 3D objects with two fingers and restricted cutaneous feedback. Whether meaningful information can effectively be gleaned by force-feedback alone is questionable and raises doubts about devices enabling blind people to explore objects in virtual environments with current technology.

1 Experiment 1

Since the 1960's research has shown increased awareness of the haptic system in its own right, recognising it as a highly efficient information processing system [1, 2, 3]. Klatzky, Lederman and Metzger [4] have demonstrated highly accurate recognition rates of real 3D objects by the haptic system alone. However haptic picture recognition studies reveal low recognition rates, especially for blind people [5, 6, 7, 8]. Those researching tactile picture¹ recognition are generally divided into two schools of thought, either supporting the notion that blind people can understand 2D depiction [8, 9] or refuting such claims [7]. This debate is still unresolved. However, Millar [10] alternatively suggests that successful tactile picture recognition and production depends on learning rules governing 2D representation, and that teaching these principles to blind children could be beneficial. In previous experiments, blindfolded sighted people have generally been found to achieve higher identification rates than blind people [5, 6, 7, 11], who appear to find it difficult to assign semantic meaning to 2D patterns [11]. Visual experience is important for tactile picture understanding. The importance of visual experience was explored by Lederman et al. [7], who found that blindfolded sighted participants achieved higher recognition rates

¹ Tactile pictures are relief pictures for blind people. The pictures referred to in the present paper are of a uniform relief and are therefore considered to be 2D. 3D pictures depict 3D information via perspective and hidden lines, as opposed to 3D objects.

overall and found 2D pictures (representing only one object face) easier to recognise than 3D pictures (incorporating perspective cues and internal lines depicting edges), unlike the congenitally blind participants who showed no preference. They concluded that ‘image-mediation’ is vital for tactile picture recognition, without which tactile picture recognition is extremely difficult. This is due to a lack of ‘substance’ features (e.g. texture), which the haptic system uses in object recognition [7]. Kennedy [8] contends that not all pictures are equally understandable. His research with Heller has shown that congenitally blind people have problems recognising perspective pictures compared with side views [12]. Both Lederman et al. [7] and Kennedy and Fox [6] approached the issue of tactile picture design in exploring the differences in recognition rates for 2D and 3D tactile pictures. Despite predictions to the contrary, both studies found that congenitally blind people recognised equal numbers of each picture type. It may be that the extremely low recognition rates for all picture types in both studies are masking important effects. For example Heller et al. [12] found perspective pictures were harder to recognise than side-view pictures for congenitally blind people. Thus, the aims of the present study were twofold: to explore the role of visual knowledge, experience and ‘image-mediation’ on tactile picture recognition, whilst investigating the effects of picture depiction on picture perception.

1.1 Method

Thirteen congenitally blind (CB), 13 adventitiously blind (AB) and 22 blindfolded sighted (BS) people participated. Twenty raised-line pictures of everyday objects were selected from Snodgrass and Vanderwart’s [13] set of 240 pictures, standardised on 4 variables of central relevance to memory and cognitive processing: Name Agreement, Image Agreement, Concept Familiarity and Visual Complexity [see 13]. The pictures included ten 2D and ten 3D pictures. 2D pictures showed one object face and 3D pictures showed 3D information via pictorial conventions. In order to assess each participant’s vividness of visual and/or cutaneous and kinaesthetic imagery they completed a vividness of imagery questionnaire (VIQ) devised from Betts’ Questionnaire Upon Mental Imagery [14]. A practise picture was used to familiarise each participant, then they were randomly presented with the tactile pictures and asked to recognise each as quickly and accurately as possible. Ninety seconds maximum exploration time was allowed for each picture, timed from when pictures were first touched to when the final answer was given. Participants were told that objects were not drawn to scale but depicted nothing larger than a table nor smaller than a 5p coin. The only other feedback was confirmation of guesses being correct or incorrect. After feeling each picture participants rated how difficult it was to form a mental image of a real object (Picture Imagery Difficulty measure). Those with vision looked at each picture after feeling it and gave a score for how closely it resembled what they imagined it would look like (Resemblance of Picture to Mental Image measure). Finally participants were given a list of all of the objects depicted and rated how familiar they are with each one (Object Familiarity Rating).

1.2 Results

Kruskal-Wallis tests confirmed there were significant differences between the 3 groups regarding 2D and 3D picture identification rates and 2D and 3D picture exploration times (see Table 1).

Table 1. Overall 2D & 3D Picture Recognition Rates and Median Picture Exploration Times.

Heading level	Congenitally blind (CB)	Adventitiously blind (AB)	Blindfolded sighted (BS)
Median Total Picture Recognition	5 (25%)	10 (50%)	8.5 (43%)
Median 2D Picture Recognition	3 (30%)	6 (60%)	5 (50%)
Median 3D Picture Recognition	2 (20%)	5 (50%)	3 (30%)
Total Picture Exploration Time	55 secs	22 secs	83 secs
2D Picture Exploration Time	40 secs	35 secs	53 secs
3D Picture Exploration Time	57 secs	29 secs	89 secs

Mann Whitney-U tests confirmed significant differences between the CB and BS groups on 2D and 3D picture identification scores ($z=-3.786$, $p<0.001$, $z=-3.235$, $p=0.001$, $z=-3.479$, $p=0.001$ respectively), the sighted group identifying significantly more pictures in each case. AB performed significantly better than CB on all three measures ($z=-3.653$, $p<0.001$, $z=-3.503$, $p<0.001$ and $z=-3.319$, $p=0.001$ respectively). There were no significant differences between the BS and AB on any performance measures ($z=-1.791$, $p=0.073$, $z=1.736$, $p=0.082$, $z=-1.709$, $p=0.087$ respectively) or in time taken to explore any of the pictures by either blind group. However exploration times of CB and AB differed from BS on all of the pictures except the 2D pictures, where BS did not take significantly longer than the CB. Wilcoxon Signed Rank Tests showed all groups were significantly better at identifying the 2D pictures than the 3D pictures (CB $z=-2.829$, $p=0.005$, AB $z=-2.836$, $p=0.005$, BS $z=-3.352$, $p=0.001$). However, only the AB and BS took significantly longer to explore the 3D pictures (CB $z=-1.782$, $p=0.075$, AB $z=-2.353$, $p=0.019$, $z=-3.380$, $p=0.001$). High correlations included tactual experience level and exploration time for all stimuli, 'visual experience' and overall 2D and 3D recognition rates, plus 'length of visual impairment' and all picture recognition rates. Only sighted participants showed a high negative correlation between age and overall picture recognition ability ($\rho=-0.478$, $p=0.025$). No correlations were found between VIQ scores and picture accuracy rates, picture exploration times and picture imagery difficulty scores but previous diagram usage and experience, correlated with haptic imagery scores ($\rho=-0.420$, $p=0.003$). Finally, both visual experience and length of visual impairment correlated with haptic imagery scores. No effects of object familiarity on picture recognition and no within-group differences were found between 2D and 3D object familiarity ratings for the blind groups. However the sighted group gave higher familiarity ratings to the 3D objects. Overall correlations showed that less vision was related to higher (better) object familiarity scores ($\rho=-0.466$, $p=0.001$). Finally, both Snodgrass and Vanderwart's [13] Concept Familiarity measure and the overall Object Familiarity ratings were found to be highly correlated ($\rho=0.574$, $p=0.008$).

1.3 Discussion

Tactile pictures are extremely difficult to identify unaided. Accuracy rates for both blind and blindfolded sighted people rarely exceed 50% [5, 6, 7, 8, 10]. Analysis indicated the importance of visual knowledge and experience in tactile picture recognition. It is proposed that visual knowledge (including knowledge of pictorial conventions) is important to all tactile picture recognition. Visual experience and ability to use visual imagery facilitates 2D picture recognition but is critical in 3D picture recognition. Results showed that some conventions can rarely be perceptually experienced by touch alone, such as perspective, so it is not surprising that 3D pictures were harder than 2D for CB people to recognise. The critical factor for successful tactile picture recognition is an understanding of the rules of pictorial representation. This process is termed here as ‘knowledge-mediation’, as knowledge of vision and the rules of pictorial representation dictate the extent to which 2D tactile pictures can be understood, as Millar suggested [10]. For those with visual experience, all pictorial conventions can be understood perceptually, but it is more difficult to recognise pictures depicting purely visual phenomena by touch alone. Image-mediation may therefore be required in identifying such pictures. Thus 3D pictures should take longer to process than 2D, a finding confirmed by the results as exploration times for 3D pictures were only significantly longer than for 2D pictures for those with access to visual imagery. General tactual experience was important only with respect to exploration time. Previous vision meant better picture recognition but slower exploration. Those with more tactual experience were quicker at exploring but ultimately were less successful at recognition. Although other 2D tactile tasks may be related to haptic imagery ability, correlations revealed that tactile picture recognition specifically is not: there is a difference between tactile picture recognition and general 2D tactile pattern perception. Thus it seems tactile picture recognition at present is not able to operate via ‘direct haptic apprehension’, proposed by Lederman et al. [7] as the optimal way for the haptic system to operate. This study suggests that many 2D tactile pictures without annotation may be unsuitable for blind people, especially for those with early-onset blindness. There is a need for further exploration of how congenitally blind people understand pictorial conventions used in tactile pictures, which are currently derived from visual, rather than haptic, appropriateness. This could lead to a revision of the conventions used, which in turn may call for radical new ways of representing 3 dimensions in 2 dimensional space. It is vital that such conventions be deliberately taught to congenitally blind people to ensure that the 3 dimensional implications of the 2 dimensional conventions used are realised.

2 Experiment 2

Perceptions of the world combine input from several senses. When an object is explored by sight, an almost instantaneous understanding of its shape, size, texture and even temperature occurs. But purely haptic exploration is serial and therefore more time-consuming and memory dependent. Sighted and adventitiously blind people may rely on visual memories of objects in order to build mental representations of objects explored haptically. However congenitally blind people cannot utilise visual memory and therefore it is of interest to understand the nature

and accuracy of their mental representations and the usefulness of mental representations developed through touch alone. Originally this experiment was to test the feasibility of a force-feedback device enabling blind people to haptically explore 3D objects in a virtual environment. The device would restrict cutaneous feedback and technical limitations would only allow use of the tips of two index fingers or the index finger and thumb of one hand. Thus the experiment tried to replicate these restrictions. The objects chosen were based on two potential applications for the device: exploring a sculpture, and exploring a 3D map. The feasibility study provides information on the viability of such devices and a basis for future research in the field.

2.1 Method

Twenty-nine blind, partially sighted and sighted people explored busts of Mozart and J.S. Bach, and a vacuum formed contour map. Participants wore rubber gloves and those with any sight wore blindfolds. The tips of the thumb and index finger, or two index fingers were used to explore. During exploration audio information was provided e.g. when an eye was touched, the tester said “eye”. After this, a detailed description of the objects was played. Those with sight were shown nine photographs of other composers and had to match the objects to the photographs, from memory.

2.2 Results & Discussion

Accuracy of Mental Representation. Participants gave a rating on the perceived accuracy of their mental representation. There was an even split, regardless of visual status, between those who felt their mental representation was poor and those who thought it was accurate, for both the busts and the map. Later, having explored the objects with their whole bare hands, or seen the objects (if they had any sight) and listened to detailed descriptions of the objects, another rating of mental representation accuracy was given. i.e. they were asked to rate how accurate their mental representation was now that they had more tactile, audio and/or visual information. With regard to the busts, some felt their mental representation was not as good as previously thought. But it was only partially sighted and sighted participants who thought this, implying either that blind people are better at developing a mental representation by touch than sighted people, but more likely, that blind people cannot see what they have haptically explored and so can only make a limited objective judgement on the accuracy of their mental representation. This is an inevitable shortcoming of this study. It may be impossible to know what type of mental representation a blind person holds and how accurate it is. Implications were that blind participants felt their mental representations were better than they actually were. One said “I don’t easily have a mental representation of 3D objects”. Another said: “It is difficult to relate something physical to an image. Trying to get me to understand what art looks like, is like getting someone who speaks a foreign language to appreciate my poetry.” In contrast, some sighted participants felt that their mental representation of the map was better than expected, but blind participants tended to think their map mental representation was worse than previously thought.

Audio feedback. Approximately two thirds of participants said that basic audio feedback was useful, but not vital, as a face is "standard" in terms of features. However the majority of participants felt basic audio feedback was useful for the map because, unlike the layout of a face, a map is not standard and its scope hugely variable. Blind participants particularly found the detailed audio description of the map useful whilst many partially sighted and sighted participants did not as they were accustomed to reading and interpreting maps without any audio description. Participants listened to detailed audio descriptions of the busts and were asked to match the descriptions to each bust explored. Two thirds made a correct match, regardless of visual status, but importantly, almost nobody made a correct match until the description of Bach was heard. Bach had a very distinct wig and as one participant said "I wasn't sure who was who when I had only heard the [Mozart] description. The description of [Bach's] wig gave it away". Virtually every participant based their match on Bach's wig. Thus information was gleaned by comparison and positive affirmations were not forthcoming without the help of cruder details, calling into doubt the usefulness of the information that can be gleaned about an object in this way.

Comparing what can be seen with what was haptically explored. Sighted and partially sighted participants thought the busts differed from how they had imagined by touch alone. Subtleties such as facial expression were not easily gleaned, if at all. Some implied that their mental representation of the busts was based on existing knowledge of busts of classical composers, rather than on what they gleaned haptically. When asked to match one photograph to each of the busts explored, a third of participants made an incorrect match, regardless of visual status. It was strongly evident that participants were making the match by a process of elimination as opposed to ascertaining the correct photograph through positive affirmation. With the map, sighted participants were most surprised that it was transparent and it differed from expectations in terms of height, depth and other details, with some thinking it had been a different size completely. Blind participants commented on how much quicker information could be gleaned and how much clearer it was, when explored with two whole hands. However, most felt that they had a good understanding of the relational heights of the map. Haptic exploration is serial and can mean that certain pieces of information that would be instantly gleaned visually are missed altogether. Two bodies of water were represented in the map, but only half of all participants correctly identified them. Partially sighted participants made slightly more correct identifications than other participants.

Ease of exploration. Number of fingers used and cutaneous feedback was restricted to replicate the restrictions that a haptic device would impose on the user. In the bust experiment, six participants felt that restricted exploration was difficult, fifteen were undecided and eight said they found it easy. Using two index fingers was considered by a few to be slightly easier than exploring with thumb and index finger, which some felt made it difficult to build a mental picture of how features related to each other. Visual status had effect. Some blind participants felt that braille reading experience was helpful, although many were tempted to use their other fingers because it was

"more natural" and it was harder to get an idea of three dimensions when exploration was restricted. Reduced sensitivity due to the gloves made it difficult to discern details. In the map test there was an even split with regard to perceived ease of exploration. Some preferred using two index fingers so that one could be used as a reference point whilst some said that the thumb combined with index finger helped in gauging distances. Speed of exploration was slow and often regarded as frustrating. Finally, some considered the map easier to explore because it was less complex in terms of features.

Preferred exploring methods. Participants were asked how much value is added to audio description by being able to touch the object being described. Most participants said that they would like the option of being able to touch an object, whilst listening to a detailed audio description. The second preference was haptic exploration with basic audio feedback, with last preferences for detailed audio description alone. In the experimental context most considered it desirable to have maximum information. The second most popular preference of 'touch plus basic audio feedback' was unexpected because many had previously said they gained a lot of information about the busts via detailed audio feedback, but not via the basic. It may be that people prefer the activity of touching, even though they may get less meaningful information. Preference was felt to depend upon context, e.g. if an exam was to be taken then their first preference would be touch plus detailed audio description, followed by detailed audio description alone, implying that indeed, basic audio feedback combined with haptic exploration might not be enough for gaining an accurate understanding of an object. Comments suggested that detailed audio description was informative, but touch was desirable to verify what was described. Similarly for map-exploring preferences, most felt that using a 3D map plus detailed audio description was maximising information. Although this seems obvious, it is interesting to note that information is often felt to be at its best when kept to a minimum, one blind participant said "information is redundant unless it is brief". Sighted people are most familiar with 2D maps with no description, so it would be interesting to know whether visually 2D maps would be preferred over 3D maps with detailed descriptions.

Perceived usefulness of the GRAB device. The majority of participants felt that a device which enabled exploration of a 3D sculpture or map in a virtual environment would not be useful. Two thirds of those who thought it would be useful were sighted. Only one blind participant thought the device would be useful for such applications. Often sighted people think a device may be useful to blind people when in fact blind people themselves might not be of the same opinion. A device like GRAB was generally felt to be a barrier to exploration whilst 2-D tactile diagrams were considered to be more practical, taking up less room and easily explored with both hands.

3 Conclusions

These studies consider the usefulness of both 2D tactile pictures and 3D haptic devices for blind people. Results suggest that redesigning tactile pictures with greater

knowledge of haptic perception may result in more useful 2D pictorial displays. Current technical limitations of 3D force-feedback devices severely restrict the nature of haptic exploration, thereby limiting their usefulness. Research in this area needs to address technical capabilities and the interpretation of user feedback. Both studies highlight a need to focus on the nature of haptic perception and exploration, the extent of previous visual experience and the opinions of end-users, when designing information systems for blind people.

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Microelectrical Mechanical Systems Actuator Array for Tactile Communication

Eniko T. Enikov¹, Kalin V. Lazarov¹, and Gilbert R. Gonzales²

¹ AME Dept., University of Arizona, 1130 N. Mountain,
Tucson, AZ 85721, USA
enikov@engr.arizona.edu
<http://www.ame.arizona.edu/>

² Memorial Sloan-Kettering Cancer Center, 1275 York Avenue,
New York, NY 10021, USA
gonzale6@mskcc.org

Abstract. Tactile perception of alpha-numerics is possible using a tactile illusion (TI). The illusory sensation of motion is produced by mechanical actuators applying points of pressure on the skin. Vibrating points induce a nonveridical perception of motion from point to point. Intact lemniscal and parietal cortex are necessary for perception of the TI and can be used as a neurophysiological testing tool and an additional human-machine communication channel. We describe a 4 x 5 actuator array of individual vibrating pixels for fingertip tactile communication. The array utilizes novel micro-clutch MEMS technology. Individual pixels are turned ON and OFF by pairs of microscopic thermal actuators, while the main vibration is generated by a vibrating piezo-electric plate. Physiological parameters required for inducing TI and the fabrication sequence for the thermal micro-actuators along with actuation results are presented. Fingertip perception of micro-actuators could be built into a variety of data acquisition interfaces for handicapped persons.

1 Introduction

Tactile perception of complex symbols such as alpha-numerics through fixed points of tactile stimulation is possible through a phenomenon known as tactile illusion (TI). Sensation of motion on the skin can be produced by a limited number of discrete mechanical actuators applying light pressure over the body surface. The tactile communication technology to date is dependent upon actuators, such as solenoids, piezos, shape memory alloy actuators, pneumatic devices, etc., that do not allow for the creation of easily portable miniaturized devices for handicapped persons. Tactile communication devices for blind persons are generally limited to transduction of written text into a cutaneously perceived and spatially discriminated format or a synthetic language such as braille. The cutaneous surface where tactile stimulation is perceived is generally large and applied over several body surface dermatomes by existing devices.

Our preliminary studies have shown that at given frequency of stimulation and number of vibrations per actuator point, the central nervous system (CNS)

interprets these stimuli as a continuous motion over the skin [1]. This phenomenon results from the transmission of afferent input from pacinian corpuscles through the lemniscal pathways and integration by the parietal cortex for the perception of various shapes and symbols, such as alpha-numerics. This phenomenon can thus be used as a neuro-physiological testing tool to determine central and peripheral nervous system integrity and injury as well as providing an additional human-machine communication channel.

Tactile communication [1] and both central and peripheral nervous system pathway integrity testing has been shown to be possible using a TI crossing multiple dermatomes [2,3]. Stimulating a single dermatome on the index finger (higher density of Pacinian corpuscles and greater cortical representation) may activate a single dermatome and spatially reduce CNS somatotopic activation. This may provide more precise determination of peripheral inputs needed to produce the TI ultimately effected by cortical activity. In addition, stimulating a single dermatome may assist in functional magnetic resonance imaging (f-MRI) studies to determine factors that may modulate TI discrimination as well as injury-associated sensitivity changes of the lemniscal system and define whether the TI perseveration or "tactile palimpsest" [2] is dependent on (1) multiple peripheral nerve or dermatomal activation, or (2) spatial summation in a single nerve or dermatome distribution.

This paper describes the first phase of the development of a 4 x 5 actuator array of individual vibrating pixels for fingertip tactile communication. More specifically we discuss the design and the fabrication of the MEMS actuators responsible for redirecting the vibration of a single vibrating plate to individual pixels (tactors). The array is approximately one square centimeter and utilizes novel micro-clutch MEMS technology. The design and the simulation of the MEMS array is described in **Section 2**, the fabrication sequence and the experimental results are presented in **Section 3** and **4** respectively.

2 Design of the Actuator Array

The use of the tactile actuator array as a neuro-physiological diagnostic tool has been previously demonstrated [2,3]. In this study the illusory effect was used to test the integrity of peripheral nerves, spinal cord sensory pathways and somatosensory cortical and sub-cortical areas in human subjects. The reported experiments were conducted using wrist-mounted solenoid device to measure the perception of numbers produced by tactile illusion. These initial studies on the tactile illusion phenomenon were the starting point in the design of a MEMS actuator array, capable of delivering cutaneous stimulation with much greater surface density, reduced size within a single dermatome and unit-cost. Some of the required actuator parameters measured by micro-solenoid experiments are listed in Table 1. To achieve these requirements we have developed a hybrid solution: (1) meso-scale vibrating plate driven by a set of piezo-actuators coupled with (2) MEMS mechanical switch (clutch), which re-directs the vibrations of to the individual protruding pins (tactors). A solid model of the MEMS array is

shown in Figure 1. The lateral dimensions are 15mmx15mm and the thickness is 150-500 μm (thickness of a silicon wafer).

Table 1. Settings on solenoid tactile illusion-producing device

Parameter	Value
No. of vibrations	Total number of protrusions of each solenoid while activated = 5
Required force	>10mN
Required displacement	>20 μm
Solenoid on-time	Time of core protrusion for each vibration of each solenoid = 10 ms
Solenoid off-time	Time of no active core protrusion for each vibration cycle = 10 ms
Solenoid delay	Time between end of last solenoid vibration and onset of next solenoid vibration = 5 ms



Fig. 1. Model of 5x4 array of micro switches for tactile illusion applications: Bottom View (*left*) and Top View (*Right*)

2.1 Construction

The MEMS array will be mounted on top of the vibrating plate assembly as illustrated in Figure 2. The pixels are turned ON and OFF by pairs of microscopic thermal actuators, while the main vibration is generated by a vibrating piezoelectric plate. A 3D close-up view of one pair of thermal actuators is shown in Figure 3. The actuator consists of a composite (polymer/metal) beam, which is heated by the electrical current passing through it. Due to the difference in thermal expansion coefficient of the polymer and the metal sections of the beam, it deflects towards the material with lower coefficient.

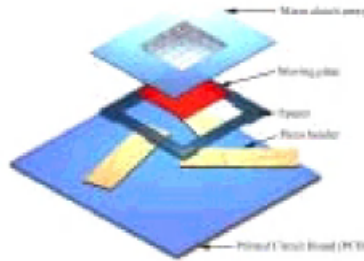


Fig. 2. Vibrating Plate Assembly

2.2 Simulation

A coupled finite element analysis with ANSYS was used to predict the displacement, the temperature rise and the response time of each of the thermal actuators. The composite beam was discretized using three dimensional tetrahedron elements - SOLID98, with 7 active degrees of freedom: temperature, displacement and current density. The result for the displacement is shown in Figure 3. The simulations show that the response time is limited by the rate of cooling of the thermal actuators, which is proportional to the temperature difference between the actuator and the substrate. In order to achieve the required response time, we cycle the actuator at elevated temperatures - between 200°C and 130°C . Since the displacement is a function of the temperature difference alone, the improvement in the response time is due to the faster cooling from 200°C to 130°C as opposed to cooling from 90°C to 20°C (same temperature change). A summary of the numerical results of these simulations for a single actuator is provided in Table 2.

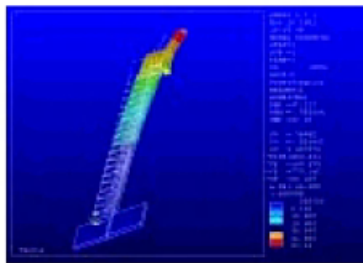


Fig. 3. Deformed shape of the thermal clutch (color designates displacements)

Table 2. Simulated actuator characteristics

Parameter	Value
Displacement	80 μ m
Length	1500 μ m
Width	75 μ m
Operating voltage	0.15V
Operating current	0.348A (per actuator)
Resistance	0.43 Ω (per actuator)
Power consumption	52mW (per actuator)

2.3 Power Consumption Estimates

The device consumes power for the thermal micro actuators, piezo-benders and the control logic:

$$P_{tot} = P_{th} + P_{piezo} + P_{\mu C}. \quad (1)$$

The power consumption of the thermal switches is $P_{th} = IV/\eta_t$, where V is the operating voltage, I is the current through the actuators and η_t is the conversion efficiency of the low voltage DC-DC converter. The estimated values are $\eta_t = 0.8$, $I = 350$ mA and $V = 0.3$ V, which results in $P_{th} = 131$ mW. The power consumed by the high voltage generator and driver is $P_{piezo} = 66$ mW, while the power consumed by the micro-controller is $P_{\mu C} = 3.3$ mW. Thus the total power consumption is

$$P_{tot} = 200mW. \quad (2)$$

Since the duty cycle is 25%, the average power consumption is $P_{av} = 50$ mW.

3 Fabrication

3.1 Processing Sequence

The thermal actuators are metal-polymer composite beams [6,7]. The polymer in this case is SU8 photosensitive epoxy and is used to achieve larger displacement in comparison to conventional thermal actuators. The individual factors are formed from silicon via single step reactive ion etching (RIE, Bosch process). The process flow is shown in Figure 4, with each step labeled separately. The thermal actuators are formed via electroforming [4] of metal inside SU8/photoresist mold. We are developing two types of actuators - copper and nickel. The copper version is designed to work in high-magnetic field environments such as MRI. A sacrificial layer of photoresist (steps 1-4, Figure 4) is used to release the movable structures from the substrate. In this design the SU8 is part of the permanent structure and does not require stripping step. The fabrication results are discussed in the next subsection.

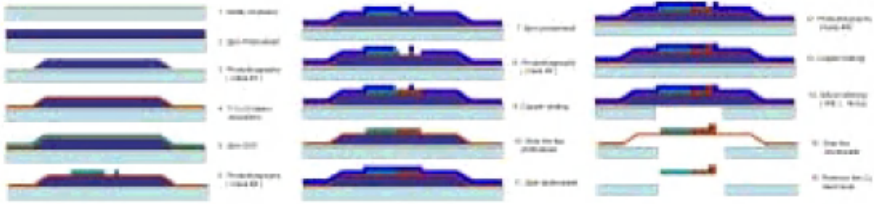


Fig. 4. Fabrication Sequence

3.2 Fabrication Results

At the time of this publication, the fabrication sequence was completed up to step 11 in Figure 4. The backside of twelve tactile arrays (copper) are shown in Figure 5. Each tactile array is enclosed by a U-shaped spacer structure and a standard connector array. In contrast with the usual thermal actuators [5],

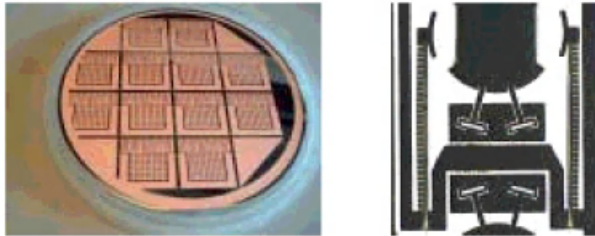


Fig. 5. Twelve fabricated tactile arrays (*Left*) and single thermal actuator pair after release (*Right*)

the composite beams utilize the difference in the thermal expansion coefficient between the SU8 and the metal [6,7]. A single pair of these actuators is shown in Figure 5(right). The two beams are connected in series and deflect towards each other upon current application.

4 Actuation Experiments

The released actuators were powered by a current source with currents ranging between 150mA and 250mA. Each actuator pair has a resistance of 1.6Ω . The total power used to displace one actuator ranges from 18mW to 50mW. We have measured displacements ranging from $23\mu\text{m}$ up to $69\mu\text{m}$ for the higher power limit (50mW). Transient response time was also measured. Since the CCD camera has a bandwidth limitation of 33Hz, we used an indirect technique to measure

the temperature change in the actuator. The method relies on the variation of the electrical resistance of the actuator due to temperature changes. The total resistance R_{tot} is the sum of constant series resistance R_s and variable actuator resistance $R_a(1 + \alpha(T - T_0))$. Assuming that the heating and cooling cycles have a thermal time constant τ_{th} , the average temperature change during cooling is

$$T(t) - T_0 = \Delta T e^{-t/\tau_{th}}, \quad \Delta T = T_{max} - T_0. \tag{3}$$

The voltage drop across the thermal actuator is then

$$\Delta V = IR_{tot} = I(R_s + R_a(1 + \alpha\Delta T)) = I(R_s + R_a) + I\alpha R_a \Delta T e^{-t/\tau_{th}} \tag{4}$$

We used a two level current source. High current level was used to heat the device to its working temperature and a low current level was used to monitor the change of the resistance during the cooling cycle. Figure 6 shows the voltage drop across the thermal actuator due to the two-level current excitation. As evident from the figure, the resistance increases during the heating cycle and decreases during the cooling cycle. Since it is always possible to decrease the time for reaching the operating temperature, it is important to find the cooling time, which is a function of the system itself and cannot be reduced by any other means. Assuming an exponential temperature decay as predicted by equation (4), a nonlinear curve fit yields $\tau_{th}=17ms$. Summary of all measured param-

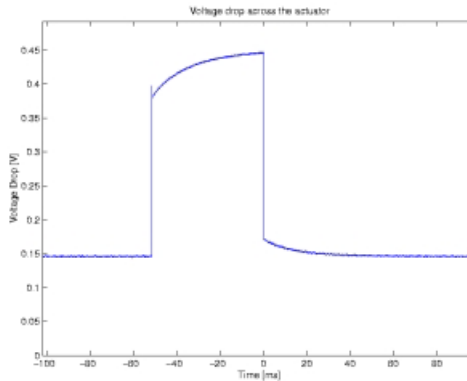


Fig. 6. Voltage drop during heating and cooling

ters is compiled in Table 3 below. The projected values from Table 2 and the measured values listed in Table 3 are in good agreement, except for the reduced values of the displacement. The difference can be attributed to the use of nickel instead of copper which results in higher stiffness of the actuator beam. Further, a noticeable de-bonding between the metal and the SU8 photo-epoxy occurred, which can further reduce the displacement.

Table 3. Actuation data

Parameter	Value
Displacement	23-69 μ m
Operating Current	150-250mA
Operating voltage	Less than 0.2V(per actuator)
Resistance	0.8 Ω (per actuator)
Response Time	17ms
Power consumption	50mW

5 Conclusions

The first phase of the development of tactile communication array has been presented. The critical component of the device - a switching mechanism based on polymer/metal thermal actuators has been discussed in detail. The simulated and measured performance data is in good agreement. One of the technical challenges is the adhesion between the polymer and metal. This problem can be eliminated using an additional adhesion layer such as self-catalytically deposited metal film or ion-beam sputtering. The small power consumption of the mechanical switches will allow their use in battery-powered devices. Although the demonstrated structure contains nickel, we are currently developing a copper-based actuator, which will be compatible with f-MRI environments for real-time neuro-physiological tests. This device can be used as a neurophysiologic testing tool to determine central and peripheral nervous system injury and provide an additional human-machine communication channel. Alpha-numeric and other complex symbols can be perceived as a rapid receptive communication device for blind persons and others.

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Designing Interactive Tactile Diagrams

Ben Challis

School of Engineering, Leeds Metropolitan University, Leeds, UK
b.challis@lmu.ac.uk

Abstract. Tactile diagrams are relatively easy to produce yet there are no standard guidelines to assist during the design process. Attempting to include as much information as possible can lead to diagrams that are simply too confusing to be of use. Research into a previous project on non-visual access to music notation (Weasel) has shown that an interactive multimodal approach to presentation could be of benefit in these circumstances. A set of design principles to assist with this process is discussed.

1 Introduction

One commonly employed method for producing tactile diagrams is to use swell-paper. Raised diagrams can be created by drawing directly onto the swell-paper but more accurate and detailed diagrams can be achieved using a computer and printer. However, the simplicity with which tactile diagrams can be produced is contrasted by the lack of standard guidelines available to be used during the design process. There is a substantial body of knowledge on the psychological properties of common tactile symbols [1,2,3] but until recently much of this information had not been brought together to make a usable set of guidelines. As a result, tactile diagrams are often unnecessarily complex.

1.1 The Weasel Project

One study into this area has explored possibilities for creating a computer-based approach to displaying music notation to blind people. The project, known as *Weasel* [4], aimed to demonstrate a new approach to the non-visual display of such notation but also aimed to establish a set of design principles that could be used to assist with the integration of tactile interaction into the human-computer interface [5]. It was quite apparent during the study that many of the principles would be likely to remain valid when applied to static tactile diagrams. In addition, the study also demonstrated that a multimodal approach to non-visual display (auditory-tactile) could be of benefit in terms of reducing unnecessary complexity within non-visual diagrams for many different purposes. In effect, a tactile diagram becomes a top-level means of exploration that can be further interrogated by pressing onto 'active' locations within the diagram. Speech and non-speech audio can be used to provide further levels of information. The design principles derived from the Weasel project are summarised in the following sections.

2 Design Principles

2.1 General Layout

A consistency of mapping should be maintained such that descriptions of actions remain valid in both the visual and the non-visual representations. It does not matter what a tactile diagram looks like so long as the mapping between it and what it represents remains valid.

A literal visual-to-tactile mapping is likely to produce problems and is therefore unlikely to be the most efficient strategy. Visual-to-tactile mapping will often result in areas of ‘empty space’; those areas on a diagram which do not communicate anything to the user. Finding adequate solutions to these type of problems may result in tactile diagrams that do not ‘look’ particularly good.

Good design practice should, where possible, encourage a specific strategy for exploration in a particular display. A user’s strategy for exploration may be unknown but a strategy can still be encouraged e.g. guidelines, networks, grids or columns.

A display should be sized and orientated such that users are not expected to overreach to discover the full display. Expecting individuals to reach too far to discover tactile objects will increase the likelihood that these objects are missed.

2.2 Tactile Symbols

Tactile objects should be simple. Complexity can be reduced by keeping tactile symbols simple and communicating further properties using speech or audio.

Both height and texture should be used to provide sources for filtering information. Height and texture both provide a means of representing comparative difference between tactile objects.

2.3 Interaction

Double-clicking is an inappropriate form of interaction within static displays. Little haptic feedback is available from an overlay on a touchpad and this makes certain actions difficult even with audio reinforcement.

Whenever possible, a user’s intuition to interact directly with tactile objects should be accommodated.

2.4 Non-visual Multimodality

A basic level of auditory reinforcement is necessary within static displays. At minimum an audible click or beep can be used to reinforce a ‘button-press’ action.

The tactile aspect of non-visual multimodal interfaces should focus on data that is static. Any information that can be considered dynamic will need to be conveyed using audio.

Combined auditory-tactile tasks should be tactually simple. The tactile aspect of a combined auditory-tactile task will usually be the slowest part; keep this simple.

3 Example Design Problem

A recent student project to create an audio-guide for a local visitor centre also attempted to include a tactile map for blind visitors. The map produced was visually accurate but was also quite complex to use. A direct visual-to-tactile translation had been adopted and this had resulted in a considerable excess of 'empty space'. Additionally, there was a complex path to follow; this changed direction frequently throughout the map. Successfully tracing such a path is a difficult task. There were also a number of tactile symbols that required learning. One of the most noticeable features is that to make the map 'look' okay the relative size of each room had been maintained even though this is of less interest than the content. On the map, the path changes direction frequently. In reality, there is only a single path available and this has handrails on both sides for much of the time; the path may change direction but the visitor cannot wander from it. In fact, much of the detail on the map would not really be required.

Other approaches could have been adopted. A grid of boxes arranged in rough approximation of where each house lies in relation to the next. Small points connected by simple straight lines displaying the approximate direction of entry and exit to each house. Whichever approach is used, many of the items that were confusing the map could be transferred to the audio domain; the tactile map would become a very simple structural overview.

4 Conclusion

If tactile diagrams are designed to look like a visual counterpart it is likely that they will be inefficient in practical use. It follows on from this that an efficient tactile diagram may not actually 'look' that good; appreciating this should probably be the first-step towards a better strategy for design. Unnecessary tactile complexity can be reduced by adopting a multimodal approach to diagram display.

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3D Audio in the 21st Century

Damian T. Murphy, Michael C. Kelly, and Anthony I. Tew

Music Technology Research Group, Department of Electronics, University of York,
Heslington, York, UK, YO10 5DD
{dtm3, mck104, tew}@ohm.york.ac.uk

Abstract. 3D audio is concerned with the artificial construction and playback of realistic and stable sound images within a Virtual Auditory Space and has been shown to be useful within the context of the human computer interface. This paper examines some of the issues informing current research in 3D audio and personalised, binaural sound, highlighting potential problems and discussing solutions and future directions for this work.

1 Introduction

The ultimate goal in 3D audio is to artificially construct a complex three-dimensional Virtual Auditory Space (VAS) that is indistinguishable from what we normally hear around us. The potential result has many applications especially in the development of alternative computer or virtual reality interfaces for visually impaired users.

Although 3D audio systems are now widely available, often being designed into modern PC soundcards and home entertainment systems, they have as yet to be exploited effectively for this particular user group. The notion of Auditory Icons or Earcons, as used to present information in a Human Computer Interaction (HCI) based environment dates back to the late 80s [1]. The use of personalised binaural sound or 3D audio technology to render these Earcons became popular through the early 90s with advances in computing and DSP power. However, the wider acceptance of this technique has been hindered by the often variable results that are produced. If a consistent and useful 3-D audio based human-computer interface is required then this will ultimately depend on the accuracy of the 3-D audio rendering engine used, so that robust and repeatable results can be produced for all users.

2 The Head Related Transfer Function

The amplitude and time delay differences imparted on a sound source arriving at both ear drums due to the shape of the head together with the additional spectral differences caused by the complex shaping of the outer ears (pinnae), result in the binaural head related transfer function (HRTF). These HRTFs vary with sound position and can be obtained via an analytical signal and used to filter any audio material such that it appears to emanate from the original source location. HRTFs are therefore a core element of any 3D audio system and, as each individual has a unique

set, the best perceptual results are usually achieved with the listener's own measurements. However, obtaining reliable, accurate, individual HRTF data is neither practical nor possible to carry out for all those who might benefit from such a set of measurements. As an alternative, a more generalised set of HRTFs can be measured and obtained from a single generic dummy head although this can affect the perceived accuracy of the VAS in terms of timbre and spatial localization for some listeners.

Implementing a head-tracking system to monitor the position of the listener's head and update the HRTF pair used accordingly, significantly improves the stability of the VAS due to sound sources maintaining their relative positions as the head moves. Such systems offer improvements in localization [2] with results comparable to natural hearing even when dummy heads are used [3].

Headphones are usually used to audition a VAS as they allow the most accurate control over what is delivered to the listener's ears. However an associated problem is the lack of environmental context leading to "in head localisation". This can be resolved, resulting in general improvements to VAS quality, when the HRTFs used also include the response of a room via reverberation or acoustic modelling [2]. Using early room reflections rather than full reverberation gives equivalent results with a more efficient acoustic representation. In head localisation and the general discomfort and isolation that arises from wearing headphones can also be alleviated by multi-speaker presentation and an optimised transaural processing scheme [4]

3 Image Resolution

An earcon based human computer interface is also limited by the spatial resolution of the hearing system. The positioning of our ears ensures optimum localisation in the horizontal plane. The most accurate localisation occurs for sounds placed directly in front where average judgement errors for source positions are around ± 5 degrees, although we are able to determine discrete angular separations of around 1-2 degrees. Where multiple sound sources are present, localisation accuracy and intelligibility of individual sources are potentially reduced. In certain HCI applications where there is a requirement to present multiple sound images, one or both of these consequences may lead to errors in perception. However, localisation and intelligibility are maximised by increasing separation between competing sources [5]. Further, the greater the variation in spectral, temporal and spatial characteristics between individual sources, the more sources can be effectively rendered.

4 VAS Presentation and Processing Considerations

Despite increases in computing power, the real-time processing required for HRTF based 3D audio VAS realisation is still a relevant issue for consideration. Each sound source requires separate spatialisation, effectively limiting the total number of simultaneous sources that can be processed. The relatively short filter lengths required for HRTFs (around 5ms) cause few problems although when reverberation is included the filters can be several seconds in length introducing significant processing overhead. Similar overheads are incurred if early reflection imaging or room models

are implemented as an alternative to full reverberation. Real time processing is paramount in applications using head tracking as interpolation between HRTF measurement points will be required, potentially introducing unwanted artefacts or an unacceptable delay.

Further difficulties lie in finding efficient ways to store a VAS and minimise processing requirements at the point of reproduction. One solution involves dynamic sound source placement based on amplitude panning for surround-sound systems or using an encoding scheme such as Ambisonic B-format. HRTF based processing over headphones is then used to render virtual speaker locations around the listener, as before. Individual control of the sound sources within the VAS is normally realised at the encoding stage being considerably less computationally demanding than the manipulation of a potentially large HRTF database.

Spatial manipulation of sound sources in a pre-generated VAS usually relies on the representation of separate individual sources at the receiver. This requires a high bandwidth proportional to the number of sources. Kelly and Tew are currently investigating methods for reducing this bandwidth by exploiting perceptual redundancies within a multisource VAS [6].

5 Conclusions

Despite advances in the understanding and implementation of 3D audio there is still some way to go before arriving at our ultimate goal. For the interface designer working in the area of HCI for the visually impaired there is a requirement to work with a wider knowledge of the perceptual and acoustic matters at hand. Accurate generalised HRTF measurement, head-tracking, reverberation and VAS encoding and presentation have all been highlighted as areas of significance.

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Going Places with “KnowWare”: Virtual Reality Maps for Blind People

Myron W. Krueger¹ and Deborah Gilden²

¹Artificial Reality Corporation, Box 786, Vernon, Connecticut 06066, U.S.A.
Myronkru@aol.com

²The Smith-Kettlewell Eye Research Institute
2318 Fillmore Street, San Francisco, California 94115, U.S.A.
debby@ski.org, <http://www.ski.org>

Abstract. Through a combination of gesture input with audio output, the KnowWare™ system offers blind users a new way to access spatial information. An invisible virtual map is defined on the desktop. When the user “touches” a feature on the map with the tip of an index finger, the computer identifies that feature via generated speech or synthesized sound codes. “Touching” (merely placing the finger on a virtual feature that cannot be seen or felt) is detected by means of an overhead video camera that looks down at the user’s hands as they rest upon the desktop. Because KnowWare™ is an electronic medium, it can instantly zoom in on a particular country to display it in more detail. The twenty blind subjects who have tested KnowWare™ were able to use it for most tasks as well as they do traditional raised-line maps.

1 Introduction

While there have been many efforts over the years to provide the vision-impaired community access to information, these efforts have not kept pace with the new technologies that are becoming available to the sighted. As a consequence, blind consumers are actually falling farther behind rather than catching up. Screen readers make Windows™ applications accessible, but they circumvent the spatial layout, rather than making it available to the blind user.

The need to present two-dimensional information has traditionally been addressed through raised-line tactile graphics. These materials remain expensive to produce, cumbersome to store, and difficult to distribute.

There are also electronic aids for the blind. The Optacon and SKERF Pad were limited to reading text. The TAG (Tactile-Audio-Graphics) system from Repro-Tronics is an improved version of an earlier device--the Nomad. It combines a raised-line overlay with a touch pad. The complete system costs \$1700.

The most important problem with currently available approaches is that their inherent design makes it impossible for most blind people to have access to them.

2 KnowWare™ Concept

KnowWare™ was conceived by Dr. Krueger in the early 1970s. [1] [2] The research described here was supported by grants from NIH and The Smith-Kettlewell Eye Research Institute. [3] [4] [5]

To use KnowWare™, the blind user sits at an illuminated desk with a translucent tactile grid scored on its surface. His/her hands rest upon the surface of the desk and are viewed by a ceiling-mounted video camera. An invisible virtual map is defined upon the surface, and when the user's index fingers "touch" a feature on the map, the name or category of that feature is communicated to the user through sound. That sound can be sampled speech, computer-generated speech, representational sounds, or musical tones.

KnowWare™ is an electronic medium and can zoom in on a single state or country to allow the user to explore its boundary in more detail. For this study, a tone indicated that the user's index finger was inside the boundary, and short clicks signaled that the finger was on the boundary. When two fingers are used, each receives a distinctive sound.

3 KnowWare™ System

The KnowWare™ system is based on a patented video processing technology which finds the edges of the fingers, follows the contour of the hands, and makes measurements across the boundaries to identify the tips of the fingers. [6] The locations of the fingers are determined 30 times a second and posted in hardware tables without placing any demands on the processor.

While KnowWare™ was conceived to provide access to all kinds of spatial information including diagrams, flow charts, spread sheets, and page layout, geographic information was chosen as a starting point. The KnowWare™ system allows users to look at the political boundaries in any of the world's continents and hear what country their fingers are pointing to at any given moment. They can also select any state or country and have its map expanded to fill up the entire desk surface in order to examine it in more detail.

4 Testing

The investigators performed a more rigorous comparison of blind people's ability to use KnowWare™ with their ability to access the same information from traditional raised-line maps. Our hope was that the subjects would be able to locate map features with KnowWare™, although we assumed it would take them longer than with tactile graphics. Fourteen adult braille readers participated. Half were exposed to KnowWare™ first and then tested with raised-line maps. The other half were tested with tactile materials followed by KnowWare™. The countries of Africa were used because they are unfamiliar to most Americans. Even though all of the subjects had used tactile materials extensively when they were in school, we allowed them only 10

minutes of familiarization with KnowWare™ before we started testing them on it.

The subjects were given similar tasks on the two technologies including: finding specific countries, identifying their neighbors, comparing their sizes to that of other countries, and describing their shapes.

We discovered that subjects’ overall performance was faster using KnowWare™ than with using the raised-line materials, at the .03% level of significance. All but two of the subjects strongly preferred KnowWare™.

KnowWare™’s advantages stemmed from the inherent weaknesses of tactile materials rather than from the maturity of its own techniques, which we believe can be significantly improved.

5 Opportunity for KnowWare™

KnowWare™ is an all electronic medium. It can be used to present almost any kind of diagrammatic spatial information. Content for it can be developed by sighted volunteers using standard GUI interfaces and be instantly ready for consumption by blind people all over the world via the Internet. Unlike tactile technologies, the KnowWare™ system lies in the mainstream of technological development. The cost of the requisite video cameras and image processing is approaching zero.

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Mental Models of Blind Users in the Windows Environment

Sri Hastuti Kurniawan and Alistair Sutcliffe

Department of Computation, UMIST
P.O. Box 88, Manchester M60 1QD, U.K.
{s.kurniawan, a.g.sutcliffe}@co.umist.ac.uk

Abstract. The study investigates blind computer users' mental models in Windows environments through interviews and user observation. Five blind users described their strategies in dealing with a new Windows application. The study showed that blind users had similar and highly structured strategies. They adopted three stages of strategy: exploration, task-action and configuration. Blind users were also observed to have three types of mental models of the Windows environment: structural, functional or a combination of these two models. Users have more problems in using a new application when there is a mismatch between the user's established mental model and the way the application works.

1 Introduction

For blind and visually impaired people, computers are considered as one of the keys to their occupational and social integration [1]. Blind and sighted users acquire mental models of computers and the Windows environment in a slightly different way. Sighted users have a general mental model of Windows as a collection of visible objects, and organised metaphor as a graphical space with menus, buttons and icons, which unburdens them from memorizing commands and reading long sections of text on the screen [3].

Holst [2] speculated that blind users may possess two alternative mental models: 1) Users do not know what the screen looks like; they usually memorize a large set of options to achieve a given effect, and 2) Users have a good cognitive or mental map of the screen.

Despite a general understanding that blind users interact with computers in a different fashion compared to sighted users, little research has investigated mental models of blind users. The present study aims to investigate blind users' mental models in Windows environment and a screen reader and their strategies in dealing with a new Windows-based screen reader.

2 Methods

Five blind computer users who accessed computers using screen readers on a regular basis were recruited to participate in the study. All of them were familiar with the

Windows environment, screen reader software and word processors or text editors. The experiments consisted of a short session of interaction with a new screen reader application to perform simple text editing with Microsoft Word for Windows 2000 in experimenter's lab. The experiments were captured using video recording equipments directed at the screen and participants' hands. The video records also incorporated participants' comments and the outputs of the speech synthesizer. Afterwards, participants were interviewed to acquire their mental models of Windows environment and screen reader and their strategies in dealing with new application. Users' mental models were derived from interviews and observations of user interactions. Participants' demographic data are listed in Table 1.

Table 1. Participants' demographic and computer experience data

Participant	CE	BH	PH	SS	RS
Gender	M	M	M	F	M
Age (yrs)	54	31	44	47	36
Computer use (yrs)	13	21	24	31	12
Job	Unemployed (IT background)	Education officer	Second line IT support	Student	Lecturer in Computer Science
Screen readers used	JAWS	HAL, JAWS, Window Eyes, Window bridge, LookOut	HAL	HAL, JAWS, Window Eyes, Outspoken, IBM Screen reader	JAWS, IBM Screen reader, Vocaleyes
Blindness	Some vision	Total	Total	Almost total	Total
Blind since	1966	birth	birth	birth	1989

3 Results and Analysis

3.1 Mental Models of the Windows Environment

Three users visualized the Windows environment as a one- or two-dimensional arrangement of icons or symbols associated with applications. Each application is represented by a physical location on the desktop. This model is called a *structural* mental model. However, some individual differences were observed. One user described the desktop as a place where he can move from object to object without imagining any geometrical structure. Another user pictured a strict column and row array of icons.

Users with structural mental models run into problems when the applications were not arranged in a pattern that matched their mental models. Some participants had

problems finding a file because they expected a one-dimensional array (hence only used the up and down arrow keys) while the directory was arranged as a two-dimensional array. As one user suggested, a good screen reader should tell users that there were still items on the left/right of the highlighted item. In broader terms, a screen reader should provide information about the layout of a desktop.

One user associated each application in the computers with a user-defined shortcut key (e.g. CTRL+MW = Microsoft Words). In other words, their mental model of the Windows environment is a series of functions and commands. Therefore, this model can be called a *functional* mental model.

Participants with functional mental model were less dependent on how the applications were arranged on the desktop because they associated each application/function with a shortcut key. Difficulty arose when using a new desktop with different shortcut key-to-application mapping. This problem can be alleviated through informing users about available applications on the desktop and their associated shortcut keys and providing wizard to redefine the shortcut key associated with each application.

One user associated part of the windows environment with shortcut keys and part of it with a structure. For example, to get to Microsoft Word, press ALT+P (for program) and Microsoft Word is the fourth item from the top of the list. This mental model is simply called a *hybrid* model.

Two mental models of the Windows environment were mentioned. Some participants thought of the desktop, windows applications and screen reader as an integral whole, hence they did not have separate mental models for each. Others thought of them as three different entities. It can be argued that participants with structural mental models would think of these three items as separate entities, with the windows being the placeholder of the icons (which represents the applications) and the screen reader being the vehicle that describes where the icons were in relation to the placeholder. Participants with functional mental model will be more likely to think of these three items as inseparable because at the end every command was just a shortcut key (as one participant remarked).

There were additional comments on mental models, such as that they did not bother forming a mental model of a complex diagram/structure because the screen reader will not have the capability to describe it to them. This represents a challenge to software developers to build an application that can describe a complex diagram/structure or a desktop layout to blind users.

3.2 Strategies in Coping with a New Windows Environment or Applications

The study observed that blind users adopted similar strategies in dealing with a new Windows application. Their strategies are depicted in Figure 1.

Blind users in general adopted three stages of strategy in dealing with a new system: exploration, task-action and configuration. In the exploration stage, users first explored the desktop to see what applications were available. Depending on their need, they would then explore the necessary application. When the application was new, users iterated between discovering and trying out new functions. In this loop, users utilized either the system's help or an existing mental model to help remembering and learning the features. The result of the exploration stage is a refined or expanded mental model. In the next task-action stage, users created another loop of

planning how to interact with the system and executing the task. When the planning didn't achieve the action they desired, they changed strategy. For example, when a shortcut key did not achieve the result that a user wanted, he changed strategy by selecting the desired command from a pull-down menu. The last stage was the configuration stage, which users only performed after they were comfortable with the application. In this stage they configured the application, e.g. by redefining shortcut keys.

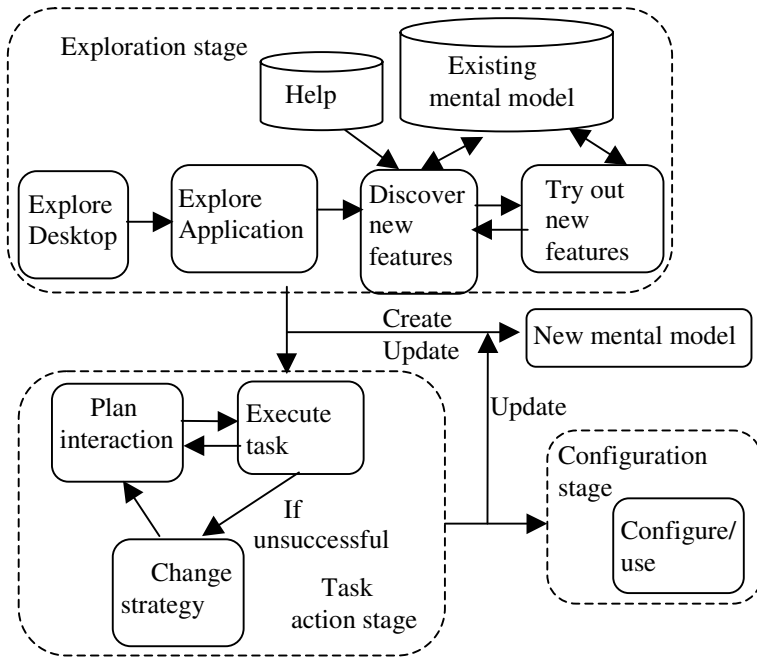


Fig. 1. Flow diagram of strategy in coping with a new Windows environment or application

Individual differences were observed in users' strategies. Some participants had a highly procedural strategy, while others were much quicker in changing strategies when their current strategy failed. Some spent more time in performing trial and error experiments, while others immediately asked the experimenter when they got stuck with a problem. Some users blamed themselves when the system did not do what they expected, while others quickly blamed the system.

When help was needed, some participants preferred to seek help from other users from a mailing list for blind users, while others preferred help from sighted colleagues. It was observed that most participants mentioned that they would only seek outside help as the last resort. Some participants preferred Braille manual while others were content with online help and virtual cursor mode.

Although all participants described their strategies in coping with new windows environments or applications, some mentioned that only very occasionally did they face a totally new environment or application. Therefore, there were some expectations that the new system was similar or could be configured with carried-over knowledge of the previous system.

3.3 Problems of Established Mental Models When Learning a New Application

Because participants recruited for the study were experienced in using a different screen reader, it was expected that they would have problems when using a new screen reader due to mismatch of the established mental model and the way the new screen reader works. The problems were recorded from observation of user interactions as well as participants' comments and answers to the question: "What are the differences you encounter between this screen reader and your current screen reader that bother you?"

Three types of mismatch were observed. The first was in overlapping shortcut keys between Microsoft Word and the tested screen reader. Both applications used the same shortcut keys for different functions (e.g. ALT+N is for creating a new file in Microsoft Word and it is a bypass key in the tested screen reader), causing interference between the user's established mental model of how Microsoft Word works and the assignment of shortcut keys in the new screen reader.

The second type of mismatch consisted of features that the participant's screen reader had that were missing from the tested screen reader (e.g. shortcut keys to read the whole document). The third type of mismatch was caused by the tested screen reader performing a certain function differently from the participant's normal screen readers (e.g. participants considered "CTRL+numeric keypad", which a popular screen reader uses, as the appropriate way of assigning shortcut keys).

Different users had varying tolerance toward these mismatches. While some users would find an excuse for it ("It is fine because this product is perhaps the least expensive screen reader in the market"), some expressed a strong opinion ("I *hate* this interference"). Although there was no evidence that degree of tolerance is an indicator of willingness to use a product, it might be induced that the stronger the intolerance is, the less likely a user would be to use the product in the long run.

In addition to the intolerance voiced by users, these mismatches also added difficulties to remembering the shortcut keys. Some participants complained that, unlike in the case of the screen readers they were used to, the shortcut keys of the tested screen reader were hard to associate with the actions.

3.4 Participant's Mental Model of a Screen Reader

To understand the participant's mental model of a screen reader, participants were asked "What features do you think a good screen reader should have?" The answers were expected to mirror the participant's established mental model of a screen reader.

The most important feature suggested was one that enables blind users to finish their tasks more efficiently. As one participant commented, blind users are keyboard-based, as compared to sighted users who are mostly mouse-based. Therefore, powerful and easy-to-remember combinations of shortcut keys are important for them. Participants in the present study suggested a vast range of shortcut key combinations, mostly based on the features they observed from the screen readers they were used to. Because of the nature of the task environment in the present study, some suggestions were related to text editing (e.g. shortcut keys for cutting/copying a paragraph).

The second feature mentioned was audio-related. For blind computer users, audio provides most if not all of the information they need to perform a computer task.

Therefore, it is important for a screen reader to provide the audio information at the right time and to have user-controlled verbosity. As one participant remarked, although a rich audio environment was beneficial to blind users in most cases, when the computer talked or made sound, users tend to stop whatever they were doing and listened to the computer. Hence, it is important to provide the audio information only when needed and in an unobtrusive way unless the sound indicates a warning with severe consequences. One user also suggested a feature of temporarily disabling the speech without unloading the program, especially in the case of computers that have to be shared with sighted users.

The next suggested feature was setting flexibility. A screen reader has to cope with many different applications and levels of user's expertise and experience. Therefore, it is important for a screen reader to have global and application-dependent settings as well as novice and expert modes.

Blind users also wanted to see features that will help shorten their learning curve, e.g. virtual cursor mode (a mode which allows them to look around the desktop or the overall application and to get information on available and greyed out menus), screen review mode (the ability to visit menu items and physically try out the shortcut keys without actually executing them) and task-time (e.g. a shorter verification question) when using a new application, especially because they felt that they need to compete with sighted users in information technology use.

Blind users are prone to editorial problems due to inability to view a document's layout. Therefore, there were several suggestions on features to help minimize these problems, such as warnings on accidental CAPS LOCK, and shortcut keys to give them information on a document's layout (font size and type, justification, spacing, etc).

Finally, as with any other products, reliability and product quality (including product upgrade and technical support) were a concern for users. Blind users in the present study translated reliability as the ability to recover after crashes. Because Windows environment and screen reader were inseparable for blind users, there was an expectation that the screen reader should be uploaded automatically when Windows is reset after a crash.

4 Conclusions

The present study investigates blind users' mental models in the Windows environment. The findings indicate that users have the second type of mental model suggested by Holst [2], although they were observed to possess different types of mental map. The observations derived from the study highlight the importance of understanding blind users' mental model to improve the usability of Windows applications for blind users.

Blind users possess either a functional or structural mental model or a combination of the two. Each model has its requirements that need to be satisfied by developers of screen readers. They also adopt a rich and highly procedural strategy for interacting with a new system or application, as described in Figure 1.

The study showed that when users already possess an established mental model, a mismatch between users' mental models and the new system can potentially cause problems when learning a new system.

5 Implications for Practitioners

The study shows that a user's established mental model can contribute to problems when learning a new system when the new system does not match their established mental model. However, although Redish [3] suggested that it is very difficult to change an established mental model substantially, participants of our study were certain that it would be possible to alter their established mental model if they were given enough exposure to the new system. It is then necessary to provide good training, a manual or help to new users to assist them to re-establish their mental model to match the new system.

In summary, the study highlights the need for system designers to:

1. Help users acquire a mental model of the screen overview mode.
2. Assist users refresh their mental models through the help sub-system.
3. Provide an option to customize user interfaces based on users' preference and abilities.

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An Approach to Producing New Languages for Talking Applications for Use by Blind People

D.G. Evans, K. Polyzoaki, and P. Blenkhorn

Department of Computation, UMIST, PO Box 88, Manchester, M60 1QD, United Kingdom
{g.evans, p.blenkhorn}@co, kleanthi.polyzoaki@postgrad
.umist.ac.uk

Abstract. This paper describes an approach that allows text-to-speech synthesisers to be produced for new languages for use with assistive applications. The approach uses a simple rule-based text-to-phoneme stage. The phonemes are passed to an existing phoneme-to-speech system for another language. We show that the match between the language to be synthesised and the language on which the phoneme-to-speech system is important for the perceived quality of the speech but not necessarily the understandability of speech.

1 Motivation for and Introduction to the Work

The work described in this paper is motivated by ongoing work in the development of screen readers. Our screen reader (LookOUT [1]) uses the Microsoft Speech Applications Programming Interface (SAPI) [2] in order to speak. In simple terms, LookOUT makes a call to SAPI, passing the text to be spoken as a parameter. SAPI uses one of the voices from one of the installed SAPI-compliant speech engines¹ in order to speak to the information. Other functions, such as stopping the speech synthesiser can be performed by making other calls to SAPI. The use of SAPI is beneficial² to the user because he/she can select an appropriate speech synthesiser that matches his/her requirements in terms of language, intelligibility and quality. From the authors' perspectives as developers of assistive software, a variety of speech engines can be driven through a single well-documented interface.

¹ A speech engine is provided by a particular manufacturer and is generally capable of speaking one language. A speech engine can have more than one voice, each voice has different characteristics. Many speech engines provide two voices, a male and a female, but some engines provide a greater variety of voices.

² The comments made here apply not only to the use of SAPI, but also to the use of any well defined speech engine interface used in the context of an assistive tool such as a screen reader.

There are a number of freely available SAPI-compliant speech synthesisers for the major languages³. There are also a number of other SAPI-compliant speech synthesisers that either have different speech characteristics with regard to speech quality and perceived naturalness or support different languages. However, there remain a significant number of languages that are not supported by a SAPI-compliant synthesiser or, where such a synthesiser exists, it may be of relatively high cost. Our work is motivated by the need to provide low-cost speech synthesis support for screen reader users who do not have access to SAPI-compliant speech synthesisers.

Our goal is to be able to produce speech synthesisers for new languages that are suitable for use with a screen reader. In doing so, we wish to expend the minimum amount of time in developing the new language and make it available at no cost to the user. We contend that for use with a screen reader, the minimum requirement is that the speech has to be consistent and understandable, but does not necessarily have to be the especially natural sounding or indeed linguistically accurate. The key requirement is that the speech synthesiser speaks the language consistently and can be fully understood by a speaker of the language. In this paper we describe a very simple approach, which we refer to a ‘gibbering’. This can produce acceptable quality speech with relatively little effort. However, it does require the existence of a freely available SAPI speech synthesiser for a ‘related’ language⁴.

The goal of our work is to produce a TTS system that can be configured in the minimum amount of time. It should be possible to configure the system by constructing a small number of text-based tables (these are explained later). The scenario by which a new language is created is that someone familiar with the format of the rule tables uses a relatively simple source of information (such as a phrase book) to construct the rules. The synthesiser will then be evaluated with a native speaker and the rules will be fine tuned. This will not result in perfect speech and the degree of naturalness and linguistic accuracy will be below that of a full implementation provided by a speech synthesiser manufacturer. However, the speech should be understandable after a period of acclimatisation.

2 Speech Synthesis

In this section we give a brief introduction to text-to-speech (TTS) synthesis. In doing so some simplifications and generalisations will be made. A TTS can be broken down into two major stages, which will refer to as the Text-to-Phoneme stage (TtP) and the Phoneme-to-Speech (PtS) stage as shown in Fig. 1. In this paper we are assuming that the TtP passes a stream of Phonetic Element Triples (PETs) to the PtS stage. A PET is the identification of the phoneme to be spoken, the duration of the phoneme (in

³ These can be found at <http://www.microsoft.com/MSAGENT/downloads.htm>. American English, British English, Dutch, French, German, Italian, Japanese, Korean, Brazilian Portuguese, Russian and Spanish are available for SAPI 4 at the time of writing.

⁴ The meaning of the term ‘related language’ will become clear later. In short, we mean that the ‘related language’ is similar to the language that we wish to synthesize in terms of its set of phonemes and prosody (pitch and duration variation).

milliseconds) and information about the fundamental frequency (F_0) of the phoneme (which may vary during the phoneme).

The TtP stage is responsible for translating the incoming text stream into a stream of PETs. This means that the incoming text must be translated into a phonetic representation and the prosody (pitch and duration) of the phoneme stream must be determined.

In a modern speech synthesiser, the text stream is pre-processed (or normalised), this translates text items that are not full words, such as numbers and abbreviations, into their written equivalents (for example in English 37.65 becomes “thirty seven point six five and €37.65 becomes “thirty seven euros and sixty five cents”).

The text is then converted to phonemes on a word-by-word basis. In many systems there are three stages to this. Firstly, an attempt is made to find the word’s phonetic equivalent in a dictionary, if it is present the equivalent set of phonemes are used, if not the word is broken down into its morphs.⁵ The system then looks up the morphs in the dictionary. If a morph is present, its phonetic equivalent is used. If it is not found in the dictionary, letter-to-sound rules are then used to produce the phonemes from the text.

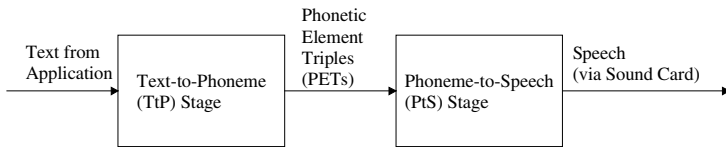


Fig. 1. A simple view of the architecture of a TTS system

The prosody (pitch and duration) is also determined from the text stream. This is often achieved by syntactically parsing the text to determine the parts of speech of the words (so to determine stress) and the mood and structure of the sentence (to determine the overall pitch contour). By employing one or more of a number of algorithms the pitch variation and duration for each phoneme can be determined.

The PtS stage is responsible for converting the PET stream into the information required to drive the sound card to produce speech. There are two major approaches to implementing the PtS. One approach uses the concatenation of speech elements (diphones, triphones or demisyllables) that have been recorded by a human speaker. The appropriate speech element is replayed (with suitable pitch and duration modifications) in response to the incoming phoneme stream. The second approach is to use a formant synthesiser, which is a software model that models or ‘emulates’ the output of the human vocal tract. The PtS stage controls the parameters of the formant synthesiser according to the incoming phoneme stream.

Recalling that the goal of our work is to produce new synthesisers with the minimum of effort, a TtP stage that relies on large dictionaries, with or without

⁵ A morph is the “*smallest sequence of phonological units into which words are divided in the analysis of morphemes*” [3] and a morpheme is “*a unit of grammar smaller than the word*” [3].

morphological decomposition, is quite labour intensive. An approach based on rules, on the other hand, is much more feasible. A reasonable first cut translation from text to phonemes can be accomplished in between 100 and 200 rules for many languages, and the quality of the translation can be improved by the addition of new rules that capture exceptions and subtleties of pronunciation.

The PtS system is, in the general case, probably best implemented using a formant synthesiser because the parameters can be adjusted for the phonemes of the target languages relatively easily. A concatenative speech synthesiser would require that the speech elements be obtained (there are around 1600 diphones and 3000 demisyllables in English [4]). This obviously requires considerable effort, especially as the samples have to be recorded and processed with considerable care. However, as we indicate below, the approach that we have adopted does not require the construction or alteration of PtS system because we use an existing PtS system for another language.

3 The Gibbering Approach

The approach relies on that fact that some commercial and other speech synthesisers accept a stream of phonemes as input. For example, the Lernout and Hauspie TTS3000 speech engines⁶ will accept phonemes as well a text as input. It should be noted that these engines accept phonemes rather than PETs, so there is no requirement for the pitch and duration information to be computed, because this is handled by speech engine. Given that a speech engine exists for a given language (referred to here as the ‘base language’) and that it accepts phonemes, the TtP stage can pass it phonemes that correspond to speech in another language (referred to here as the ‘target language’). There are a number of restrictions on the choice of the base language for a given a target language the most significant of which is that the base language’s set of phonemes should approximate to that of the target language. The resultant system is shown in Fig. 2.

To produce a new language the TtP stage needs to be configured for the target language. This requires that a pre-processor and a text-to-phoneme translator be developed. Currently the pre-processor requires code to be developed to handle the abbreviations and numbers in a language. However, ongoing work is investigating the use of table-driven normalisation, so that a text file can be used to specify many, if not all, of these rules.

The text-to-phoneme translation uses a rule-based approach. The rules are contained in a text-based table and applied by a generic piece of software that is capable of applying any appropriately specified rule set. Thus, to construct a new language the text to phoneme rules for the target language need to be developed and encoded in a table. It is important to realise that the phonemes specified in the table must be those supported by the speech synthesiser. The rule table format is similar to that presented in [5] for text-to-Braille translation. The basic rule format is:

Left Context [Focus] Right Context = Phoneme String

An example taken from the Welsh TTS for the letter ‘l’ is

⁶ Found at <http://www.microsoft.com/MSAGENT/downloads.htm>


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1 [11] _ =hT
1 [11] =hT1
[11] =h1
[1] =1

```

The rules are operated on the following way. The next letter in the text stream to be translated is set to be the focus. The first rule that has a focus that starts with this letter is then applied. The procedure for matching a rule is as follows. Firstly, the system attempts to match the text stream with the focus. In the Welsh example given above, the focus will match for all four rules if the next letter is an 'l' (el) followed by a second 'l'. If only a single 'l' is present, only the fourth rule matches on focus. If the focus matches the system then attempts to match the left and right context for the rule. The context is the set of letters in the text stream that are to the left and right of the focus⁷ but which would not be translated into the phoneme string. The context can be specified using letters or wild cards that can stand for a set of letters. In the first example rule given above the wild card '1' (one) is used to stand for any alphabetic character. Wild cards are user defined and are specified in the rules file. If the left and right contexts match the context of the focus, the rule is applied and the phoneme string is added to the phoneme stream. If the rule fails, the next rule that matches the focus is applied. The way in which rules are ordered is important, more specific rules should be given before more general rules. The example rules handle three instances of the Welsh letter 'll' that, for reasons that given later, is translated into a different set of phonemes dependent on whether it is at the end of a word (first rule, the '_' character in the right context represents a space), in the middle of a word (second rule) or at the start of a rule (third rule). The fourth rule provides the translation of the character 'l'.

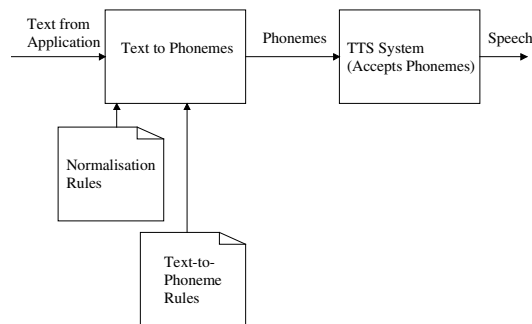


Fig. 2. The Gibbering Approach. The developer of a new language constructs the two rule files

The specification of the context can be relatively sophisticated as the language allows sequences of wild cards and letters to be used and also further specified by

⁷ The process works irrespective of whether the language is written left-to-right or right-to-left. However, a flag must be set in the rule file to indicate in which direction the text should be translated.

modifiers that allow ‘zero or more’ or ‘one or more’ instances to be specified. This leads to quite complex rules. For example, in Welsh the penultimate syllable of a multisyllable word is stressed and rules have been written to handle this.

As noted earlier, the prosody is handled by the speech synthesiser. This has the advantage that prosodic information does not have to be calculated for the new language, but has the disadvantage that the prosody will be for the base language rather than the target language. This may cause problems although these can be partially alleviated because stress markers and punctuation markers can normally be added to the phonetic representation of the text. However, as noted below, it is the overall prosody of the base language, rather than the target language, that is applied.

3.1 Phonemes

It should be apparent that there needs to be a good match between the phonemes of the base and target languages. In producing a prototype Welsh synthesiser we have used English as the base language. English provides most of the Welsh phonemes. However, some are not present. For example, Welsh has a voiceless alveolar fricative [θ] that corresponds to ‘ll’ in written Welsh (as in the town name Llanelli, which is often mispronounced by English speakers). English does not have this phoneme. Our strategy in cases such as this is to approximate to target phoneme by using one or more phonemes in the base language. In the case of ‘ll’ we use one of three phoneme combinations (for the rules see Section 4) dependent on whether the ‘ll’ is at the start, in the middle or at the end of a word. The approximations certainly do not give the correct pronunciation, but are sufficiently close for the speech to be understood and give a better approximation than many English speakers’ attempts to speak this letter.

3.2 Allophonic Variation

An allophone is a “variant of a phoneme” [6]. The “allophones of a phoneme form a set of sounds that (1) do not change the meaning of the word, (2) are all very similar to one another, and (3) occur in phonetic contexts different from one another” [6]. In many TTS systems allophonic variation is handled by the PtS stage either explicitly by applying rules in the case of a formant synthesiser or implicitly through the speech samples in a concatenative synthesiser. Our approach is subject to errors in allophonic variation because they will be applied for base rather than the target language. For example, consider the English phrases ‘the cat’ and ‘the ant’. Most speakers will pronounce the sound of the vowel in the word ‘the’ differently. With the British English synthesiser that we are using the translation, from text to phonemes, of the word ‘the’ will have the same phonetic transcription, but the PtS will generally give a different pronunciation. This may cause slight problems in that phonetic transcriptions for the target language will be subject to allophonic variations associated with the base language. There is little that can be done to address this issue. However, we can note that allophonic variation is generally small and therefore even inappropriate allophonic variation may not be excessively disruptive.

3.3 Prosody

As noted above, our TtP system has only very limited control over the prosody of the PtS system. This extends to adding stress and syllable break markers and by passing through some punctuation markers. This is not sufficient to fully control the prosody of the speech and the prosody that is produced will tend to that of the base language. The problem can be partially addressed by the selection of base language. As we note below, we have implemented a Greek synthesiser using both English and Spanish bases. The Spanish base should be more appropriate since Spanish and Greek have quite similar prosodic models. Welsh has a prosodic model much closer to Spanish than English and if prosody were the chief consideration in selecting a base language, Spanish, rather than English, would be chosen. However, Spanish does not have a sufficiently rich set of phonemes to implement Welsh and therefore our prototype system is implemented on an English synthesiser.

4 Results and Concluding Remarks

In order to evaluate the approach we have conducted some limited testing a prototype Greek synthesiser that uses both English and Spanish as the base language.

In the first set of evaluations we conducted a variation of the Modified Rhyme Test for the Greek language. Three native Greek subjects (who are based in the UK and are fluent English speakers), were presented with fifteen tests that each contrasted five words that differed in their initial or final consonants. For each test, one word was spoken and the user was asked to select which of the set of five options was spoken. The tests were conducted with both Spanish and English as the base language, the words spoken differed between the two base languages. With the Spanish synthesiser as the base language, there were a total of 7 errors in 45 trials. With the English synthesiser were a total of 10 errors in 45 trials. The most significant cause of error with English as the base language concerned the phoneme that corresponds to the letter 'r' in English. In Spanish and Greek this is an alveolar trill [8] whereas in English it is generally a frictionless continuant [8]. In effect, to Greek listeners, in the context of Greek words, the English 'r' is more similar to the approximant 'l' than a Greek 'r' and consequently words are misheard. The lack of a 'rolled r' in English is one of the major problems when using English as a base language for gibbering.

In the second set of evaluations, a set of isolated nonsense syllables were played to two native Greek speakers. Each subject was played four groups of five nonsense words and asked to identify what was being said. The structure of the four groups was VC⁸, CV, CVC and VCV. Overall, around 50% of the words were identified correctly. There appeared to be no significant difference between the English and Spanish-based systems, but the subjects reported that the English was easier to understand. It is not really clear why this might be the case. It may be that the subjects were based in the UK and are therefore used to listening to English speakers.

⁸ V = Vowel, C = Consonant

It could also be that the phonemes are more clearly enunciated in the English synthesiser.

Finally, three subjects were tested with a number of complete sentences. These included common simple sentences and a small number of ‘tongue-twisters’. Overall, the subjects correctly identified the sentences in all cases. However, the subjects felt that the Spanish-based system was more natural, sounding like Cypriot speaker of Greek. The English-based system was acceptable but sounded like a native English speaker speaking Greek. It is likely that the prosody and allophonic variation is better matched to Greek by the Spanish-based system.

The results of this preliminary evaluation should be treated with some caution. Firstly, too few subjects were used and too few tests were conducted to make the results statistically significant. Secondly, all subjects were fluent English speakers who had lived for some time in the UK and were therefore familiar with English phonemes and prosody. Finally, the tests were not conducted in support of the eventual target application, i.e. screen reading.

We tentatively conclude that ‘gibbering’ may be a way to construct speech synthesisers for new languages. We believe that it will be of particular interest to screen reader users who do not traditionally place high demands on the naturalness of speech.

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User Requirements for Technologies for Personal Communication and Information Use for Deafblind People

Wendy Fisher and Helen Petrie

Centre for Human Computer Interaction Design, City University, Northampton Square,
London EC1V 0HB, United Kingdom
{w.fisher|h.l.petrie}@city.ac.uk

Abstract. There are an estimated 130,000 deafblind people in the European Union. Although a range of specialist technologies for personal communication and information use have been developed for this user group, but these do not meet the range of users needs. To better understand the needs of this user group, interviews were conducted with thirteen deafblind people. These interviews revealed the urgent need for innovative technologies to enable deafblind people to communicate more independently with others and to use information. A portable, robust system that also allows use of residual sight or hearing is required. This project is currently developing early prototypes to explore new technological possibilities for such a device.

1 Introduction

There are an estimated 130,000 people who could be considered deafblind in the European Union. Not all of these individuals are profoundly deaf and totally blind, but they have a range of hearing and vision impairments which cause them to require assistance when communicating with others and using information. Over 20 specialist technologies for personal communication and information use have been developed for this user group, but currently even this range of equipment does not fully meet the range of needs presented by deafblind people. As a user group, deafblind people face particular problems, in that their needs tend to fall between specialist technologies and services for blind people and those provided for deaf people. Often their needs are not fully understood by specialists in each area which leads to a diminished assessment and provision of the correct equipment.

2 Participants

To better understand the needs of deafblind people for technologies for personal communication and information use, interviews were carried out with thirteen deafblind people. Of these participants six were both profoundly deaf and totally blind and the interviews were carried out using the deafblind manual alphabet; The other participants were either profoundly deaf with some visual impairment (6) or totally

blind with some hearing impairment (1). The average age of the participants was 53 years, nine were men and four were women. The interview schedule included questions on the cause and extent of the participants' disabilities, their current use of communication and information aids and their unmet requirements for other assistance with personal communication and information use.

3 Findings

The major finding of the study was that if the deafblind person is unable to use a computer and appropriate assistive technology, they were only able to communicate or use information via their personal carers. When asked how they communicate with people they do not know, the most common answer was that they did not do this. Deafblind people need to continue using any residual sight or hearing they have for as long as possible, they therefore require not only a tactile system such as Braille, block letters and deafblind manual alphabet but auditory and visual output which can be altered gradually as their needs change. In order to allow the active deafblind person to be as independent as possible, a portable system incorporating a Braille keyboard, large print, block letters, a hearing loop and a form of deafblind manual is urgently needed. However it must be robust and reliable enough to allow users the confidence to explore the outside world independently.

One of the real challenges to any new system to be developed is that it must be easy to use. The deafblind person needs to be able to access the systems' different functionalities with the minimum of steps. At each step, receiving the appropriate feedback of the system status is vital for deafblind people. Most people who are deafblind use vibration as a form of alerting for doorbells or telephones and this method could be used as feedback from the system.

4 Conclusions

This project is currently developing early prototypes of this system for personal communication and information use. The prototypes will be extensively evaluated with users as part of an iterative design lifecycle. The use of scenarios to illustrate the type of situations the device may be used in, as this will enable us to be more effective in our information gathering from deafblind people who may have had limited contact with information and communication technologies.

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Project IPSIS – Web Portal and Linux for the Blind

Danko Butorac

Croatian Association of the blind, Draskoviceva 80, 10000 Zagreb, Croatia
danko@ipsis.hr

Abstract. Open-source and web technologies open a new approach in aiding the blind, as well as building assistive technology for blind users. Through IPSIS project in last 2 years this became a fact for blind people in Croatia. IPSIS project offers open-source solutions for building end-user computer system as well as web accessibility. Linux distribution was used for purpose of making free, complete software solution for the blind. Many open-source applications have been integrated in this solution, but some adaptations have been made in area of speech synthesis (Croatian language), and interface design. Designing a web-portal, an open-source solution was used once again. The portal is working on a Linux web-server, MySQL database and PHP-based administration. The Talking Linux for the Blind (TLB), and web-portal for the blind people make an integrated, easy to use solution for blind Croatian computer users.

1 Problems and Project History

The greatest problem that blind computer users encounter in Croatia is non-existence of Croatian software speech synthesizer. Available hardware solutions are both too expensive and poor in quality. Consequently few blind people use computers (40 users on 5800 blind persons in Croatia). Having in mind a lot of benefits blind people can gain through every-day computer usage, this situation is unsatisfying. Another big issue is (un)ease of use. Commercial software solutions are too complex for beginners, and require good knowledge of English language.

Not many websites in Croatia are blind friendly. Inaccessible designs with lot of graphical elements cause blind people to become uninterested in web-content such as online news, magazines, etc. Blind computer users in Croatia seldom surf the world-wide-web. They mostly use Internet for e-mail. This situation can also be improved.

In solution to these problems we are trying to develop:

- Free Software with speech and Braille output in Croatian language
- Dynamic blind-friendly site (portal) with accessible web content such as daily news, online-books and magazines

This project was started in February 2001, and as end-user part of the project we introduce Talking Linux for the Blind TLB, an ultimate, simple to use tool - free for everyone. News, online-books, and other material interesting to our users can be found on the Web portal for the blind. This portal is dynamic web- tool for users to upload, and download files, access news, get help and interact with the blind and sighted users on-line. Most of the project expenses so far have been covered by Open society's grant. Project team consists of people with many different fields of expertise

(IT-professionals, programmers, psychologists, special education teachers and phonetics experts). All these experts, and many others, together with blind testing personnel are working daily on TLB development.

2 TLB – Current Development Status

So far we have prepared the first releases of applications and tools as follows: Simple reader/editor, Web browser, Calculator, SpeechAPI, Menu/control system. All applications have similar user interface, with single-key-stroke keyboard input, simple navigation system, and Croatian speech output. It is important to emphasize that the main approach used in application development is the use of open-source (free of charge) products, which have stable user communities and therefore are well documented and maintained. Following that approach we have developed our talking web browser based on "lynx" (text based web browser). Moreover, our SpeechAPI (interface between speech synthesizer and applications) uses MBROLA speech synthesizer and FESTIVAL system for other languages. It's easy to customize TLB system for any language supported by MBROLA or FESTIVAL.

Applications are developed using Python, open-source easy-to-learn programming language. Developers that join our project as volunteers or through civil military service can master the language within a month.

Open-source projects that we already use are: lynx (text-based web browser), mpg123 (mp3 audio file player), sox (player for other audio file formats), antiword (MSWord .doc to .txt converter), wvdial (internet connectivity application) and MBROLA (speech synthesis system). As time goes by, other projects will be included, as they are needed (for more information see project web-site: www.ipsis.hr/static).

3 www.ipsis.hr – Web Portal

Development is based on PHP-Nuke, an open-source tool for web-portal design. We made adaptations to the original design to get more accessible interface with less confusing formatting elements. Simple interface is enabling users to easily build their web-environment. It also helps user to post information and comments, seek help, etc.

Even though TLB users can now access every feature of IPSIS web-portal, we plan to integrate TLB and IPSIS even better, allowing users online storing of TLB system settings, documents and other data.

4 Future

Both TLB system and IPSIS web-portal make an excellent basis for further development. In the next year we plan to implement OCR and other new features into TLB. Through IPSIS portal we plan to offer facilities for web shopping, banking, access to digital texts (books and magazines), etc. Main project strengths are our blind team members who actively engage in development adapting results to their needs.

An Analysis of Layout Errors in Word Processed Documents Produced by Blind People

T. Diggle, S. Kurniawan, D.G. Evans, and P. Blenkhorn

Department of Computation, UMIST, PO Box 88, Manchester M60 1QD, United Kingdom
{t.diggle, srik, g.evans, p.blenkhorn}@co.umist.ac.uk

Abstract. This paper reports the initial results of an ongoing project concerned with the formatting of documents for blind people. It presents an analysis of formatting and layout errors for two corpora of, in total, 155 documents from 46 authors.

1 Introduction

Although many blind people successfully use word processors, they may have difficulties in controlling the layout and format of documents. Our hypothesis is that there is potential to produce tools that can enable users to improve the presentation quality of documents. This paper reports on the first stage of an ongoing project to explore ways in which tool support can be provided to blind word processor users.

Two corpora consisting of documents produced by visually impaired authors have been studied. The first consists of 89 documents by 14 experienced users of word processors, who have had no help from sighted users in preparing their documents. The second consists of 66 documents by 32 visually impaired authors, about whose experience or the level of assistance is unknown. After an informal analysis of the first corpus, distinct error categories were decided upon for a more precise and statistical analysis of the document errors.

2 Initial Results and Tool Status

We have identified two basic types of formatting error. *Incorrect* format is an error which violates one or more of a set of basic formatting rules set out by the authors. An incorrect error is counted every time such an error is found. *Inconsistent* format is where a style or convention previously adopted (in the same document) has been varied in some way, resulting in an inconsistent layout and format of the document. An inconsistent error is counted for every different “variety” of that particular formatting, minus one. For example, if the names of machine parts in a list are sometimes bold, sometimes underlined and sometimes in standard text, this would be counted as two *inconsistencies*.

An *indentation error* is one relating to the indentation, or “tabbing in” of an item of text.

An *alignment error* should not be confused with an indentation error, it relates only to the justification of a paragraph.

A *line spacing error* relates to use of either too many or too few lines between any two items of text.

A *font size error* relates to inappropriate choice of size for text.

A *font selection error* is solely concerned with the font chosen (Times New Roman for example).

Bolding, Italicising and Underlining errors relate to inappropriate use of bold, italic or underlined text.

A *capitalisation error* often results from the author leaving the “caps lock” key on, resulting in a long string of capitalised words.

A *word spacing error* is caused by there being either too many or too few spaces between words.

A *broken text error* occurs where a section of text, such as an address, or table is broken over two pages in an unacceptable way.

A *text distribution error* occurs when the text of a document is entirely contained within a small section of a page.

Fig. 1. presents the severity of each error category in each of the sample corpora, where severity is the percentage of documents from each corpus that contains one or more instance of the error in question.

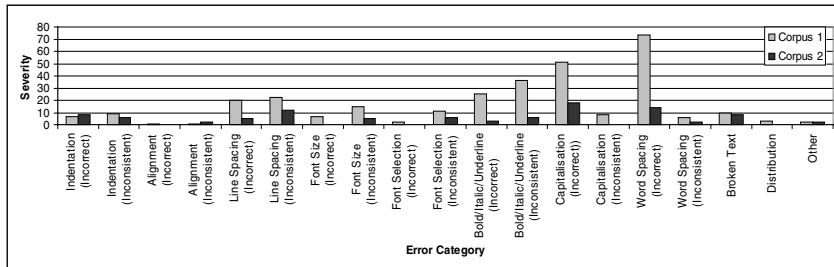


Fig. 1. The severity of errors for each corpus. Note that the origin of the material in Corpus 2 is less well known than that of Corpus 1, and it is quite likely that the some of the documents were produced on behalf of a blind author or proof read by a sighted assistant before delivery

We are in the process of developing a set of tools that are intended to support blind people to independently assess the format of their documents. These tools take two forms. Firstly, document creation tools that provide configurable templates into which the user types. This type of tool is designed to attempt to reduce the introduction of errors. Secondly, document checkers evaluate a completed document and report errors and inconsistencies to the user (in a similar way to a spell checker in a word processor). Initial prototypes are currently being evaluated.

Windows Screen Reader User Survey in Japan

Tetsuya Watanabe¹, Chuji Sashida², and Shinichi Okada²

¹ National Institute of Special Education,
Nobi 5-1-1, Yokosuka City, 239-0841 Kanagawa, Japan
twatanab@nise.go.jp
<http://www.nise.go.jp/research/kogaku/twatanab/indexEn.html>

² National Institute of Vocational Rehabilitation,
Wakaba 3-1-3, Mihama-ku, Chiba City, 261-0014 Chiba, Japan
{csashida, sokada}@jaed.or.jp

Abstract. We conducted a Windows screen reader user survey to gather information on Windows accessibility by blind and visually impaired PC users in Japan. Its results show that nearly half of respondents were using more than one screen reader. As for hardware, half of them were using scanners and one sixth of them Braille printers and Braille displays at workplaces. As for software, more than half of respondents were using word processors or editors, e-mail software, voiced Internet browsers, spreadsheets, CD-ROM dictionary viewers, and OCR software. The commonest problem respondents faced when they learned Windows was that Windows was hard to comprehend.

1 Introduction

These days computers and screen readers are indispensable tools for the QOL of people who are blind. Therefore the number of blind people who can use them is expected to grow and their computer environment to be improved than ever. For the former purpose, information, such as what kind of tasks can be done with computers and what hardware and software are needed to do them, is required for people who have never used computers. For the latter purpose, information, such as what kind of problems blind users have while learning and using computers, should be sent to developers, researchers and trainers. Our Windows screen reader user survey was conducted to fulfill these purposes.

2 Survey

We called for respondents on four mailing lists that were run for the promotion of QOL of blind and visually impaired people. Distribution of the questionnaire and collection of answers were done through e-mail. The survey was conducted from June 26 to July 10, 2000. We asked user profiles, what hardware and software were used at

workplaces and/or homes, and what kind of problems respondents had while learning and using Windows and its screen readers.

3 Results

3.1 Respondents

Effective respondents were 81 visually impaired persons who were using Windows screen readers. Their age ranged from 19 to 64 years old. Sixty-eighty of them were male. Seventy-seven were severely visually-impaired.

There were 17 massagers; 10 teachers; 9 computer-related workers; 8 clerical workers and others. Sixty-one respondents who reported about their work environment spent 5.1 hours using PCs on the average.

3.2 Software and Hardware

Screen reader programs used were 95/98Reader, PC-Talker and outSPOKEN (listed in the order of number of users). Nearly half of the respondents used more than one program. Seven people used screen magnifying program (ZoomText) along with speech both at workplaces and at homes.

As for hardware, half of them were using scanners and one sixth of them Braille printers and refreshable Braille displays at workplaces. The number of Braille printer users decreased to three at homes.

As for software, more than half of respondents were using word processors or editors, e-mail software, voiced Internet browsers, spreadsheets, CD-ROM dictionary viewers, and OCR software both at workplaces and at homes. Respondents complained that specific popular programs of word processor and database were not accessible by speech.

Interestingly, three fourth of respondents were still using MS-DOS for many purposes such as word processing, file managing, Braille editing and so on although the same tasks could be achieved on Windows.

3.3 Problems while Learning and Using Windows

There were many problems the respondents faced when they learned Windows. The commonest problem was that the concept of Windows was hard to comprehend. Secondly, speech output was frequently terminated during the use. Thirdly, appropriate manuals, such as Braille documents, cassette tapes, and text files, were not available. Fourthly it was not easy to get support from the family members, friends and acquaintances.

Tools for Creating Documents in ‘Preferred Format’ for Visually Impaired People

D.G. Evans and P. Blenkhorn

Department of Computation, UMIST, PO Box 88,
Manchester, M60 1QD, United Kingdom
{g.evans, p.blenkhorn}@co.umist.ac.uk

Abstract. A suite of tools is described that allow a word-processor operator to produce documents in large print, Braille and on cassette tape so that the documents can subsequently be read by visually impaired or blind users. The tools integrate with Microsoft Word, are written in Visual Basic for Applications and make use of the Word Object Model.

1 Introduction

In this paper we describe a suite of tool that are integrated with a word processor so that a word-processor operator can convert documents into any of three formats suitable for blind and visually impaired people. The work was motivated by the United Kingdom Guide Dogs for the Blind Association (GDBA) which has a policy of corresponding with Visually Impaired People (VIPs) in ‘preferred format’. This means that a VIP can ask for correspondence and documents to be sent in any of three formats, namely, large print, speech (distributed on cassette tape) and Braille. The tools are designed so that minimal training is required for the word-processor operator. The word-processor operator produces the document as if he/she were communicating with a sighted reader, selects the appropriate item from the word processor’s menu and the document is produced in the appropriate format. The key issue that we are attempting to address is the minimization of specialist skills needed and effort expended in order to produce documents in preferred formats.

Our work focuses exclusively on Microsoft Word. We feel this is appropriate because this application is so widely spread. However, we believe that the fundamental ideas presented in this paper could be adapted to other word processors running under Windows or under different operating systems, provided that they provide a suitable means for accessing, creating and modifying documents through software control.

The key requirement of the tools is that they have access to the text and formatting information in the original document. This can be obtained in a number of ways. One method involves parsing the files produced by the word processor, whether these are in proprietary format (e.g. the .doc files in Word) or a standard document interchange format, such as Rich Text or XML. This approach has a significant advantage, in that it will work with any word processor that produces information in the file format.

However, there are some disadvantages. Firstly, the tools are not integrated with the environment – the word-processor operator creates the document, saves it and then subsequently applies the tools. Whilst this may not be a major problem, it may be more convenient for the user if the tools are integrated into the word processor. Secondly, the tools must be able to parse the file format; whilst this is based on well established techniques, parsing the file to extract all formatting information is a complex task. In our tools, rather than operate on files, we rely on the word processor to provide us with the information. In the particular case of Microsoft Word we access, create and modify documents using the Microsoft Word Object Model. This allows us to have a high degree of integration with the word processor and to reduce the complexity of obtaining formatting information.

Microsoft Word, together with other Microsoft Office applications, provides an object model. This exposes the functionality of Microsoft Word through a set of objects whose properties can be altered under programmatic control. For example, a Word document is exposed as an object and methods are provided to, for example, save and close a document. Text is also represented in Word as a set of different objects and a program can read the text in a document and control its presentation (for example its font size).

The Word Object Model can be accessed from outside Word using a program written in a programming language such as Visual Basic or Visual C++. In this case Object Linking and Embedding (OLE) is used. The other method of accessing the Word Object Model is to write a macro in Visual Basic for Applications (VBA). VBA is a programming environment and language that is included within Word itself. In our work we choose to use VBA for two reasons. Firstly, our work on Braille translation indicated that there were significant performance penalties in using OLE in a situation where a large document has to be examined a character at a time (the reasons for this are postulated in [2]). Secondly, VBA integrates closely with Word allowing new menu items to be created within the word processor.

2 Tools

The simplest way of creating large print using a word processor is to select all the text and to change the font size. However, this can lead to a number of problems. Firstly, this changes all text into the same font size thereby removing distinctions between headings and normal text for example. Secondly, it can severely disrupt tables. Finally, this method does not enlarge diagrams. Because we have access to the Word Object Model we can address these problems. We can give the user control over the enlargement of the text. Typically the user will select a minimum font size and all text is scaled relative to that size. This means that text that was in a larger font in the original document will be displayed in a proportionally larger font in the final document. Secondly, the macro ensures that tables will fit on the printed page and that all text is readable. Finally, diagrams are enlarged by the same factor as the font. If this means that the diagram is too big for the printed page, the diagram is enlarged to the limit of the page.

Spoken material can be produced automatically from Word provided that the computer system has a Microsoft SAPI-compliant speech synthesiser [3] installed. When the user selects the spoken word option, he/she is prompted to connect a tape recorder to the headphone socket of the computer's sound card and to press the record button. The macro simply sends the text a paragraph at a time to the speech synthesiser, which will speak the text through the sound card and onto the tape. When the document is finished, the user is prompted to switch off the tape recorder.

The word-processor operator has some limited control over some aspects of the speech production. The user can select from the set of speech synthesiser voices that are installed on his/her machine. In general, the operator will not need to change the voice and the default will be used. However, there are circumstances when changing the voice may be appropriate. The most common case is when the voice is changed to match the gender of the signatory of the communication. It makes sense for a letter with a female signatory to be read with a female voice. Secondly, in countries where communications are commonly produced in more than one language, the operator will need to select the appropriate speech synthesiser for the language. The current version of the system has only been used for English and the menus and controls are given in English.

Braille production is somewhat similar to cassette tape production, but rather than passing a paragraph of text to a speech synthesiser text is passed to a text to Braille translation DLL (Dynamic Link Library) [4]. The text that has been translated by the DLL is routed into a new Word document, where it is represented in American Computer Braille [5]. This can be subsequently sent to a Braille printer.

One of our goals is to present as much of the formatting of the original document in the Braille document. This requires fairly significant processing of the text to handle issues such as bold text, page numbering and tables. The issues and the algorithm are fully discussed in [2]. The Braille translation DLL is a table-driven software system that contains language specific translation rules. These must be created for a given language; currently English [2] and Hungarian are documented.

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Braille Printing System

Shunsuke Hara¹, Ryoko Kawamitsu², Kanako Kusunoki³, Hiroshi Sato³, and Mamoru Fujiyoshi⁴

¹ Tsukuba College of Technology, 4-12-7 Kasuga, Tsukuba-shi, Ibaraki 305-0821, Japan

`hara@k.tsukuba-tech.ac.jp`

² Department of Computer Science, Ochanomizu Univ., 2-1-1 Ohtsuka, Bunkyo-ku, Tokyo 112-8610, Japan

³ Graduate Course of Human Sciences, Ochanomizu Univ., 2-1-1 Ohtsuka, Bunkyo-ku, Tokyo 112-8610, Japan

`sato@is.ocha.ac.jp`

⁴ The National Center for University Entrance Examinations, 2-19-23 Komaba, Meguro-ku, Tokyo 153-3311, Japan

`fujiyoshi@rd.dnc.ac.jp`

Abstract. It is believed that for the newly blind, to use large size Braille is more effective than to use that of standard size in practising Braille recognition. On the other hand, it may be preferable to use small size Braille for young blind children. Taking account of these facts, we have developed a “size-variable Braille printing system”, which can produce Braille of arbitrary size on swell paper (micro-capsule paper). Our system takes, as input data, the same input data as that for Braille printers and produces a \LaTeX file to typeset Braille image as output data. This system can be applied to more general representations of Braille text since it is possible to draw symbols other than Braille on the paper. In this research, two-dimensional expression of fractions in Braille is presented.

1 Introduction

For the newly blind (those who become blind in their midlife), to learn reading Braille is very difficult, although many can master writing it. It is believed that for these people, to use large size Braille (larger dots, larger spaces between dots and between Braille cells) is more effective than to use that of standard size, at least in the early stage of practising Braille recognition by tactile perception. Besides, the newly blind people may prefer large size Braille since their tactile sensation is not as good as that of young people.

For the young blind children, it requires much time and effort to master Braille reading. It may be preferable to use rather small size Braille while their fingers are small.

To understand the mechanism for tactile recognition, Braille texts with various sizes will be useful.

In spite of these facts, to prepare texts with large or small size Braille is very difficult, since ordinary Braille printers can produce only Braille of standard size. The Jumbo dot[1] Braille printer is one answer, but that printer can produce only one fixed large size Braille. For some users, Jumbo dot Braille seems to be too large. Several preliminary research studies have been carried out to find the relation between the readability of Braille and the size of Braille. The results are not very conclusive, partly because of the difficulty in preparing the texts of various Braille sizes.

It is, in principle, possible to produce Braille of arbitrary sizes by using a dot-plotter type Braille printer. For practical purposes, however, the existing plotter type Braille printer[2] cannot plot a dot at an exact desired position because of the resolution power of the apparatus (0.3 mm). Furthermore, diameters of the plotting pin are variable only to 0.8, 1.4 and 1.8 mms, and the printing speed is rather slow.

To overcome this situation, we have developed, in this research project, a "size-variable Braille printing system: Braille-Print", which can produce Braille of arbitrary sizes on swell paper (micro-capsule paper), according to the initial setup for the diameter of Braille dots, spaces between dots and spaces between Braille cells. Some preliminary results are presented elsewhere[3].

Until recently, Braille on swell paper was not as readable as that embossed on Braille paper. However, since the quality of swell paper is improving and some of it[4] is said to be as good as Braille paper, and since the cost of swell paper is getting less expensive, swell paper will be used more frequently in future.

Our system can be applied to more general representations of Braille text like DotsPlus[5], since it is possible, by using the system, to draw mathematical symbols other than Braille on the swell paper. In this research, a two-dimensional representation of fractions in Braille is presented.

2 Braille Size

Ordinary Braille is composed of six dots. The left three dots are called from the top to the bottom, dot 1, dot 2 and dot 3. And the right three dot 4, dot 5 and dot 6 (see the top left Braille cell in Fig. 1).

2.1 Dimensions for Braille

The parameters that determine the physical characters of Braille document are, (a) the distance between dots 1 and 4, (b) the distance between dots 1 and 2, which is the same as that between dots 2 and 3, and also usually the same as that between dots 1 and 4 (except for Japanese Braille, see Table 1), (c) the vertical distance between Braille cells, (d) the horizontal distance between Braille cells, and (e) the diameter of the dots. These parameters are illustrated in Fig. 1 and values are compared for several types of Braille in Table 1. Distances (a) and (b) are called inter-dot separation, and (d), inter-cell separation. It should be noted that in some articles, distances (a) + (d) and (c) + 2(b) are defined. The height

of the dot is also an important parameter for Braille characters, but the height is not taken into account in this research.

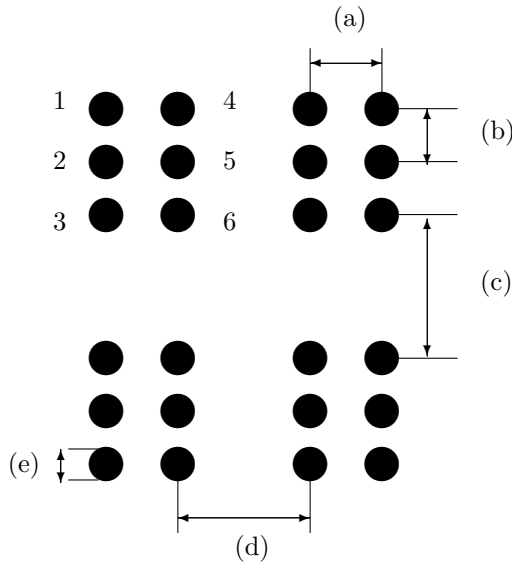


Fig. 1. Parameters for Braille size
See Table 1 for (a)–(e)

Table 1. Approximate dimensions for Braille (in mm)

	(a)	(b)	(c)	(d)	(e)
Japan ¹⁾	2.2	2.3	10.6	2.9	1.4
Sweden ²⁾	2.5	2.5	5.0	3.5	1.0
U.S.A. ³⁾	2.3	2.3	5.6	4.1	1.5
Jumbo dots ⁴⁾	3.1	3.1		6.5	1.7

- (a) Distance between dots 1 and 4
- (b) Distance between dots 1 and 2 or 4 and 5
- (c) Vertical distance between Braille cells
- (d) Horizontal distance between Braille cells
- (e) Diameter of a dot

¹⁾ See ref. [6], ²⁾ see ref. [7], ³⁾ see ref. [8], ⁴⁾ see ref. [1]

3 Size-Variable Braille Printing System: Braille-Print

Our system takes, as input data, a file of Braille computer code, that is, the same input data as that for Braille printers and produces a \LaTeX file to inkprint

Braille images as output data. Regarding the Braille computer code, the NABCC (North American Braille Computer Code) code has been adopted.

3.1 Preparation of Input File

Input data for the system is a file written in the NABCC Braille code. To obtain the input file, the text file which is used to produce inkprint output is transformed, by a Braille translation system, into the strings of ASCII characters that correspond to the NABCC. When the text file includes mathematical equations written in the \LaTeX format, these equations should also be transformed into the corresponding mathematical expression in Braille code. Fig. 2a is an example of the text file which includes \LaTeX commands, and Fig. 2b, the inkprint result obtained by processing the text of Fig. 2a by \LaTeX . Fig. 2c is the NABCC file transformed from the text of Fig. 2a by the Braille translation system “Math-Braille” [9]. In Figs. 2 and 3, spaces between lines are modified from the original text or output for visual clarity.

3.2 Usage of the System

The procedure to complete Braille text by this system is as follows:

- (1) Execute the Braille-Print system and assign the name of input NABCC file and input the values of parameters (a)–(e).
- (2) The system takes characters from the ASCII strings of the NABCC file and produces the output \LaTeX file to typeset Braille characters (dots) corresponding to the ASCII characters at the desired position in the coordinates.
- (3) The output \LaTeX file is processed by \LaTeX and the inkprint Braille text is produced by printer.
- (4) This inkprint Braille image is copied on the heat-sensitive swell paper. The paper is then put through a tactile image maker that heats the paper to acquire the final Braille text.

Fig. 2d is the image of inkprint Braille results obtained from the NABCC data of Fig. 2c. The mathematical equation in Fig. 2d is expressed in the Japanese Braille math code.

By using this system, it becomes possible to produce texts with various Braille sizes according to the request of Braille users. As mentioned in the Introduction, it has been difficult, so far, to investigate the relation between the readability of Braille and the size of Braille. This system will help such investigations.

In a Braille printer, the number of Braille cells in one line is fixed by the design of the printer (usually 32 cells in one line). In Figs. 2d and 3d, the number of Braille cells in one line is fixed at 32. In this system, however, one can typeset Braille images both sideways and lengthwise. Furthermore, one can enlarge small size Braille (on a scale of $1/\sqrt{2}$ in length) printed on A4 size paper to normal size Braille on A3 size swell paper. Thus it is possible to make a Braille text with more than 70 cells in one line.

```

Math equation

$$1/3\times2/5=(1\times2)/(3\times5)=2/15 \ \cdots(1)$$
    
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Fig. 2a. Text file for inkprint (L^AT_EX file).

Math equation

$$1/3 \times 2/5 = (1 \times 2)/(3 \times 5) = 2/15 \cdots (1)$$

Fig. 2b. Results compiled by L^AT_EX

```

; ,MATH ;EQUATION

#A/#C*#B/#E338#A*#B0/8#C*#E0,

33#B/#AE 111 8#A0
    
```

Fig. 2c. Input Data for Braille-Print (Text in NABCC).

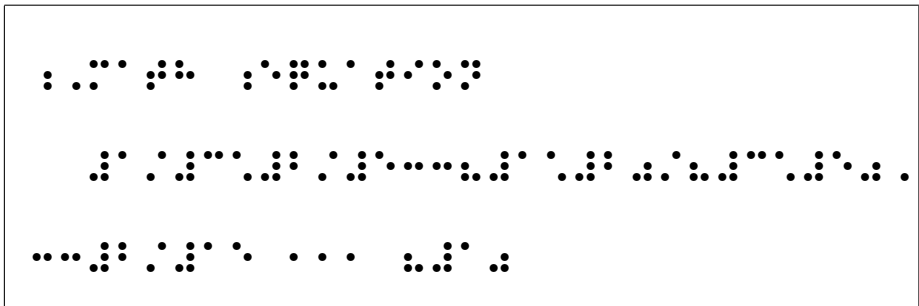


Fig. 2d. Braille Expression of eq. (1) in Fig. 2b

4 Two-Dimensional Representation of Fractions in Braille

4.1 Motivation

For blind children, one difficult problem in learning mathematics at elementary school is understanding the concept of and the manipulation of fractions. One reason for this difficulty must be due to the expression of fractions in Braille. In an inkprint textbook, fractions are expressed in two-dimensional form and manipulation of fractions is also explained in two-dimensional representation. An example is shown in eq. (2) of Fig. 3b. On the other hand, in a Braille textbook, fractions are always expressed in one-dimensional form. That is, the Braille expression for eq. (2) in Fig. 3b is identical with that for eq. (1) in Fig. 2b. This difference also causes some problem for teachers.

The blind children have to practise manipulation of fractions in the form like eq. (1) of Fig. 2b. The second and third lines of Fig. 2d are the actual one-dimensional Braille representation corresponding to both eq. (1) in Fig. 2b and eq. (2) in Fig. 3b.

Therefore, a system for expressing fractions in Braille in the same form as inkprint textbook will be useful both for teachers to teach the concept of fractions, and for the blind children to understand the manipulation of fractions.

4.2 Input Data for Two-Dimensional Representation

The ASCII character set contains 128 characters, whereas the number of Braille characters is 64 including the blank. In many Braille printers, the first 32 ASCII characters 00h–1Fh are assigned to the control codes for the printers and the next 64 characters 20h–5Fh, that is, characters from “`␣`” to “`_`” which include capital Roman letters are assigned to Braille characters. The remaining 32 characters 60h–7Fh (from “`‘`” to “`DEL`”), which include small Roman characters are, like the NABCC code, doubly assigned to Braille characters for the characters 40h–5Fh (from “`@`” to “`_`”). That is, in many Braille printers, ASCII characters “a” and “A” give the same Braille. In some other Braille printers, characters 60h–7Fh may be left unassigned.

It is possible to assign the characters 60h–7Fh, or combinations of these characters, to symbols other than the 64 Braille characters. In the present system, ASCII characters 7Bh and 7Dh (“`{`” and “`}`”) are assigned to shift up and/or shift down the position of Braille characters and to draw the fraction bar.

In the original Braille translation system Math-Braille[9], two expressions of a fraction in \LaTeX , Fig. 2a and Fig. 3a, which give two different inkprint expressions, are transformed into the same NABCC strings given in Fig. 2c (See also Table 2 of ref. [9] (b)). That is, for example,

$(1\times 2)/(3\times 5)$ and $\text{\frac{1\times 2}{3\times 5}}$ \longrightarrow (#A*#C)/(#C*#E)

In order to produce an appropriate input file for the present system, Math-Braille system is modified so that the \LaTeX command $\text{\frac{1\times 2}{3\times 5}}$

gives the input data for a two-dimensional expression in Braille, whereas the command $(1\backslash\times 2)/(3\backslash\times 5)$ remains to give the data for a one-dimensional expression. That is

$$(1\backslash\times 2)/(3\backslash\times 5) \longrightarrow (\#A*\#C)/(\#C*\#E)$$

$$\backslash\text{frac}\{1\backslash\times 2\}\{3\backslash\times 5\} \longrightarrow \{\#A*\#C\}\{\#C*\#E\}$$

Fig 3c. is the data obtained from eq. (2) of Fig. 3a, and Fig. 3d the two-dimensional Braille representation for eq. (2).

```


$$\frac{1}{3} \times \frac{2}{5} = \frac{1 \times 2}{3 \times 5} = \frac{2}{15} \cdots (2)$$


```

Fig. 3a. Source file for \LaTeX .

$$\frac{1}{3} \times \frac{2}{5} = \frac{1 \times 2}{3 \times 5} = \frac{2}{15} \cdots (2)$$

Fig. 3b. Results compiled by \LaTeX

```

{\#A}\{\#C}\*\{\#B}\{\#E}33{\#A*\#B}\{\#C*\#E}33{\#B}\{\#AE},
111 8#B0

```

Fig. 3c. Input Data of Braille-Print for two-dimensional representation of fractions (Text in NABCC).

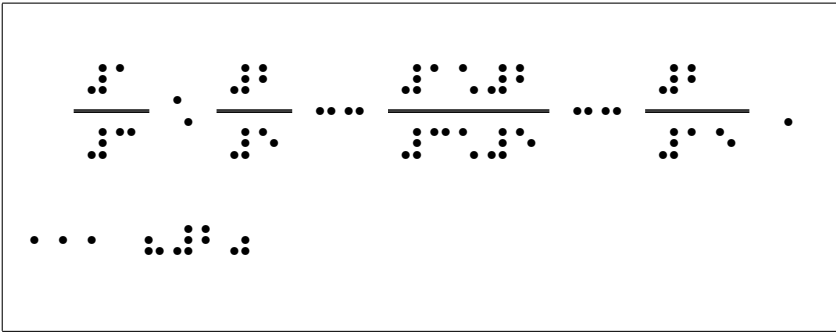


Fig. 3d. Two-Dimensional Braille Representation for eq. (2) in Fig. 3b

5 Conclusion

A system, Braille-Print, has been constructed. By using this system, texts with Braille of arbitrary size (diameter of dots, distance between dots and between cells) can be produced easily and quickly. This system also enables expressing fractions in Braille text in the form identical to that in inkprint text.

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Braille Contractions in WinBraille

Mats Blomquist

Luleå University of Technology, 971 87 Luleå, Sweden
Mats.Blomquist@sm.luth.se

Abstract. WinBraille is a free program containing Windows drivers for Index Braille embossers, emboss-direct macros for famous Windows programs like Microsoft Word, a built-in editor for viewing and editing the text in prior to embossing, and a translation engine for Braille contraction translations. The translation engine can handle both grade 1 and grade 2 in many languages, including Greek and Russian. A language, SLIB, "Script Language for Index Braille", has been created to define contraction rules. WinBraille also includes a rule file editor to edit the contraction rules and to compile them into a binary form, which the engine uses during the translation process.

1 Introduction

The paper will focus on the Script Language for Index Braille (SLIB), the SLIB compiler's structure and the WinBraille rule file editor.

The contraction rule file is preferably edited with the built-in rule file editor, Wbrfe, but any Windows text editor can be used, as the rule file is a plain text file. The benefits of using the built-in editor are:

- Foreign characters will be correctly shown for foreign contraction rules.
- The rules can be compiled and tested within the editor.

With the free program WinBraille, text can be contracted and translated to Braille. The author has created the SLIB language to make it possible to easily define and change WinBraille's contraction rules.

2 The Structure of a WinBraille Contraction Rule File

The file is divided in four main sections, the header, definitions, the rules proper, and the Braille character table. The header contains information about the language, grades, the author and the date and version of the file. The header must be the very first part of the file, and the first row must start with a hyphen and a line of equal signs. The tag "-Language" is mandatory, since this tag is used as a sorting key in WinBraille. The header ends with a row of equal signs.

Since the header is used in WinBraille only to inform the user about the rule file content, and not used in the contraction engine, all lines in the header are treated as comments, and thus must start with a hyphen. Example:


```

=====
-Description: American Grade 1
-Language: English
-Author: Mats Blomquist
-Version: 3.0
-Date: 2001-11-29
=====

```

SLIB is a symbol manipulation language. All text, single letters, words or complex word combinations are treated as symbols. No predefined symbols exist. All symbols must be defined in the definitions part, except for text strings, which can be directly used in the contraction rules, encapsulated within citation marks. The definitions section contains the symbol definitions, character set definition, lists, list equivalencies and list rules definitions, externally defined contraction rules, password protection, definition of text attributes (like bold and italic), default character, state definitions, and interface definitions.

3 SLIB Reserved Words and Special Symbols

The following reserved words have specific meanings in the SLIB language: `ascii`, `attribute`, `braille`, `brailletable`, `charset`, `default`, `define`, `depend`, `equivalence`, `extern`, `gstate`, `include`, `interface`, `istate`, `list`, `listrule`, `lstate`, `param`, `password`, and `state`.

Some symbols are used for specific purposes: The hyphen (-) in the beginning of a line is used to mark a comment. Every SLIB statement must be defined on a single line, thus a plus sign (+) in the beginning of the line denotes a continuation of the previous line. The equal sign (=) is used as an assignment operator. Brackets ([and]) are used to define the content of a list. Contraction rules are defined between the symbols < and >. Parentheses enclose state variable expressions.

Variable assignment is performed with curly brackets ({ and }). Symbols enclosed within curly brackets are assigned to a variable. The symbols @1 to @9 and &1 to &9 are used to denote variables, the @ symbol is used in a direct variable assignment, whereas the & symbol is used in recursive assignments.

The symbols %LR, %RL, %TLR, %TRL, and %LTR are order specifiers. They override the default order of the rule context validation.

Comma (,) separates symbols and semicolon (;) separates contexts in a contraction rule. Citation marks (") define text strings.

Braille symbols are defined with the small letter p and the Braille symbol dot numbers, example: The Braille "a" is p1, "b" is p12 and "c" is p14. The text string "Braille" is denoted as p3456 p12 p1235 p1 p24 p123 p123 p15.

Since the citation mark is used to define text strings, the citation mark itself and the back-slash are escaped with a back-slash (\) when used in a string. The text string symbol containing a single citation mark is thus written as "\'", and a symbol with a single back-slash is written as "\\ ". Non printable ASCII characters in a text string can be defined with the sequence \dnnn or \hxx, where nnn is the decimal equivalence and xx is the hexadecimal equivalence of the symbol, example: The tabulator character, decimal 9, can be defined as a SLIB symbol as "\d009".

3.1 Basic Reserved Words

Most of the SLIB reserved words are used in statements in the definitions section:

Include

Include files. Syntax: `include <file>`

Example: `include definitions.txt`

Define

Define constants. Syntax: `define <identifier> = <symbol(s)>`

The `define` statement is a text assignment statement.

Example: `define HYPHEN = "-"`

Charset

Define character set. Syntax: `charset = <integer constant>`

Example:

```
define GREEK_CHARSET = 161
charset = GREEK_CHARSET
```

Password

Define a password to protect the source code. Syntax: `password = <string>`

Example: `password = "drowssap"`

Default

Define a default character if no rule applies. Syntax: `default = <symbol>`

The symbol can either be a string with one character, a Braille symbol, an empty string, or the escape character “\d027”. The escape character will use the source text character as the translated character. An empty string will not translate the source text at all. Example: `default = "?"`

Attribute

The Braille text attribute options like bold, underline or italics, are by default disabled in WinBraille. If the contraction rules can translate text options, the attribute options check boxes can be enabled with `attribute` statements.

Syntax: `attribute = <attribute constant>`

The attribute constant can be one of either BOLD, ITALIC or UNDERLINE. More than one attribute statement can be defined. Example: `attribute = BOLD`

List

Define a list of symbols. Syntax: `list <identifier> = [<string list>]`

A `<string list>` is a list of comma-separated string symbols. Example:

```
list uppercase = ["A", "B", "C", "D"]
```

Listrule

Define list rules. Syntax: `listrule <identifier>=<list>:<specifier>`

The list must previously have been defined in a list statement. The list rule specifier specifies how the elements in the list are treated, see below.

Example: `listrule capital = uppercase:1#`

This list rule defines a capital as exactly one element from the list of uppercase letters.

List rule specifier

The list rule specifier specifies how the list rule handles the list elements.

* “Zero or more”, example: `listrule space = space_list:*`
n# “Exact number”, example: `listrule letter2 = letter_list:2#`
*n** “Or more”, example: `listrule letters = letter_list:1*`
 ! “Zero or more of the same symbol”, example: `listrule pm = pmlist:!`
n! “Exact number of the same symbol”, example: `listrule AA = AtoZ:2!`
n!* “Or more of the same symbol”, example: `listrule same = AtoZ:2*!`

Equivalence

Define character equivalence between characters in lists.

Syntax: `equivalence <list> = <list>`

Example: `equivalence lowercase = uppercase`

3.2 State and Interface

State variables can be used to control the contraction rules. Four conceptually different types of state variables can be defined: user defined states, declared with a `state` declaration, local states, declared with an `lstate` declaration, global states, declared with a `gstate` declaration, and internal or interface states, declared with an `istate` declaration. User defined and global state variables keep the state information between contraction translations. Syntax:

```
state <state variable> = [<state list>]
lstate <state variable> = [<state list>]
gstate <state variable> = [<state list>]
istate <state variable> = [<state list>]
```

A `<state list>` is a list of comma-separated state symbols. Example:

```
state GRADE = [GRADE0, GRADE1, GRADE2]
```

User defined state alternatives must be declared with a `define` statement in prior to usage. The first must have the ordinal number 0, the second must be a rise of 2, and the rest must be multiples of the second. Local and global states are assigned ordinal values automatically. The `istate` state variables can only be one of the predefined symbols `BRAILLETABLE`, `SOURCE` and `TRANSLATION`, with the predefined state alternatives `CUSTUMBRAILLE`, `EUROBRAILLE` and `MITBRAILLE`, `SOURCE_PRINT` and `SOURCE_BRAILLE` respectively `TRANSLATION_ON` and `TRANSLATION_OFF`.

Interface

The interface declaration is closely related to the definition of state variables. An interface declaration creates a user interface in WinBraille. Two types of interfaces exist. A state variable interface creates a list box in the rule file parameter dialog in WinBraille, from which a state variable's state alternative can be selected. Variable interfaces create edit boxes, where the user can supply a text, which will be applied to a variable. Syntax:

```
interface <state variable> = <title> [<option list>]
interface @<variable> = <title>
```

Example:

```
interface GRADE = "Grade:" ["Grade0", "Grade1", "Grade2"]
interface @1 = "Bullet symbol"
```

3.3 Externally Defined Rules

Existing contraction rules can be incorporated in a WinBraille rule file if the translation can be performed through a Windows 32-bit function, located in a Windows 32-bit DLL. Three SLIB statements are involved in the definition of the external rules: `extern`, `depend` and `param`. The actual function and DLL file are defined with an `extern` statement. The DLL file is embedded in the binary WinBraille rule file during compilation. Dependent files, like dictionaries etc. can be embedded as well with a `depend` statement. A parameter can be supplied through a `param` statement. The parameter option is created with a state and an interface definition. The `param` statement connects the state variable to the parameter. Syntax:

```
param = <state variable> [<parameter value list>]
extern = <dll file>, <function name>, <method>, <parameter>
depend = <file>
```

Each value in the parameter value list corresponds to a state variable option. The ordinal number `method` indicates how to call the function and number and types of the parameters.

3.4 Variables

Up to nine variables can be defined. The variables are typed as @1 (or &1) to @9 (or &9). Assignment is performed either through an interface declaration or in the contraction rules with curly brackets. The variable @1 in the example below will be assigned the letters in the text proper before validation of the left context.

```
< pm @1 ; "-" {letters} ; pm ; p5 >
```

The next example demonstrates assignment of more than one variable:

```
< ; "{" {letter} {digit} "}" ; ; &2 &1 >
```

Assignment is performed from left to right. The first bracketed group will be assigned to variable 1, the next group to variable 2, etc. The text "{A5}" would in this case be translated to "#ea". The ampersand symbol indicates recursive translation, which will translate the first bracketed group ("A") to "a". (We assume no capital prefix). The second bracketed group ("5") translates to "#e".

3.5 The Contraction Rules

Of particular interest are the Contraction Rules. These are divided into "Inserting Rules" and "Replacing Rules". For example, the "Inserting Rules" section contains rules to insert number prefixes and capital prefixes. These are usually rather complex rules. The replacing rules are used to replace a text symbol with its Braille counterpart. These are preferably sorted in alphabetic order. The syntax of a contraction rule is:

```
< "left context" ; "text proper" ; "right context" ;
  "Translated Braille symbol" ; "Translated Print symbol" >
```

The meaning of the five sections in the contraction rule quintuple can best be explained with some examples, with and without left and right contexts:

```
< ; "e" ; ; p15 ; "e" >
```

This first example is a rule, which will replace the letter "e" in the source text with the Braille symbol 1,5 and the corresponding print symbol "e". The print symbol is the symbol that will be shown on the screen in WinBraille, and read with a Braille display. This does not necessarily need to be the same as the source text symbol, as is shown in the next example:

```
< ; "!" ; ; p235 ; "+" >
```

In many languages an exclamation mark is coded as the Braille symbol 2,3,5. If a Braille display is used where the American Computer ("MIT") code is used, the Braille symbol 2,3,5 will be equivalent to the print symbol "+". Thus, to read the correct Braille symbol on the Braille display, the "+" sign must be shown on the screen. The use of the left and right contexts is shown in the next example:

```
< number ; "." ; number ; p3 ; "." >
< ; "." ; ; p256 ; "/" >
```

The first of these rules insert a Braille cell with dot 3 for the decimal point when both left and right contexts are numbers. If this rule is not fulfilled, the decimal point will be treated as a period (a full stop), and thus the Braille symbol 2,5,6 should be used.

3.6 Braille Table

An optional Braille table can follow the contraction rules. The Braille table defines all Braille symbols used in the rules, for example:

```
p = " "
p1 = "a"
p2 = "b"
p12 = "c"
...
```

Two predefined Braille tables exist, the European (EUROBRAILLE) and the American (MITBRAILLE) tables. These can be selected with a `brailletable` statement, example:

```
define MITBRAILLE = 776
define EUROBRAILLE = 784
brailletable = MITBRAILLE
```

Note the ordinals for the two constants MITBRAILLE and EUROBRAILLE.

4 A Simple Example

The rules section containing the contraction rules is the only section actually needed in a rule file. A simple rule file with rules for space and the 26 letters in the English alphabet thus contains the following lines of code:

```
< ; " " ; ; p      ;" " >
< ; "a" ; ; p1     ;"a" >
< ; "b" ; ; p12    ;"b" >
...
< ; "Y" ; ; p13456 ;"Y" >
< ; "z" ; ; p1356  ;"z" >
```

Testing these rules gives this result:

Original text: WinBraille rule file example.

Converted text: inraille rule file example

This simple example shows some limitations of these rules: The capital letters are not translated. We also need to define rules for the punctuation symbols, such as:

```
< ; "." ; ; p256   ;"4" >
```

Note: If we include a `brailletable` statement at the end of the file, we do not need to define both the fourth and the fifth elements in the rule tuple.

4.1 Capital Letters

To be able to translate capital letters, we can incorporate rules for those as well:

```
< ; "B" ; ; p12    ;"b" >
< ; "W" ; ; p2456  ;"w" >
```

As an alternative, we can define lists of upper case and lower case letters and a list equivalence statement in the definitions section. This is extremely useful when we define grade 2 rules, since we can avoid defining rules for all combinations of upper case and lower case letters. Example:

```
list lowerletter_list = ["a","b","c","d", ... "y","z"]
list upperletter_list = ["A","B","C","D", ... "Y","Z"]
equivalence lowerletter_list = upperletter_list
```

Testing the rules with the list and equivalence definitions gives this result:

Original text: WinBraille rule file example.

Converted text: winbraille rule file example4

4.2 Numbers

Adding rules for the numbers involves both “replacing rules” for the figures and “inserting rules” for the number prefix. The replacing rules:

```
< ; "1" ; ; p1     ;"a" >
...
< ; "0" ; ; p245   ;"j" >
```

An inserting rule is recognized by the absence of a symbol in the second tuple element. The actual inserted element is inserted between the left and the right contexts.

The number prefix inserting rules apply to digits. A list of digits is defined with a `list` statement, and a single digit element from the list of digits is defined with a `listrule` statement. The identifier `digit` defined in this way can then be used in the number prefix inserting rules.

Two rules are defined for the number prefix. The second rule inserts a number prefix in front of a digit. The first rule applies in case a digit follows a digit, to prevent the number prefix to be inserted between two digits.

```
list digit_list=["1","2","3","4","5","6","7","8","9","0"]
listrule digit = digit_list:1#
< digit          ; ; digit          ;           ;           >
<                ; ; digit          ; p3456 ; "#" >
```

5 The Rule File Editor and Compiler Wbrfe.exe

The editor `Wbrfe.exe` can be used to create and edit contraction rule files. The editor has a built-in compiler to produce a binary contraction rule file for the translation engine. The compiler is a "multipass compiler's compiler", `multipass`, as the compilation is performed in four passes, and compiler's compiler, because the compiler builds tables which are used by the translation engine to compile text to contracted Braille.

The following tables are built: print string table, Braille string table, string index table, list element table, list index table, list rule table, contraction rule table, contraction rule index table, Braille to print table, print to Braille table, and state table. Most of these tables are located in the beginning of the binary file (after the file header), and are loaded statically when the translation engine loads the rules. The file also contains the interface, the (eventually password protected) source and other definitions, but these are read from the file dynamically when needed and not loaded by the translation engine during the text translation.

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Braille to Text Translation for Hungarian

Andras Arato¹, Theresa Vaspori¹, Gareth Evans², and Paul Blenkhorn²

¹ KFKI RMKI LSTR H-1525 Budapest PO Box 49, Hungary
Arato@sunserv

²Department of Computation, UMIST, PO Box 88, Manchester, M60 1QD, United Kingdom
{g.evans,p.blenkhorn}@co.umist.ac.uk

Abstract. This paper discusses the translation of Hungarian Braille to text. A multi-lingual, table-driven Braille translator is described. The types of Hungarian Braille are discussed and a set of rules are derived and presented for 44-rule Hungarian Braille for the Braille translator.

1 Introduction

The Braille code is not international. There are, of course, many common characters but the correspondence between Braille characters and print characters is specific to particular countries. In some countries the Braille code uses contractions – context specific abbreviations for parts of words or whole words – which can reduce the amount of space needed by Braille.

For many blind people Braille is their natural medium for literacy and the work here was prompted by our desire to enable blind people to enter information into their computer system using a Braille keyboard rather than a QWERTY keyboard. This can be done using either an external Braille keyboard (e.g. [1]), a suitably modified Perkins Braille [2, 3] or using specific keys on the QWERTY keyboard (we use SDF and JKL) to enter Braille. This paper explains how an existing multilingual Braille-to-text translator [4] has been adapted to convert Hungarian Braille to text. For reasons of space, we restrict our discussions to 6-dot Braille.

2 Braille Translation

English Braille has uncontracted and contracted versions. Uncontracted is rarely used and the Grade 2 (contracted) English Braille system is commonly used. It uses context specific contractions for frequently appearing strings such as /ing/, /with/, /the/ etc. [4].

Hungarian Braille has three levels of abbreviations. The first level, which corresponds to English Grade 1, is contracted (in a similar manner to German Braille). Hungarian sounds marked in black print /zs/ /sz/ /cs/ etc. [5] are represented by a single Braille cell. Usually this code is symmetric so that phonetically similar groups

¹ Where text is presented between // it represents the text form of the language.

of letters have similar Braille representations, for example /s/-/sz/ /t/-/ty/ /l/-/ly/. This underlines the fundamentally "phonetic nature" of Hungarian Braille.

The second level of the Hungarian contracted Braille is the so-called 44-rule abbreviations. This does not mean that there are 44 rules but rather 44 groups of rules. Hungarian is a casing language with many similar endings. The endings follow the vowel harmony rule. Words containing low vowels /a/, /aa/, /o/, /u/ end with /-hoz/, /-bol/, /-rol/, /-tol/ endings. Words containing mid vowels /e/, /ee/, /i/ end with /-hez/, /-boel/, /-roel/, /-toel/. Finally words containing high vowels /oe/, /ue/ end with /-hoetz/, /-boel/, /-roel/, /-toel/. Usually the words containing mixed vowels end with endings corresponding to the last type of vowel e.g. /notesz-boel/. It should be noted that there are many exceptions to these rules. There is one abbreviation for the endings /-hoz/, /-hez/ and /-hoetz/ the Braille string /1-2-5/ /3/. This is counted as one rule in the Hungarian 44 contractions system.

The third level of contracted Hungarian Braille is not commonly used. This system (developed by Dr. Miklos Bano) contains 159 main rules. The rules can be ambiguous and some of the rules are very complicated. For example, the abbreviated code containing both sides of the Braille cell e.g. /1-2-5-6/ represents strings containing high vowels and consonants, whilst the code containing only the right half of the cell e.g. /5-6/ represents low vowels and consonants in the first syllable. This system is considered to be difficult to learn and so the 44-rule system is commonly used and we restrict our work to the first and second levels of contraction.

3 The Text-to-Braille Translator

The translation system is a rule-driven state machine. The rules are described in a text file, which also specifies the state transitions. The text file is the only language-specific part of the system and thus the system is configured for new languages by writing the text file for the language; in this case Hungarian. A rule has the following format:

<Current State> <Left Context> [Focus] <Right Context> = <Translation> <New State>

The Current State specifies the state in which the state the system must be in for the rule to be applied. Focus specifies the characters that are to be translated. These are written in American Computer Braille (ACB) [6]. The system requires the input device to place these characters in the computer's keyboard buffer. The left and right context parts of the rule specify the context in which the focus is to be found. These can be specified as ACB characters or special characters. The special characters may represent particular characters in the input text (for example ':' represents one or more punctuation characters) or modify the characters that follow (for example '!' means one or more of the characters that follow). The Translation is the text equivalent of the focus and the New State indicates the state which the state machine should enter following the application of the rule.

The rules are presented in alphabetical order of focus. The translator takes input text and attempts to match the first character (or characters where a rule has a focus of more than one character). It then attempts to apply each of the rules that start with that character. If the focus and the left and right context match the rule is applied and the

² Where numbers are given between // they represent dots in the Braille cell.

state and current focus are updated. If not it attempts to apply the next rule for that focus. Rules should be organised so that the more specific rules appear ahead of the more general rules. Further details of the algorithm and rule format are given in [4].

4 Hungarian Text-to-Braille

The following states are used:

1. We are at the start of the word.
2. We are in a low vowel word.
3. We are in a word with vowels: /e/ /ee/ /i/ /ii/.
4. We are in a word with vowels: /oe/ /oee/ /ue/ /uee/.
5. Within the scope of a Letter Sign.
6. Within a number.

Knowing the type of the vowels in the word permit the resolution of the abbreviation by using the Hungarian vowel harmony rule, e.g. in state 2 the ending /b/ at the word has to be resolved /ban/ while in states 3 and 4 it should be /ben/. The appropriate rules are:

2 [B]: =ban 1 3 [B]: =ben 1 4 [B]: =ben 1

Three different conversions are needed in the case of the ending /h/ for the endings /-hoz/, /-hez/, /-hoez/

2 [H']: =hoz 1 3 [H']: =hez 1 4 [H']: =hoez 1

Attention has to be paid of the words ending with /b/ because the endings /-ban/ and /-ben/ are abbreviated with a simple /b/. These words have to be included in the table as exceptions like /dob/ (drum) to prevent their unnecessary "decontraction".

1 [DOB]=dob 2

There are abbreviations with no special Braille characters like /olvas=os/, /keres=ks/, /forr=rr/, /uegg=gg/. In these cases, when these words are verbs we choose the following approach: abbreviate verbs only at the beginning of the word. (The original rule states: abbreviate the given string when it is a verb or in words composed from this verb.). The limitation "be at the start of the word" will reduce the numbers of the exceptions when the contracted string has other meaning, for example /mos/, /kormos/ (in English wash, smoky), and only those words are included in the exception dictionary that start with the given string /oson/, /ostor/ (sneak, lash). In addition, the given verbs can start with numerous prefixes modifying their meaning. These prefixes have to be also included into the table for proper abbreviation as the prefix is written close to the verb e.g. /megkeres/, /kikeres/, /felkeres/.

1 [MEGKS]=megkeres 3 1 [KIKS]=kikeres 3
1 [FELKS]=felkeres 3

The definite article /a/ precedes all nouns and attribute structures starting with consonants. The article /az/ precedes is for vowels. The Hungarian 44 rule system abbreviates them with the Braille combination /2/ and /3/ written close to the nouns or attributes and so we have the similar table entries for all consonants and vowel, e.g.

1 [1B]=a b 3 1 [1C]=a c 3 1 [1D]=a d 3
1 ['A]=az a 2 1 ['E]=az e 3 1 ['I]=az i 3

Problems arise not only with the nouns and attribute abbreviations at the beginning of a word but also with verbs. This because Hungarian verbs can be transformed into nouns and attributes with appropriate word modifiers. The only solution in these cases is to repeat the abbreviation entry in the table with the contracted prepositions, e.g. /keres/:

1 [1KS]=a keres 3

The /v/ abbreviation at the end of the word shows endings /-val/ or /-vel/ corresponding to the vowel harmony rule. The /v/ consonant in the ending assimilates to the standing before the consonant. Fortunately this is easily resolved with appropriate table entries, e.g.:

2 [TV]: =ttal 1 3 [TV]: =ttel 1

5 Discussion

The Hungarian system has not been widely tested yet so there may be exceptions not included in the full set of rules; however the initial results are promising. Perhaps the area which needs most work is that of compound words where many new words are created by concatenating existing words (rather like in the German language). This approach can be successfully used in the phonetic module of the multilingual speech segmentation system used in the EU-funded 3TBook (Tactile Talking Text) project.

The full set of rules are given in the Appendix.

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Appendix – Hungarian Braille to Text Rules

Wildcards used:

! = one or more &! (etc
 = right context white space
 ~ = one more roman letters
 _ = real space
 : = zero or more potential
 punctuation(end of word)

Decision table:

1000007
 0200007
 0030007
 0004007
 0000507
 0000060

States:

1 At the start of the word.
 2 In a low vowel word.
 3 In a word with vowels: e ee i ii.
 4 In a word with vowels oe oee ue uee.
 5 Within the scope of a Letter Sign.
 6 Within a number.
 Note: We don't allow abbreviations within the scope of a Letter Sign which is a double letter sign (4-6 4-6).

Input classes:

1 At the start of the word.
 2 In a low vowel word.
 3 In a word with vowels: e ee i ii.
 4 In a word with vowels oe oee ue uee.
 5 Within the scope of a Letter Sign.
 6 Within a number.
 7 Don't care.

Rules

1 []=	1	1 [&]=q	3	3 [*MP<V]: émpénnzel	1	1 [,@]=Á	2
7 []=	1	7 [&]=&	1	3 [*MP<]=émpénnz	3	1 [.]A]=A	2
7 [!]=!	1	5 [']='	1	1 [*~P]: =éspedíg	1	1 [.]B]=B	3
1 ["]="	1	7 ["]="...	1	1 [*]: =és	1	1 [.]C]=C	3
7 [#]=	6	1 [']=az ü	4	1 [*RV]: =érv	1	1 [.]D]=D	3
6 [#]=	6	1 [']=az û	4	1 [*V]: =év	1	1 [.]E]=E	3
5 [\$]=NY	5	1 [*RV]: =az érv	1	7 [*]=é	3	1 [.]F]=F	3
1 [\$L.V]:=nyíllal	1	1 [*V]: =az év	1	5 [+=Ú	5	1 [.]G]=G	3
1 [\$L]=nyíl	2	1 [*]=az é	3	1 [+=:úgy	1	1 [.]H]=H	3
2 [\$V]: =nnyal	1	1 [']+=az ú	2	1 [+=]: =úgyis	1	1 [.]I]=I	3
3 [\$V]: =nnyel	1	1 [']V]: =az íjjal	1	7 [+=ú	2	1 [.]J]=J	3
4 [\$V]: =nnyel	1	1 [']]=az ij	2	5 [.]]=	1	1 [.]K]=K	3
2 [\$\$]=nny	2	1 [']]=az í	3	6 [.]CL]: =centiliter	1	1 [.]L]=L	3
3 [\$\$]=nny	3	1 [']@]=az á	2	6 [.]CM]: =centiméter	1	1 [.]M]=M	3
4 [\$\$]=nny	4	1 [']ABB]: =az abban	1	6 [.]DG]: =dekagramm	1	1 [.]N]=N	3
2 [\$]=ny	2	1 [']A]=az a	2	6 [.]DL]: =deciliter	1	1 [.]O]=O	2
3 [\$]=ny	3	1 [']EBV]: =az ebbel	1	6 [.]KG]: =kilogramm	1	1 [.]P]=P	3
4 [\$]=ny	4	1 [']EB]: =az eb	1	6 [.]M]: =méter	1	1 [.]Q]=Ö	4
1 [\$]=ny	3	1 [']EBB]: =az ebben	1	6 [.]MG]: =miligramm	1	1 [.]R]=R	3
5 [%]=CS	5	1 [']E]=az e	3	6 [.]MM]: =miliméter	1	1 [.]S]=S	3
1 [%]: =csakis	1	1 [']]=az i	3	6 [.]L]: =liter	1	1 [.]T]=T	3
1 [%HAM]=csakham	2	1 [']OS]=az olvas	2	7 [.]]=	1	1 [.]U]=U	2
1 [%H]: =csakhogy	1	1 [']OGV]: =az ország ggal	1	6 [.]-]=	6	1 [.]V]=V	3
1 [%N]: =csaknem	1		1	5 [.]-]=	1	1 [.]W]=W	3
1 [%]: =csak	1	1 [']OG]=az ország	2	7 [.]-]=	1	1 [.]X]=X	3
2 [%V]: =ccsal	1	1 [']O]=az o	2	1 [.]]=	5	1 [.]Y]=Y	3
3 [%V]: =ccscl	1	1 [']QE]=az össze	3	5 [.]]=	1	1 [.]Z]=Z	3
4 [%V]: =ccsel	1	1 [']Q]=az ö	4	1 [.]S]=Ny	3	1 [.]_]=L_y	3
2 [%%]=ccs	2	1 [']U]=az u	2	1 [.]%=Cs	3	6 [']]=	6
3 [%%]=ccs	3	1 [']]=az ó	2	1 [.]&]=Q	3	5 [']]=í	5
4 [%%]=ccs	4	1 [']]=az ö	4	1 [.]()]=Ü	4	1 [']]=:így	1
2 [%]=cs	2	6 [']='	6	1 [.]()]=Ú	4	1 [']V]: =íjjal	1
3 [%]=cs	3	1 [']='	1	1 [.]*=É	3	1 [']]=íj	2
4 [%]=cs	4	5 [']()]=Ú	5	1 [.]+=Ú	2	2 [']]=í	2
1 [%]=cs	3	7 [']()]=ü	4	1 [.]A]=Í	3	7 [']]=í	3
5 [&]=Q	5	5 [']()]=Ú	5	1 [.]<]=Sz	3	2 [']]="	1
2 [&]=q	2	7 [']()]=ú	4	1 [.]<]=Z	3	3 [']]="	1
3 [&]=q	3	5 [']*=É	5	1 [.]>]=Zs	3	4 [']]="	1
4 [&]=q	4	2 [']*=é	2	1 [.]?]=Gy	3	7 [']]="	1

1	[I\$LV]:=a nyíllal	1	1	[IK]=a k	3	5	[4]=.	1	2	[<V]:=zzal	1
1	[I\$L]:=a nyíl	2	1	[1L@BB]:=a lábból	1	2	[4]=.	1	3	[<V]:=zzel	1
1	[I\$]:=a ny	3	1	[1L@BB]:=a lábban	1	3	[4]=.	1	4	[<V]:=zzel	1
1	[I%]=a cs	3	1	[1L@BV]:=a lábbal	1	4	[4]=.	1	2	[<]=z	2
1	[I&]=a q	3	1	[1L@B]=a láb	2	1	[4]=.	1	3	[<]=z	3
1	[I:ERV]:=a szerv	3	1	[1L]=a l	3	6	[5]=?	1	4	[<]=z	4
1	[I:V]:=a szív	1	1	[1M]=a m	3	5	[5]=?	1	1	[<]=z	3
1	[I:DV]:=a szabaddal	1	1	[1N*V]:=a név	1	2	[5]=?	1	5	[>]=ZS	5
1	[I:D]=a szabad	2	1	[1N]=a n	3	3	[5]=?	1	1	[>EBV]:=zsebbel	1
1	[I:ERBV]:=a szerbbel	1	1	[1PTV]:=a ponttal	1	4	[5]=?	1	1	[>EBB]:=zsebből	1
1	[I:ERB]:=a szerb	3	1	[1PT]=a pont	2	1	[5]=?	1	1	[>EBB]:=zsebben	1
1	[I:] =a sz	3	1	[1P<V]:=a pénznel	1	6	[6]=+	6	1	[>EB]=zseb	3
1	[I<]=a z	3	1	[1P<]=a pénz	3	5	[6]=!	1	1	[>RV]:=zsírral	1
1	[I>EBB']: =a zsebből	1	1	[1P/RV]:=a pírral	1	2	[6]=!	1	1	[>R]=zsról	2
1	[I>EBB]: =a zsebben	1	1	[1P/R]=a pír	2	3	[6]=!	1	2	[>V]:=zzsal	1
1	[I>EBV]: =a zsebbel	1	1	[1P]=a p	3	4	[6]=!	1	3	[>V]:=zzsel	1
1	[I>EB]=a zseb	3	1	[1R*V]:=a rév	1	1	[6]=!	1	4	[>V]:=zzsel	1
1	[I>RV]:=a zsírral	1	1	[1RDV]:=a röviddel	1	6	[7]=	6	2	[>>]=zsz	2
1	[I>R]=a zsír	2	1	[1RD]=a rövid	3	5	[7]=	1	3	[>>]=zszs	3
1	[I>]=a zs	3	1	[1RR]:=a forr	2	2	[7]=	1	4	[>>]=zszs	4
1	[I?SV]:=a gyorsal	1	1	[1R]=a r	3	3	[7]=	1	2	[>]=zs	2
1	[I?S]=a gyors	2	1	[1S/RV]:=a sírral	1	4	[7]=	1	3	[>]=zs	3
1	[I?] =a gy	3	1	[1S/R]=a sír	2	1	[7]=(3	4	[>]=zs	4
1	[1BABB'] =a bábból	1	1	[1S/PV]:=a síppal	1	6	[8]=	1	1	[>]=zs	3
1	[1BABB]:=a bábban	1	1	[1S/P]=a síp	2	5	[8]=	1	5	[?]=GY	5
1	[1BABV]:=a bábbal	1	1	[1S/KV]:=a síkkal	1	2	[8]=	1	2	[?ANABB]:=gyanabban	1
1	[1BAB]=a bab	2	1	[1S/K]=a sík	2	3	[8]=	1	1		1
1	[1B@BB']: =a bábból	1	1	[1S]=a s	3	4	[8]=	1	1	[?SV]:=gyorssal	1
1	[1B@BB]:=a bábban	1	1	[1T%V]:=a tanáccsal	1	1	[8]=	3	1	[?S]=gyors	2
1	[1B@BV]:=a bábbal	1	1	[1T%]=a tanács	2	6	[9]=*	6	2	[?]:=ggyal	1
1	[1B@B]=a báb	2	1	[1TSV]:=a teljesszel	1	5	[9]=*	1	3	[?V]:=ggyel	1
1	[1BGV]:=a boldoggal	1	1	[1TS]=a teljes	3	7	[9]=*	1	4	[?V]:=ggyel	1
1	[1BG]=a boldog	2	1	[1T]=a t	3	5	[:] =SZ	5	2	[?]=ggy	2
1	[1B]=a b	3	1	[1VGV]:=a világgal	1	1	[D]:=szabaddal	1	3	[?]=ggy	3
1	[1C*LV]:=a cállal	1	1	[1VG]=a világ	2	1	[D]=szabad	2	4	[?]=ggy	4
1	[1C*L]=a cél	2	1	[1VT]=a volt	2	1	[ERBV]:=szerbbel	1	2	[?]=gy	2
1	[1C]=a c	3	1	[1V]=a v	3	1	[ERB]:=szerb	3	3	[?]=gy	3
1	[1DOBB]:=a dobból	1	1	[1W]=a w	3	1	[ERV]:=szerv	1	4	[?]=gy	4
1	[1DOBB]:=a dobban	1	1	[1X]=a x	3	1	[V]:=szív	1	1	[?]=gy	3
1	[1DOBV]:=a dobbal	1	1	[1Y]=a y	3	2	[*K]=széck	3	5	[@]=A	5
1	[1DOB]=a dob	2	1	[1]=a ty	3	2	[V]:=sszal	1	1	[@TGD]=átgond	2
1	[1DJV]:=a díjjal	1	1	[1_]=a ly	3	3	[V]:=sszel	1	1	[@TKS]=átkeres	3
1	[1DJ]=a díj	2	6	[1]=.	6	4	[V]:=sszel	1	1	[@TRR]=átforr	2
1	[1D]=a d	3	5	[1]=.	1	2	[:] =ssz	2	1	[@T%]=áttanács	2
1	[1F]=a f	3	2	[1]=.	1	3	[:] =ssz	3	7	[@]=á	2
1	[1GG]=a függ	4	3	[1]=.	1	4	[:] =ssz	4	6	[A]=l	6
1	[1GDV]:=a gonddal	1	4	[1]=.	1	2	[:] =sz	2	5	[A]=A	5
1	[1GD]=a gond	2	1	[1]=.	1	3	[:] =sz	3	2	[ASP<V]:=anypénnzel	1
1	[1GQBB']: =a göbből	1	6	[2]=.	1	4	[:] =sz	4	4		1
1	[1GQBB]:=a göbben	1	5	[2]=.	1	1	[:] =sz	3	2	[ASP<]=anypéncz	3
1	[1GQBV]:=a göbbel	1	2	[2]=.	1	5	[:] =.	1	1	[A]=annyi	2
1	[1GQB]=a göb	4	3	[2]=.	1	7	[:] =.	1	1	[A<]:=azóta	1
1	[1G]=a g	3	4	[2]=.	1	5	[<]=Z	5	1	[A<U]:=azután	1
1	[1H*V]:=a hév	1	1	[2]=.	1	4	[<*PPTV]:=zépönttal	1	1	[ABB]:=abban	1
1	[1H/DV]:=a híddal	1	6	[3]=.	1	1		1	1	[AK@R%]:=akárcsak	1
1	[1H/D]=a híd	2	5	[3]=.	1	4	[<*PPT]=zépönt	2	1	[AK@RKI]=akárki	3
1	[1H]=a h	3	2	[3]=.	1	3	[<(STP<V):=züstpénnzel	1	1	[AK@RMI]=akármi	3
1	[1J]=a j	3	3	[3]=.	1	1		1	1	[AKI]=aki	3
1	[1KS]=a keres	3	4	[3]=.	1	3	[<(STP<]=züstpéncz	3	3	[ALEKV]:=alekkel	1
1	[1K/NV]:=a kínnal	1	1	[3]=.	1	3	[<]PTV]:=zöpönttal	1	3	[ALEK]=alek	2
1	[1K/N]=a kín	2	6	[4]=.	6	3	[<]PT]:=zöpönt	2	7	[AMI]=ami	3

1 [AM]: =amely	1	1 [C*LV]: =céllal	1	2 [FV]: =ffal	1	3 [K']: =ként	1
1 [AMTH]: =amint	1	1 [C*L]: =cél	2	3 [FV]: =ffel	1	4 [K']: =ként	1
1 [AMT']: =amelytől	1	2 [CV]: =ccal	1	4 [FV]: =ffel	1	1 [KS]: =keres	3
1 [AMT]: =amint	1	3 [CV]: =cecel	1	2 [F]: =f	2	1 [K]: =kis	2
1 [AMH']: =amelyhöz	1	4 [CV]: =cecel	1	3 [F]: =f	3	1 [KIGD]: =kigond	2
1 [AMK']: =amelyként	1	2 [C]: =c	2	4 [F]: =f	4	1 [KIGG]: =kifügg	4
1 [AMR]: =amelyről	1	3 [C]: =c	3	1 [F]: =f	3	1 [KIKS]: =kikeres	3
1 [AMV]: =amelyel	1	4 [C]: =c	4	6 [G]: =7	6	1 [KIOSON]: =kioson	2
3 [AP/RP<V]: =pírpénzzel	1	1 [C]: =c	3	5 [G]: =G	5	1 [KIOS]: =kiolvas	2
	1	6 [D]: =4	6	1 [GDV]: =gonddal	1	1 [KIRR]: =kiforr	2
3 [AP/RP<]: =apírpénz	3	5 [D]: =D	5	1 [GD]: =gond	2	1 [KIT%]: =kitanács	2
3 [ATPTV]: =atponttal	1	1 [D*LU]: =délután	1	1 [GG]: =függ	4	1 [KIVG]: =kivilág	2
3 [ATPT]: =atpont	2	1 [D/JV]: =díjjal	1	1 [GQBB']: =göbből	1	1 [K/NV]: =kínnal	1
3 [AVERV]: =averral	1	1 [D/I]: =díj	2	1 [GQBB]: =göbben	1	1 [K/N]: =kín	2
3 [AVER]: =aver	2	1 [DH]: =dehogy	1	1 [GQBV]: =gobble	1	2 [KV]: =kkal	1
7 [A]: =a	2	1 [D]: =de	1	1 [GQB]: =göb	4	3 [KV]: =kkel	1
6 [B]: =2	6	1 [DOBB']: =dobból	1	2 [GV]: =ggal	1	4 [K]: =kkel	1
5 [B]: =B	5	1 [DOBB]: =dobban	1	3 [GV]: =ggel	1	2 [K]: =k	3
1 [B@BB']: =bábból	1	1 [DOBV]: =dobbal	1	4 [GV]: =ggel	1	3 [K]: =k	2
1 [B@BB]: =bábban	1	1 [DOV]: =dob	2	2 [G]: =g	2	4 [K]: =k	4
1 [B@BV]: =bábbal	1	2 [DV]: =ddal	1	3 [G]: =g	3	1 [K]: =k	3
1 [B@B]: =báb	2	3 [DV]: =ddel	1	4 [G]: =g	4	5 [L]: =L	5
1 [B@R%]: =bárcsak	1	4 [D]: =ddel	1	1 [G]: =g	3	1 [L]: =lesz	1
1 [B@RH]: =bárhogy	1	2 [D]: =d	2	6 [H]: =8	6	1 [LERD]: =lerövid	3
1 [B@RKI]: =bárki	3	3 [D]: =d	3	5 [H]: =H	5	1 [LEV]: =levilág	2
1 [B@RMI]: =bármi	3	4 [D]: =d	4	1 [H*V]: =hév	1	1 [L@BB']: =lábból	1
1 [BABB']: =babból	1	1 [D]: =d	3	2 [H]: =hoz	3	1 [L@BB]: =lábban	1
1 [BABB]: =babban	1	6 [E]: =5	6	3 [H]: =hez	1	1 [L@BV]: =lábbal	1
1 [BABV]: =babbal	1	5 [E]: =E	5	4 [H]: =höz	1	1 [L@B]: =láb	2
1 [BAB]: =bab	2	1 [E<U]: =ezután	1	1 [HA%]: =hacsak	1	2 [LV]: =lhal	1
2 [B']: =ból	1	1 [EBB]: =ebben	1	1 [HAN]: =hanem	1	3 [LV]: =lhel	1
3 [B']: =ból	1	1 [EB]: =eb	1	7 [H/DV]: =híddal	1	4 [LV]: =lhel	1
4 [B']: =ból	1	3 [EG:D]: =egszabad	2	7 [H/D]: =híd	2	2 [L]: =l	3
2 [BB]: =bb	1	3 [EG?S]: =eggyors	2	2 [HV]: =hhal	1	3 [L]: =l	3
3 [BB]: =bb	1	3 [EGGD]: =eggond	2	3 [HV]: =hhel	1	4 [L]: =l	1
4 [BB]: =bb	1	3 [EGGG]: =egfügg	4	4 [HV]: =hhel	1	1 [L]: =l	3
2 [B]: =ban	1	3 [EGKS]: =egkeres	3	1 [H]: =hogy	1	1 [M*G%]: =mégcsak	1
3 [B]: =ben	1	3 [EGOS]: =egolvas	2	2 [H]: =h	2	1 [M*GP]: =mégpcdig	1
4 [B]: =ben	1	3 [EGPT]: =egpont	2	3 [H]: =h	3	1 [MAJDN]: =majdnem	1
7 [BE:D]: =beszabad	2	3 [EGP<]: =egpénz	3	4 [H]: =h	4	1 [MDAI]: =mindannyi	2
7 [BE?S]: =begyors	2	3 [EGQE]: =egössze	3	1 [H]: =h	3	1 [MDQE]: =mindössze	3
7 [BELE:D]: =becszabad	2	3 [EGRD]: =egrövid	3	6 [I]: =9	6	1 [MD]: =mind	3
7 [BELEGD]: =belegond	2	3 [EGRR]: =egforr	2	5 [I]: =I	5	1 [MEG:D]: =megszabad	2
7 [BELEERR]: =beleforr	2	3 [EGT%]: =egtanács	2	2 [I]: =i	2	1 [MEG?S]: =meggyors	2
7 [BERREG]: =berreg	3	3 [EGTS]: =egteljes	3	1 [I]: =is	1	1 [MEGAI]: =megannyi	2
7 [BERR]: =beforr	2	3 [EGVG]: =egvilág	2	1 [IDEFG]: =idefügg	4	1 [MEGBG]: =megboldog	2
7 [BELEOS]: =beleolvas	2	1 [EI]: =ennyi	3	1 [IDEVG]: =idevilág	2	1 [MEGGD]: =meggond	2
7 [BEOSON]: =beoson	2	7 [ELOSON]: =elocson	2	1 [IGEN%]: =igencsak	1	1 [MEGKS]: =megkeres	3
7 [BEOS]: =beolvas	2	1 [ELOS]: =elolvas	2	7 [I]: =i	3	1 [MEGOS]: =megolvas	3
7 [BEVG]: =bevilág	2	3 [EMPTV]: =emponttal	1	6 [J]: =0	6	1 [MEGRD]: =megrövid	3
1 [BGV]: =boldoggal	1	3 [EMPT]: =empont	2	5 [J]: =J	5	1 [MEGR]: =megforr	2
1 [BG]: =boldog	2	1 [ELT%]: =eltanács	2	2 [JV]: =jjal	1	1 [MEGT%]: =metganács	2
2 [BV]: =bbal	1	7 [E]: =e	3	3 [JV]: =jjel	1	1 [MEGV]: =megvilág	2
3 [BV]: =bbel	1	6 [F]: =6	6	4 [JV]: =jjel	1	1 [MEGV]: =megvolt	2
4 [BV]: =bbel	1	5 [F]: =F	5	2 [J]: =j	2	1 [M]: =mely	1
2 [B]: =b	2	1 [FEL:L]: =feliszabad	2	3 [J]: =j	3	1 [MH']: =melyhöz	1
3 [B]: =b	3	1 [FEL?S]: =felgyors	2	4 [J]: =j	4	1 [MK']: =melyként	1
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1 [B]: =b	3	1 [FELKS]: =felkeres	3	5 [K]: =K	5	1 [MT]: =melytől	1
6 [C]: =3	6	1 [FELRR]: =felforr	2	1 [K]: =kell	1	1 [MV]: =melyel	1
5 [C]: =C	5	1 [FELVG]: =felvilág	2	2 [K']: =ként	1	1 [MTHA]: =mintha	1

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1	[M@RMT]: =mármint	1	3	[R']:=röl	1	1	[V*GIGGD]=végigggond	1	1	[N]=ty	3
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3	[M]=m	3	1	[RR]=forr	2	2		2	3	[_]=lly	3
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4	[N]=n	4	4	[RV]: =rrel	1	1	[VI::ARR]=visszaforr	2	2		
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The WinBraille Approach to Producing Braille Quickly and Effectively

Mats Blomquist¹ and Per Burman²

¹Luleå University of Technology, 971 87 Luleå, Sweden
Mats.Blomquist@sm.luth.se

²Index Braille AB, 954 28 Gammelstad, Sweden
per.burman@indexbraille.se

Abstract. With WinBraille it is possible to emboss directly from a word processor like Microsoft Word on any of Index Braille's embossers, and on-the-fly contract the document into grade 2 Braille. The benefit of WinBraille is that it has a simple interface for the novice, but is still powerful for the advanced user. WinBraille contains Windows drivers for Index Braille's embossers, the WinBraille application, contraction rules for more than 20 languages, a contraction rule editor, predefined profiles and templates for immediate access, and macros to directly emboss from Microsoft Word. The combination of Word macros, drivers, predefined contraction rules, profiles and templates makes the system suitable for the user with no or limited knowledge of Braille and Braille printing. We describe how the WinBraille's approach can facilitate the daily work for people who normally do not print Braille, but occasionally have to produce materials to be read by blind or visually impaired people. We also explore some of WinBraille's less advanced features, like Braille formatting and how to select different profiles and templates.

1 Introduction

WinBraille is a Windows program for producing and embossing Braille on Index Braille's embossers. The WinBraille system contains the WinBraille program, printer drivers for Index Braille's embossers, contraction rules and macros for Microsoft Word.

A central concept is the profile. A WinBraille profile is a container for all WinBraille settings, like Braille contraction rules and Braille formatting and templates. WinBraille contains predefined profiles for a number of applications.

Contraction rules exist for the following languages: American English, Belgian, Brazilian Portuguese, Bulgarian, Czech, Danish, Dutch, English, French, German, Greek, Icelandic, Italian, Latvian, Nigerian, Norwegian, Polish, Portuguese, Russian, Sami, Slovak, Spanish, Swedish, and Turkish.

2 Embossing a Document

There is no need to specifically know how to format a Braille document for a specific purpose, or translate the context to contracted Braille. The predefined profiles contain all the necessary information. Embossing a document with WinBraille is as easy as printing the document from Word to the standard printer. The embossing process is described in the following figure:

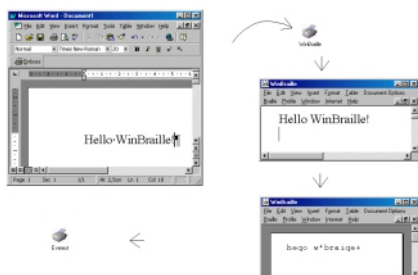


Fig. 1. The embossing Process

When we emboss from Word with the WinBraille’s Word macros, an emboss dialog, similar to the standard print dialog, will appear:

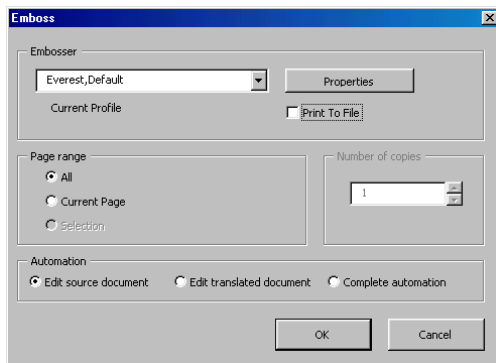


Fig. 2. Emboss Dialog

The emboss dialog gives us an option to select a proper profile. The “Complete automation” option lets us emboss to the selected embosser, using predefined settings from the selected profile.

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Haptic Device System for Upper Limb Motor Function and Cognitive Function Rehabilitation

Yoshiyuki TAKAHASHI¹, Takafumi TERADA², Kaoru INOUE³,
Satoshi SASADA⁴ and Takashi KOMEDA⁵

¹ Research Organization for Advanced Engineering, Shibaura Institute of Technology,
307 Fukasaku, Saitama, 330-8570 Saitama, Japan
i0180026@sic.shibaura-it.ac.jp

² Research and Development Department Group, Mitsubishi Precision Co., Ltd.,
345 Kamimachiya, Kamakura, 247-8570 Kanagawa, Japan
tterada@mpcnet.co.jp

³ Faculty of Health Sciences, Tokyo Metropolitan University of Health Sciences,
7-2-10 Higashi-Ogu, Arakawa, 116-8551 Tokyo, Japan
inoue@post.metro-hs.ac.jp

⁴ Faculty of Health Medicine, Teikyo Heisei University
2289 Uruido, Ichihara, 290-0193 Chiba, Japan
sasada@thu.ac.jp

⁵ Faculty of System Engineering, Shibaura Institute of Technology,
307 Fukasaku, Saitama, 330-8570 Saitama, Japan
komeda@se.shibaura-it.ac.jp

Abstract. We have developed a rehabilitation tool system utilizing a haptic device. We try to integrate motion and sensory therapy without the patients losing their interest. This system aims to integrate the training of both motor function disorder and cognitive function disorder. It consists of a haptic device, a display, a computer and software for training. The haptic device provides a virtual force in the different training programs. Patients can improve not only motor function, but also cognitive function. This system can record the training data. It can be used to evaluate the relearning degree, using quantitative analysis. We tried to evaluate the functionality of this system by introducing it to physical and occupational therapists. They had a good impression of this system.

1 Introduction

Patients with disorders of the higher brain function, including stroke survivors, are increasing in today's aging societies. Improving their impairment e.g. upper limb motor control coordination disorder helps patients on their way back to independent life. The importance of this kind of rehabilitation is acknowledged today. At present, various conventional rehabilitation programs are carried out in hospitals and in other facilities for rehabilitation. However, they involve various problems, which soon can become burdens for the patients. Almost all existing training programs are mono-

nous. This makes it difficult to keep up motivation to recover and improve the disordered function. In addition, it is difficult to train at a patient's individual preferred pace and to know the current degree of recovery. From the view point of therapist, measuring, analyzing and evaluating the patient's performance in an objective and quantitative term is required. Current research is focused on various approaches to provide effective rehabilitation. Above all, robotic therapy and using virtual reality (VR) is found suitable to solve the problems associated with conventional training. The rehabilitation system using computers can provide a simple environmental setup, exact repeated operation and at the same time gather the training data. It can also provide interactive therapy to engage the patient's interest. Various kind of research has been conducted so far in this field. For example, MIT-MANUS [1], MIME (Mirror Image Movement Enabler) [2] and Rehabilitation Training System Using ER Actuator [3], use robotic therapy to recover the motor function. VR -based system using a haptic glove is used for post-stroke hand rehabilitation [4].

Not only to solve the above-mentioned problem, we are also trying to integrate the motor function rehabilitation with cognitive function rehabilitation. Conventional training and retraining programs are traditionally separated. For example, therapeutic exercise with a physical therapist using sanding board and pegs is used for motor function disorder. Sensory integration therapy with an occupational therapist using picture cards and blocks is used for cognitive function disorder. Now to integrate these rehabilitation methods, we have developed a rehabilitation tool using a haptic device integrating both motion and sensory therapy with much less risk of the patients losing their interest.

2 Conceptions of Design

The haptic device for upper limb motion function and cognitive function rehabilitation system was designed on the assumption that it is mainly used by a patient under the supervision of a helping therapist. Of course, this system also allows the patients to do training by themselves. In order to carry out suitable training to every individual patient, this system is designed so that the therapist can set up individual environmental data for each training program. The system makes it possible to easily save and load the individual training environments to and from on the hard disk. The evaluation of the disorder and the improvement level are traditionally depending on a therapist's subjective decision. Therefore an objective quantitative analysis is a good supplement. A rehabilitation tool system using a computer can record the training data and evaluate the level of recovery and improvement of patients using quantitative analysis. It is based on their recorded training data and that is under development now. To prevent spoiling patient's concentration, all except the training program is hidden from the display. The detail of the systems control menu is hidden from the patient in training. We have tried to develop a rehabilitation system for both the motor function and cognitive function disorder rehabilitation. In addition, to realize the therapy without the patients losing their interest, we have prepared the therapeutic application with fun interaction. It is much like a computer game.

3 Rehabilitation Tool Applied a Haptic Device

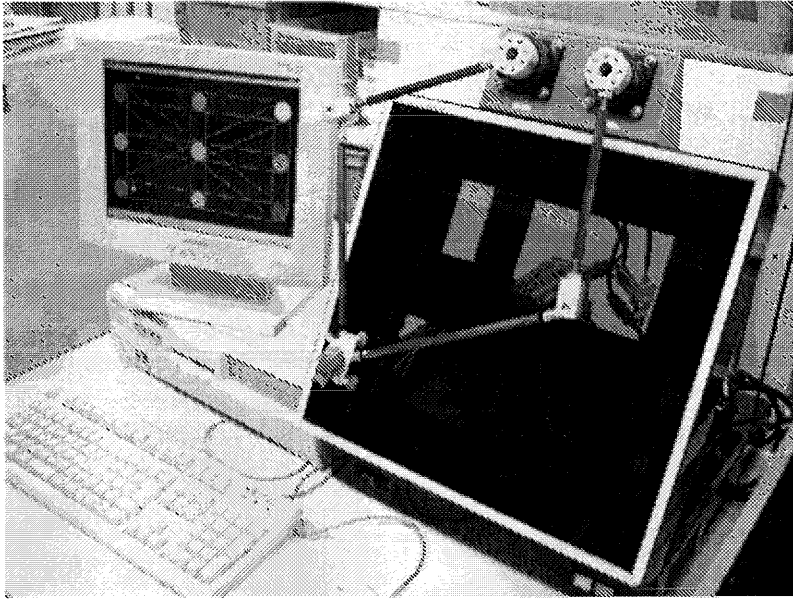


Fig. 1. Overview of the Rehabilitation System Using the Haptic Device

Fig. 1 shows an overview of the rehabilitation system using the haptic device, which we have developed. This system consists of a haptic device, a display, a computer and software. The haptic device is driven by two AC servo motors which together can deliver a maximum force of 30 N on to the hand grip. The position of the grip is measured by optical encoders that are attached on to the servo motors. The theoretical resolution is 0.01 mm. The size of the haptic device is 430 mm in height, 500 mm in width and 190 mm in depth. The patients can move the grip 400 mm horizontally and 360 mm vertically on the surface of the flat panel. The aspect ratio of the displays work field is proportion of the actual flat panel. If the patient moves the grip of the haptic device, the symbol on the display moves simultaneously with the grip and she/he can feel the virtual force applied on to the grip. The display is used for showing the exercise program visually. A 15 inches size LCD display is used. The computer has a Pentium III 700MHz CPU, GeForce2 video card, an encoder pulse counter and a discrete I/O interface card. The haptic device is controlled by the computer.

The software consists of a system control program, a user interface program, a haptic device control program, a recording program and an evaluation program. Fig.2 shows the structure of the software. The system control program sets up the training program and controls the other programs. The user interface program pops up detail of the system control menu and draws the graphics of training scenarios updated with a frequency of 30Hz. The training program consists of both basic training programs and applied training programs. The programs are selectable from a menu using the normal mouse pointer. The detail of the training program will be

menu using the normal mouse pointer. The detail of the training program will be described in a separate section. The haptic device control program calculates the position of the grip, based on the encoder pulses, and applies a virtual force on to the grip. The recording program gathers and stores the training data in memory and on the hard disk drive with information such as, time, position of the grip, force on the grip and so on. The training data can be stored related to individual patients and can be loaded for evaluation anytime the therapists likes to. The evaluation program will analyze and evaluate the relearning degree using the quantitative analysis software program for motion function rehabilitation as well as for the cognitive function rehabilitation.

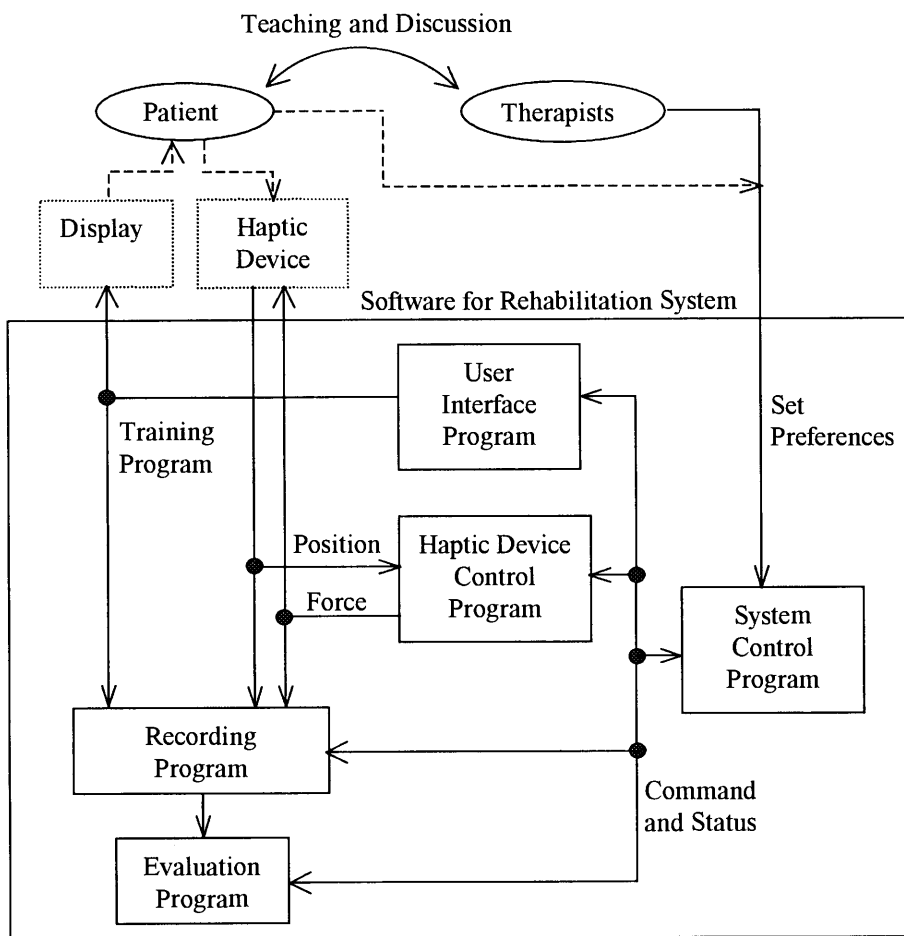


Fig.2 Software Structure

4 Training Program

This system is capable of 2 different types of training, basic training and an applied training. We have at present developed 5 different programs for basic training and 2 other programs for applied training. In the basic training programs, the patients are urged to move their arms either straight, in a circle, in a wave or voluntarily. As an example, one program shows small circles on the display and patients can try to move the cursor from circle to circle using vertical, horizontal and diagonal movement. When moving the grip, the haptic device provides a force and it can either assist the movement of the arm or work against it. The level and the direction of the force are also adjustable. Moreover, we can simulate different type of characteristics such as, contact force, viscosity, surface friction and the shapes of things. In the applied training programs, the patients can play games in order to train without losing motivation and to maintain concentration. Today a hockey game and maze game exist. The force on the handgrip is also provided in the applied training. These training programs are intended to be used together with the supervision of a therapist. However, this system can also be used by the patients themselves in accordance with guidance function.

4.1 Basic Training Program

The basic training program is not only designed to improve the motor function, shoulder and elbow coordination, but also to evaluate the current objective ability of the patient. The basic training program has 5 different programs, called POINT, LINE, CIRCLE, WAVE and TILE. The details of each program are described as follows. In the POINT program (Fig.3), 9 circles are shown on the display and patients try to move the cursor from circle to circle. The displacement of the circles and radius of the circles are changeable. In the LINE program, 9 small circles and lines, that connect the circles, are shown on the display. Patients try to move the cursor from circle to circle while staying on the lines. The displacement and radius of the circles are changeable the same way as in the POINT program. In the CIRCLE program, 4 concentric rings are shown on the display. Patients try to move the cursor while staying on the rings. The radius and width of the rings are changeable. In the WAVE program, 2 small circles and a sine wave shaped line are shown on the display. The circles are connected with the wavy line. Patients try to move the cursor from one circle to the other while keeping on the line. The amplitude and cycle of the wave are changeable. In the TILE program, Square shaped colored tiles are shown on the display. Patients try to move the cursor over all tiles. When the cursor is over a tile, the color of the tile is cleared and a hidden picture appears. Pictures with the patient's interest can be displayed to keep up concentration during the training. As for the hidden pictures, prepared arbitrary picture files can be used. The number of tiles is changeable. The magnitude and direction of the virtual force in the training is also adjustable.

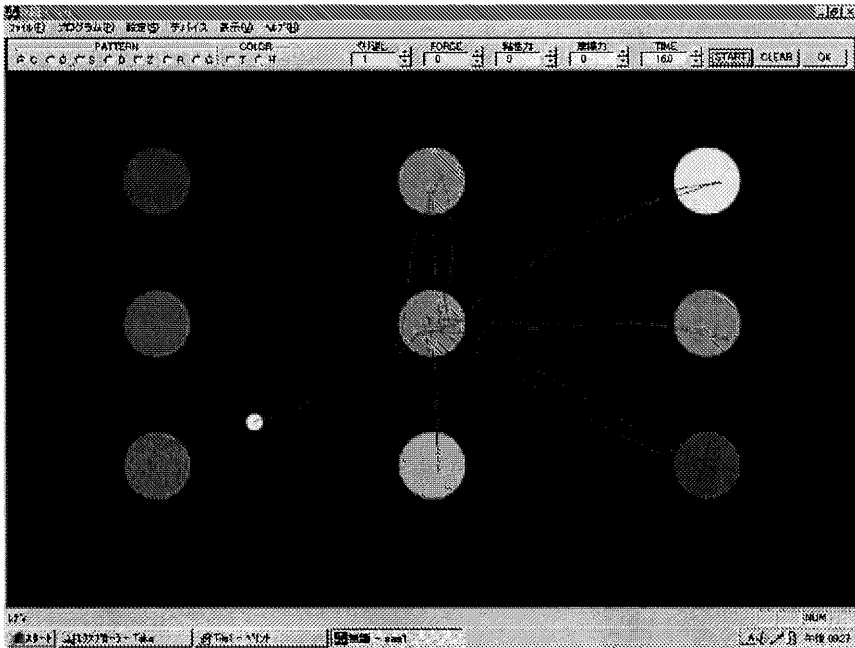


Fig. 3 Sample Image of the Basic Training Program

4.2 Applied Training Program

In order to keep up patients' motivation, we have prepared game programs. The applied training program has 2 different programs, HOCKEY and MAZE. The details of each program are described as follows. In the HOCKEY program (Fig.4), patients try to hit a puck and score against the computer program. It is similar to table hockey game. Various different haptic forces can be felt when moving the grip e.g. impact force, viscous force and spring force. The velocity of the puck and virtual force are adjustable. In the MAZE program, patients try to move the cursor from start to goal through an intricate network of passages. Somewhere in the maze, the therapist can deploy symbols, which the patient can try to pick up. Various different haptic forces can be felt hitting the walls on different special parts in the maze. The magnitude and direction of the virtual force in the training programs are also adjustable. These programs can record the movement of the cursor and applied forces like as in the basic training programs.

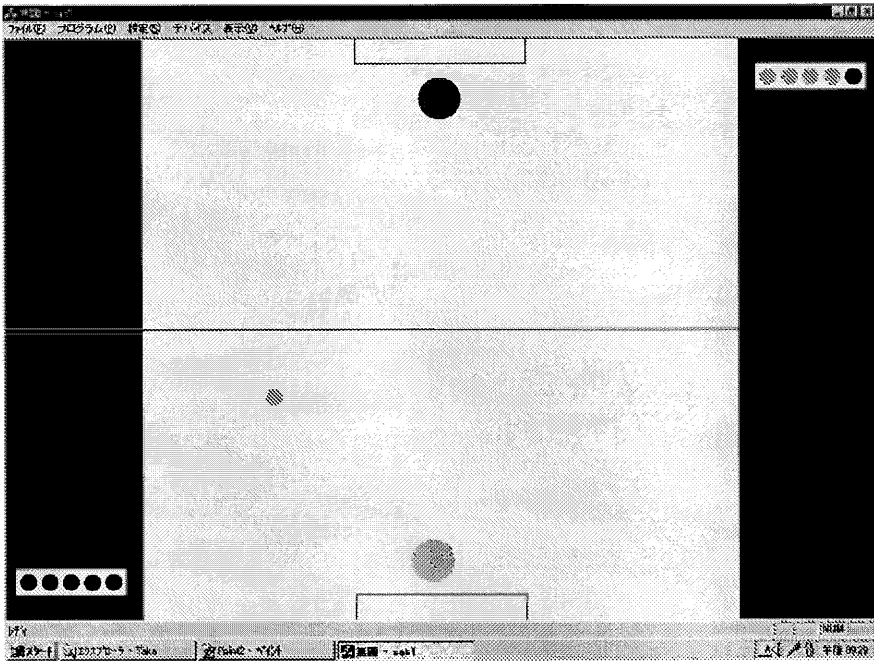


Fig. 4 Sample Image of the Applied Training Program

5 Conclusion

We have developed a rehabilitation tool system, which utilizes a haptic device. We try to integrate the motion and sensory therapy. Keeping up patients' motivation to recover and improve the disordered function has been an important issue. This system has been developed to later be supplemented with a quantitative evaluation method for motor and cognitive function rehabilitation. We investigated the functionality of this system by asking the opinions from physical and occupational therapists. They had both a good impression of this system. Especially the function of recording the training data was popular with them. We realized however that we now need a more suitable training program for adults. According to their advice, child patients can play games for fun, although, it may hurt a patients' pride in the case of an adult.

We are now making a more portable system, which we will use in a hospital and in another facility for rehabilitation. Our intension is to conduct clinical trials and develop the quantitative evaluation method for motor function as well as cognitive function rehabilitation.

Acknowledgement

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Networking for Accessibility: Elderly People and New Technology

Sirkku Männikkö-Barbutiu

Dept of Computer and Systems Sciences, Stockholm University/KTH,
Forum 100, S – 164 40 Kista, Sweden
Sirkku@dsv.su.se

Abstract. The paper investigates two specific types of practices that are evolving in order to reduce the digital divide and to bring the ICT to the elderly people. They are sensitising and social learning. Sensitising is understood here as a process through which elderly are becoming aware of the new technology, its existence and its possibilities. Sensitising may take place indirectly through everyday social interaction with family and friends as well as directly through specific, organised events, which aim to inform elderly of the ICT. Social learning refers to the organised efforts that gather elderly together to learn about the technology. This is done in local SeniorNet clubs, which connect to the long tradition of study circles in Sweden. Clubs provide both a place where the technology is available to the elderly and a community for learning about the technology.

1 Introduction

Sweden is often considered as a high-technology country, and the Swedes as a strongly pro-technology nation. This is supported by the fact that for the third year running Sweden is ranked as the world's leading information society by the International Data Corporation Information Society Index [11] which includes 23 indicators measuring the capacity of a nation's citizenry to exchange information internally and externally. This result and other surveys [2] that have followed the diffusion of the ICT in Sweden suggest that the access to the ICT in Sweden is good, in international comparison, and that the diffusion of the technology has been noticeable between 1998-2000. There are laggards in the population – mostly within working class, among elderly, and in some extent even among women. However, the tendency is clear towards a more even diffusion. The laggards are catching up, and the differences between different social groups are becoming smaller.

By the end of 1999, Sweden had the highest computer density in Europe. The year 1998 had been an extraordinary one for the computer market as a special taxation benefit boosted the market and 1.4 million personal computers were sold that year. Almost half of the households (48.5%) had a personal computer now.[7]

In the study that Österman & Timander [8] conducted in 1997, in the group of elderly born 1917-1929 only 8% reported regular computer use. The percentage increases to 49 % in the group born between 1930-1946. When it comes to the use of the Internet and e-mail, the numbers are even lower: 9 % of those born 1930-1949 use

e-mail regularly and 6 % in the same age group use the Internet regularly. It should also be noted that women are in clear minority as ICT users despite their overrepresentation in these age groups.

Another survey from 1998 [7] shows that 22% of the total population in Sweden used their computer at least once during an average day, which is less than half of those possessing a computer. There is a clear difference between men and women: 28% of men and 16% of women used the computer at least once a day. The least frequent use was found in the age group 65-79 where only 5% used the computer once a day. A comparison with the figures from 1996 show, however, a clear growth. In 1996, only 13 % of the total population used the computer at least once a day, and in the age group 65-79 the daily users made only one percent of the group. In the year 2000, 75 % of the Swedish population in age group 16-64 had access to a computer in the home, and only 20 % in the age group 65-84 had access to the computer in the home [6].

These figures plainly show that the group of elderly is in clear minority when it comes to computer ownership and use. An interview study conducted in 2001 made the Digital Divide even more visible. According to this study [3], over 50 % of those in the age group 55-79 do not have access to the Internet. It is also interesting to note that their motivations for not having access principally (69 % of the answers) is that they lack interest and/or they cannot see any real use for the Internet. Only 8 % regarded the technology to be too expensive, and the same percentage thought that the technology was too complicated for them.

If the lack of interest seems to be the major cause for not having a computer, then how should we think about accessibility? In general discourses about ICT, it is often emphasised that the technology should be made available to all groups in society, and it is somehow taken for granted that all people are interested in the new technology only if they get the physical access to it. I would like to suggest that accessibility has got several dimensions to it. First, accessibility is about attitudes, about mental disposition to engage in appropriation of a new technology. Second, accessibility is about having physical access to the new technology, and third, it is about having access to support which includes both technical support when the complex technology is causing trouble, and social support in the process of creating new practices with the new technology.

2 About the Study

In order to investigate the nature of accessibility, a three-year ethnographic field study has been carried out between 1999 and 2001. The study has focused on one particular case, a Swedish interest association called SeniorNet Sweden which has grown out of the conviction of some enthusiasts that even elderly people should be provided with the opportunity of benefiting from the ICT. The study has been done within the association and among its members inhabiting both in Sweden and even abroad, in Spain. The data has been gathered through interviews and participant observations on various locations, in the homes of the elderly, in local SeniorNet clubs, during special events organised by the association, and on the Internet. The data also includes so-called 'computer diaries' written by a number of SeniorNet members. These diaries

consist of data on actual use of personal computer during one week's time and of user's reflections on the use and their relation to the ICT.

2.1 About the SeniorNet Sweden

The SeniorNet Sweden was founded in 1996, and the governmental IT commission was involved in initiating this 'movement'. The goal of the SeniorNet is to serve as a platform where people over the age of 55 can be able to meet and socialise around the ICT [5]. The roots of the association can be found in the United States where SeniorNet was started by Dr. Mary Furlong in 1986 as a research project which was to determine whether elderly were interested in learning to use computers, and to create a model virtual community for them [1].

SeniorNet Sweden has applied the, in Sweden, popular model of association with a small central office and an ever growing number of local clubs where members within a certain geographical area (suburb, town, village, county, province) meet. In the beginning of the year 2001, there were 45 local clubs [9] in total. Half of the clubs (22) are situated in Stockholm area which suggests that this is still very much an urban phenomenon although ICT visions expressed by various actors wish to underline the potential that ICT would give to the rural areas.

The amount of members has grown steadily. By the first general meeting in 1997, around 200 members were registered. By the summer of 1999, the number of members had increased to 3 000. In the beginning of 2002, there were 6.345 members in the SeniorNet Sweden.¹ The ambition is to create a 'folk movement' with at least 20 000-30 000 members. According to the statistics presented by SeniorNet Sweden in February 2000, the eldest member was 93 years old and the youngest 52.² Six per cent of the members turned 80 during year 2000, 38 per cent were between 70 and 79 years of age, and 51 per cent of the members were between 60 and 69 years of age. The gender division is almost 50-50 as there were 51 per cent men and 49 per cent women.

The clubs are often created around existing social networks, which are in this way enhanced. But clubs may also function as arenas for entirely new networks bringing together people in the same neighbourhood who would not otherwise meet. The SeniorNet Sweden is also a virtual community. The web-site provides information on various, for elderly people interesting issues. The web-site is also a place where to meet in a chat or in a discussion forum.

The SeniorNet Sweden is engaged in practices that are evolving with the aim of reducing the Digital Divide and to bring the ICT to the elderly people. I have chosen to call these practises sensitising and social learning.

3 The Practice of Sensitising

Sensitising is understood here as a process through which elderly are becoming aware of the new technology, its existence and its possibilities. Sensitising is about 'opening

¹ According to SeniorNet Sweden administration 2002-02-16.

² 83 per cent of the registered members (3176) gave their year of birth.

the mind' to the new technology and the possibilities it may bring with it. Sensitising may take place indirectly through everyday social interaction with family and friends as well as directly through specific, organised events, which aim to inform elderly of the ICT, like special fairs for the elderly people and so-called SeniorSurf days. In the following, I will take a closer look at the phenomenon called SeniorSurf.

The very first Senior Surf was arranged in 1998 as a part of the European Cultural Capital year activities in Stockholm. In *Kulturhuset* (a cultural centre in the city), a series of three hour introductions to the Internet were arranged for the "mature beginners" [4]. The basic idea was to demonstrate the possibilities of the Internet and computing to elderly people by other elderly people who already had discovered the fun of the Internet and were eager to show their discovery to others.³ The following year, 1999, happened to be the international year of the elderly, and the SeniorSurf was carried out under an intense media coverage. The happening was now extended to all the public libraries in the country. As a whole, 375 libraries participated in the SeniorSurf event and around 30 000 elderly people came to learn about computers and the Internet [10]. The Surfs were arranged so that there usually were short introductions made by the volunteers from the SeniorNet Sweden. They showed how a personal computer is functioning and how it can be used for surfing the Internet. Besides these introductions, visitors could have a try themselves with the computers available in the library, and again the volunteers would be there to help and guide the beginners.

The event may be considered as a success. One reason for the popularity was undoubtedly the time: 1998 and 1999 were years that were characterised by the ICT hype. ICT was present in every media and everybody was talking about it. Another important reason for the success was the fact that the Surf took place in familiar surroundings, in public libraries, which are easy to access both geographically and mentally. Elderly people are often active users of their local library and thus this place is familiar to them. The event is also made as informal as possible. The atmosphere is somewhat of a folk feast. Questions and answers are criss-crossing the air and people seem to really enjoy the event. Both visitors and instructors emphasise how important it is to be in the "same age group". There are no 'besser-wisser' computer-freaks around who would make one feel inferior by their excellence. It is much easier to identify with a person within one's own age group and to accept new ideas that are presented by someone with a similar background, and similar life experiences. This kind of 'peer-guiding' has turned out to be both popular and successful. Elderly people also report that they benefit most of their Internet surf when some form of personal assistance is available. They value the presence of a person whom they can ask and who can guide them in a manner they understand. They also prefer to be continually informed about what is happening at any given time while they are using the computer which means having an assistant asking the elderly what they wish to do with the computer and guide them through that process.

Senior Surf-day can be described as one of the channels applied for communicating the innovation of computers to the elderly. It functions as a sensitising event being the very first contact with the innovation for many of the participants. This may be a crucial moment, the moment of rejection or the moment of acceptance leading to

³ SeniorNet members who volunteered as instructors.

further explorations of the new technology. It seems to be important to connect the sensitising event with try-on and training events of more permanent and frequent nature, so that the awakened interest and enthusiasm will not die out too soon.

The SeniorSurf does seem to have gained permanency as an annual, nation-wide event which introduces computers and the Internet to the elderly people. SeniorNet clubs are involved in carrying out the event, and this coupling also provides a possibility to continuation. Those who come to the SeniorSurf and find the technology attractive are easily passed further to the nearest club where they can continue their computer explorations.

4 The Practice of Social Learning

By social learning I mean the organised efforts that gather elderly together to learn about and to experiment with the technology. This is done in local SeniorNet clubs, which connect to the long tradition of study circles in Sweden. Clubs provide both a place where the technology is available to the elderly and a community for learning about the technology.

A computer is a fairly complex piece of technology. It takes a lot of effort to learn to master it in a manner that gives both pleasure and benefit. It is not seldom one hears fantastic stories of how elderly people struggle – by themselves – to conquer the new technology. In the following excerpt a lady in her seventies tells about her account with the computer:

“...Oh yes, I also borrowed a videotape from a good friend of mine, about computers. So I wheeled the computer in front of the TV in the living room. For a month at least did I sit there every now and then trying to follow the instructions on the video. It went so fast. I am quite untrained with the video. It took a long time before I realised that you could freeze the picture, wait and see and try to understand what he was saying and write it down in a hurry and then play forward. It was quite complicated. It was about moving documents from one file to another and to move from hard drive to a floppy disc and vice versa. The information on the video goes so fast. It must be difficult for a person who teaches to realise how extremely slowly he actually should proceed. It is a question of pedagogy...” [12]

This sounds like really hard work and not fun at all which would explain why so many elderly people are reluctant to approach computers. It could be said that it is the technology in itself that provides resistance instead of providing accessibility. As important as it is to train people in the use of a new technology, it should be equally important to develop technology towards better accessibility i.e. to make it easier to use.

SeniorNet clubs carry out a major work in organising computer courses on different levels. Local clubs have slightly different approaches but the backbone of the activities is always how to find ways of introducing the computer technology to those who are interested, and how to support this interest. Clubs arrange activities that are directed to the beginners, like mini courses and try-on occasions that form an introduction to the technology. In connection to course activities clubs also produce training materials; simple, easy-to-understand, and easy-to-carry-around booklets that are useful even after the course.

The most common courses are on word-processing, e-mailing, and the Internet use. These may be considered as the basis for the 'digital literacy' of the elderly. Elderly people wish to get started with practical matters as writing, contacting their relatives and friends through e-mail, and they want to surf the Internet for information. These courses are the most usual way of getting started to many of the members. Existing social networks are often the channel for finding out about the course activities, and a friend or an acquaintance acts as a guarantee that the course is worth attending.

Clubs also address the more advanced members by arranging theme meetings with demonstrations and lectures on the subjects that seem to be of current interest. Local clubs organise seminars and excursions to their members. Another important part of the activities is to facilitate consultation: the body of members form a bank of knowledge and competence and the information and experience is made available to all the members through the existing network and in the weekly/monthly meetings where problems can be discussed.

The diffusion of innovations theory emphasises the role of social networks in fostering and sustaining new practices. Our data supports this view. It would seem that the maintenance of particular forms of computer use largely depends on access to other users who can offer advice, encouragement, and practical support. Without this support it is difficult to acquire competencies and sustain interest over time.

Clubs are sensitive to the needs and wishes of their members. Activities are formed by and for the members. This gives the clubs an advantage against the general study organisations that arrange computer training that is not tailored for the elderly people but is usually structured according to the requirements of work life.

It can be said that the SeniorNet clubs enhance togetherness, the idea of facing a problem (a new technology) together with united forces. Clubs of this kind – or study circles – have long and strong tradition in Sweden and in Scandinavia. This year the adult education in the form of study circles celebrates its centenary in Sweden. The long tradition may be a natural explanation for the positive experiences of the SeniorNet. It provides a recognisable learning strategy which is powerful in its familiarity. It does not threaten existing social order but may, in fact, strengthen it by giving the elderly people an opportunity to act and face the challenge of modernity together.

5 Conclusion

Experiences from the SeniorNet Sweden confirm that sensitising activities – like the SeniorSurf – which show ways of use that bear meaning to the elderly, are important and often lead to further explorations with the technology. In order to ease the resistance that might exist among the elderly people, it is important to provide positive examples of use and positive role models which they can identify with, positive images of the technology, and most of all, provide them with places where they can examine the technology in their own terms, and make their own judgements about it. This is how SeniorSurf facilitates accessibility through demonstrating computers in the familiarity of a public library and in the presence of other elderly.

SeniorNet clubs form another 'safe haven' for the elderly, a place where they have access to the technology, and a place where they have access to the know-how and

support of their peers. It seems to be important that new practices are built upon existing traditions, that there exists both continuity and familiarity recognisable to the elderly when they are approaching the new technology.

Peer learning or social learning can be a powerful way of learning. Experiences from the SeniorNet Sweden indicate that seniors learn much better and feel more satisfied with the learning situation when they are learning within their own age group and when even the instructor is a senior citizen. The learning phase is automatically adjusted to the capacity of the elderly and examples of using the computer and issues concerning the user are naturally connected with the reality of the elderly. Elderly also need peer support. They need to share experiences and examples of use with each other in order to make sense of the information so that they can perform or communicate with the help of the technology. They simply need each other to overcome the Digital Divide.

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Tele-Help and Remote Service Provision Using RESORT Prototype System

Paul Panek¹, Christian Beck¹, Andreas Hochgatterer², Stefan Mina³, Barbara Prazak²,
Gottfried Seisenbacher¹, Mathijs Soede⁴, and Wolfgang L. Zagler¹

¹ forttec – Research Group on Rehabilitation Technology,
Favoritenstrasse 11/366-1B, A-1040 Vienna, Austria
{panek, chb, gs, zw}@forttec.tuwien.ac.at
<http://www.forttec.tuwien.ac.at/resort>

² Integr@Point, Lebenshilfe NÖ / ARC Seibersdorf research GmbH,
Viktor-Kaplan-Strasse 2, A-2700 Wiener Neustadt, Austria
{andreas.hochgatterer, barbara.prazak}@integranet.at

³ Förderzentrum Elisabethinum Axams, Mailsweg 2, A-6094 Axams, Austria
s.mina@elisabethinum.at

⁴ iRv – Institute for Rehabilitation Research, Zandbergsweg 111,
NL-6432 CC Hoensbroek, The Netherlands
msoede@irv.nl

Abstract. The DE-4208 RESORT tele help prototype provides remote support for disabled users of PC based Rehabilitation Technology (RT) and their care persons in order to reduce existing barriers in daily usage and service of RT. The current RESORT prototype and its interface specification support also synchronisation of single switch users over narrow bandwidth network channels. The IP based RESORT system with its scaleable user interface is described explaining also the remote service API which allows to make already available RT software products ready to benefit from RESORT's tele help functionality. Experiences from real life tests and an outlook to current and future activities are given.

1 Introduction, State-of-the-Art, and Aim

An increasing number of disabled people is using Rehabilitation Technology (RT) systems which help them to live more independent and self-determined lives. Analysis of the provision process shows that buying and installing an up-to-date RT system is definitively not the end, but much more the starting point of a process of continuously tailoring the system to the ever changing needs of the individual user.

In many cases the carers (teachers, therapists, family members) are the key agents in this process. Often a lack of experience in using and configuring RT systems causes a resulting lack of adaptation and frequently the total abandonment of Rehabilitation Technology. Generally spoken, it is anticipated that the actual use of RT systems is much lower than the real need. Currently, support is a complicated and expensive

procedure due to high travel efforts and to frequent hands-on involvement of professional support personnel. The RESORT system was especially designed in order to overcome this situation by providing means for tele help and remote service functionality dedicated to disabled persons and their carers [14], [32], [34].

2 Methods

The RESORT prototype system developed by the EU's DE-4208 RESORT consortium 1998-2001 provides the following functionality: (a) RCI (Remote Control Interface) for "real time synchronisation" of two RT systems, one with the disabled user and one at the location of the service provider, (b) easy-to-use scaleable User Interface, (c) real time communication and interaction: audio, video and text, (d) database access, (e) file transfer, (f) synchronisation of local and remote file systems, (g) platform independency and (h) security. It offers three different modes of operation: (1) hands-free audio communication between user and service provider with optional video link, (2) student-teacher mode for real time synchronisation of RT systems which is important for single switch users over links with narrow bandwidth and (3) tele-service-mode for technical maintenance.

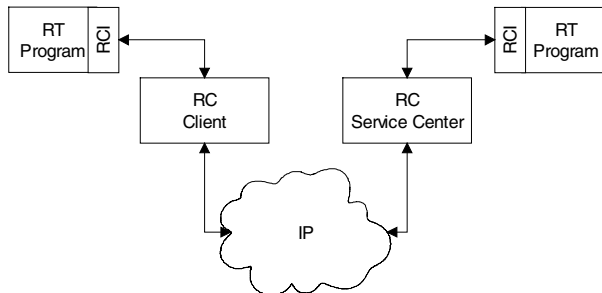


Fig. 1. Remote Control Interface (RCI) between RT software application and RESORT Controller (RC) software running on client side and on Service Centre side. The specification of remote service API [32] allows to integrate an RCI into already existing RT software products

The RESORT system exploits existing technologies for tasks like video / audio transmission according to H.323 specification and desktop/application sharing according to T.120. The user interface of the RESORT controller can be tailored according to the needs of the users. Although the full functionality is always available, the degree of complexity of functions and interactions can be varied within a wide range.

The RCI (Remote Control Interface) and the RESORT protocol allow synchronisation in real time. This is possible as only small data messages are transferred instead of changed screen contents. This method dramatically reduces the required bandwidth [4] and enables the RESORT system to provide real time monitoring of single switch

users. The RESORT controller module (RC) is linked to (a) communication modules for video, audio and text-chat, (b) to the database, (c) to the RT system and (d) via network interface to the remote RC. IP serves as network protocol. The RESORT system is a highly modular system which allows to exchange specific parts without the need of adapting other parts. This increases the independence from 3rd party products for audio, video, application sharing, etc. More details can be found in [14], [32].



Fig. 2. Screen Shot from a RESORT Client during a Tele-Service session in Vienna. A non-speaking head stick using person runs an environmental control and communication system called AUTONOMY [31], [35] which is equipped with a RESORT Interface. The service centre can be called from inside the AUTONOMY system

Two different but compatible RESORT prototypes were implemented. The first one was written in Sun Java 1.3 and was released in 2000. In 2001 a second prototype was written in Delphi and now is downloadable as evaluation kit [14]. In order to test and demonstrate the benefits two already existing RT systems [25], [35] have been equipped with RESORT interfaces. The prototype system was demonstrated in several workshops, additionally real life tests have been carried out [34].

3 Results

The results from the real life tests have shown that the system was usable by disabled people and their primary carers. Furthermore, both primary and secondary carers consider the system a viable tool for the delivery of support for users of RT systems. In general, the results of the demonstrations and trials endorsed the need for the

RESORT type architecture, but recognised that it would cause operational changes in the care services. When demonstrated to care service providers, they were particularly interested in the potential for rapid access to engineering and technical support. They also saw great potential for on-line conferences involving a group of different care providers involved with an individual client.



Fig. 3. Screen Shots from RESORT Service Centre during a Tele-Service Session. Left picture shows controls for video and text communication, right picture contains controls for remotely starting and terminating RT applications at the client side

During trials with the RESORT system features like the live video and the audio link gave most of the potential users a feeling of security. Getting a picture from the person who is actually helping me to fix my problem is a very important point for the client but also vice versa it can be helpful for the operator at the RESORT service centre to see the client. It can be recognized if the user is perhaps confused or makes an impression of being stressed by the current situation. Certainly the user has to be able to decide himself or herself if the video is transmitted to the service centre. The default mode is that the video from the service centre is enabled and the video to the service centre is disabled.

Especially for novice or less experienced computer users application sharing is very helpful but it is certainly one of the most risky features of the system. Abuse could cause serious damage to a clients system or private information could get to not authorised persons. Thus, specific security issues had to be considered [32]. At the other hand a problem on the computer may be solved in a few minutes what usually would take a technician some hours to travel to the customer (certainly charging for travel costs). Additionally it turned out during real life tests and demonstrations that there is a very good learning effect for the client user when the client can watch what the operator from the service centre is modifying remotely.

The tele-help and remote service systems will get more and more important (especially through the new high speed network systems) and bring several advantages for the users. The feedback from the RESORT users also shows that such systems are really requested by them.

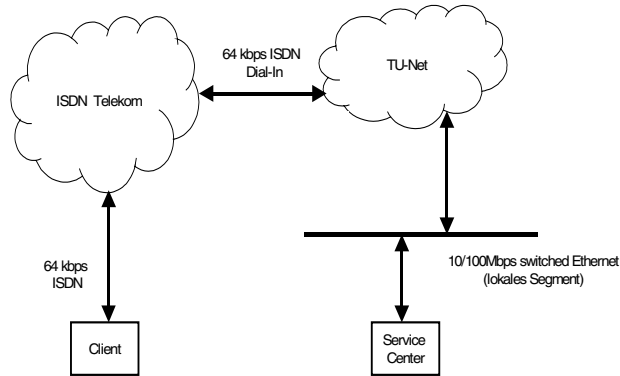


Fig. 4. Network structure using 64 kbps Uplink from Client to University Network during real life test of RESORT system with head stick using person (see Fig. 2) in Vienna. This real life test started end of year 2000 and is still on-going using the latest RESORT software version which can be downloaded from [14]

4 Discussion

The RESORT prototype system demonstrated a multitude of benefits which will help to overcome existing barriers in the field of RT service provision. One important aspect is security and data protection. It is absolutely necessary for the user to have the possibility to decide what he/she allows or not and that the tele-help session could be terminated immediately if there is the impression that something is going wrong. Another point is the education of the service centre operators and maybe the usage of network encryption technology to ban attacks by third parties.

In parallel to the RESORT prototype software the RESORT protocol has been developed and documented. A remote service API allows other manufacturers to adopt the RESORT protocol for their products in order to benefit from tele-support functionality [32]. An evaluation version of the RESORT software package is available [14]. Ongoing research and development is done under the umbrella of the RESORT Interest Group (RIG). The RIG provides a framework for disabled users, care persons, manufacturers, service providers, and researchers to continue the engagement in the area of remote service provision. Interested parties are invited to visit the RESORT and RIG home page [14].

One of the two RESORTed RT prime examples – Mr.Step [25] – heavily stresses the features provided by a telematic link between professionals and clients. The version just marketed (Mr.Step 1.1 Viewer) is a client version which allows to import modules provided by (exported from) the forthcoming Professional version. A typical scenario is that a therapist configures and creates new modules which might then be delivered over a RESORT link to the client's home PC (RESORT interfaces are already implemented and a RESORT compliant version of Mr.Step is planned to be

released). Furthermore the professionals can then guide and monitor the training process in real time (tele-training supporting single-switch users of Mr.Step as well). This enhances the process of interaction in teaching and training.

The Information Centre Integr@Point in Lower Austria, which provides RT specific consulting and is prepared to be a further part time RESORT service centre, supports clients in the surrounding of about 150 km around their premises in Wr. Neustadt. One recent example shows that only the travel costs to visit a severe motor and vision impaired client, who is currently evaluating a communication software tool with single switch input and auditory scanning features, are approximately EUR 220,-. Problem solving via telephone often was not successful and minor problems had to be solved through visits. Now a second level support became necessary because a small adaptation of the software has to be built in by the programmer (located in Germany). This example illustrates which enormous benefits the RESORT system might introduce if used in such a setting.

In mid of year 2001 first part time service centres have been set up at TU Wien and at an Austrian SME. RESORT not only aims at technical service delivery but also at pedagogic and therapeutic support via the telematic channel. Tele-Support and Remote Service Provision is an encouraging area in the field of RT which will improve significantly the quality of life of disabled persons.

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Making Yourself at Home – Portable Personal Access Preferences

Jutta Treviranus

Adaptive Technology Resource Centre
(ATRC), University of Toronto
jutta@utoronto.ca
<http://www.utoronto.ca/atrc>

Abstract. Whether using a public workstation, or engaging in an on-line learning environment, computer systems should fit the individual preferences and requirements of the user, especially if the user requires an alternative access system. An international effort is underway to create a common specification for expressing personal preferences for all systems affecting the user interface and content retrieval. The ATRC of the University of Toronto has created the first models or implementations of this common specification.

1 Introduction

Most operating systems, software applications, alternative access systems, servers, search engines and hardware drivers allow the assertion of personal preferences. For individuals with disabilities this personalization function often makes the difference between being able to use a system or not. Unfortunately, it is very difficult to find and navigate the various preference dialogs that must be set to personalize the system. For someone who is using a public, multi-user system or an unfamiliar system, adjusting the user preferences may be more onerous than performing the intended computing task. Often access to these adjustments is blocked in the interest of security. More significantly an individual who requires an alternative access system to access the dialog is caught in an impossible loop: they must assert their preferences in order to be able to access the preference dialog to assert their preferences.

An international interoperability effort is underway to create a common specification for user preferences for the desktop, applications, alternative access systems, servers, enterprise systems and learning management systems. The IMS Global Learning Consortium Accessibility Working Group is attempting to harmonize various existing and proposed schemas into a common specification that will form part of the IMS Learner Information Packaging or LIP specification (<http://imsproject.org/accessibility>). The ATRC is leading two projects that act as the first models or implementations of these harmonized specifications. These projects are:

1. The Web-4-All project [2] which automatically configures public or multi-user workstations based on the personal preference file transmitted via an Opencard smartcard.
2. The Barrier-free Project which aggregates, transforms, serves and plays video-based learning objects in response to the learners preference file. In its second phase this project will also adjust learner Web portals according to learner preferences.

2 The Specification

The overall Learner Information Package specification of the IMS [1] has an element branch entitled accessibility. This element branch contains the preference settings relevant to accessibility. The preference settings are categorized at a high level into input, output and content. The input category encompasses all preference settings that relate to controlling the computer interface. Input is further divided into subcategories, including alternative keyboards, alternative pointing devices, mouse emulation, standard keyboard enhancements, on-screen keyboards (which includes child categories direct selection and indirect selection), voice recognition and others. The output category encompasses all preference settings that relate to the computer display. Output is subdivided into categories of alternative display systems including screen readers, screen enhancement, text reading with visual highlight, Braille display, tactile display and others. The input and output declarations impact upon the system utilities, application preferences, and alternative access systems. The content category encompasses content equivalents, alternatives or enhancements. These include alternatives to visual information such as video description or alt text, alternatives to auditory information such as captioning or sign language translation, structural presentations of content, structural navigation of content, personal style sheets and others. It is intended that the content elements will have corresponding Meta-data elements in the Meta-data specification to allow repositories, servers or search engines to match requirements with appropriate content. Figure 1 shows the higher level view of the proposed accessibility branch of the IMS LIP specification. Each alternative access system category has both a generic class of preference settings and a specialized set of preferences. The generic class is intended to address preference settings that are common to all products within a given class. The special class is intended to address preference settings that are unique to specific commercial products. For example all screen readers allow control of speech rate, but only certain screen readers allow assignment of voices to specific HTML elements. Input is presently being sought from alternative access system developers and users regarding candidate generic preferences.

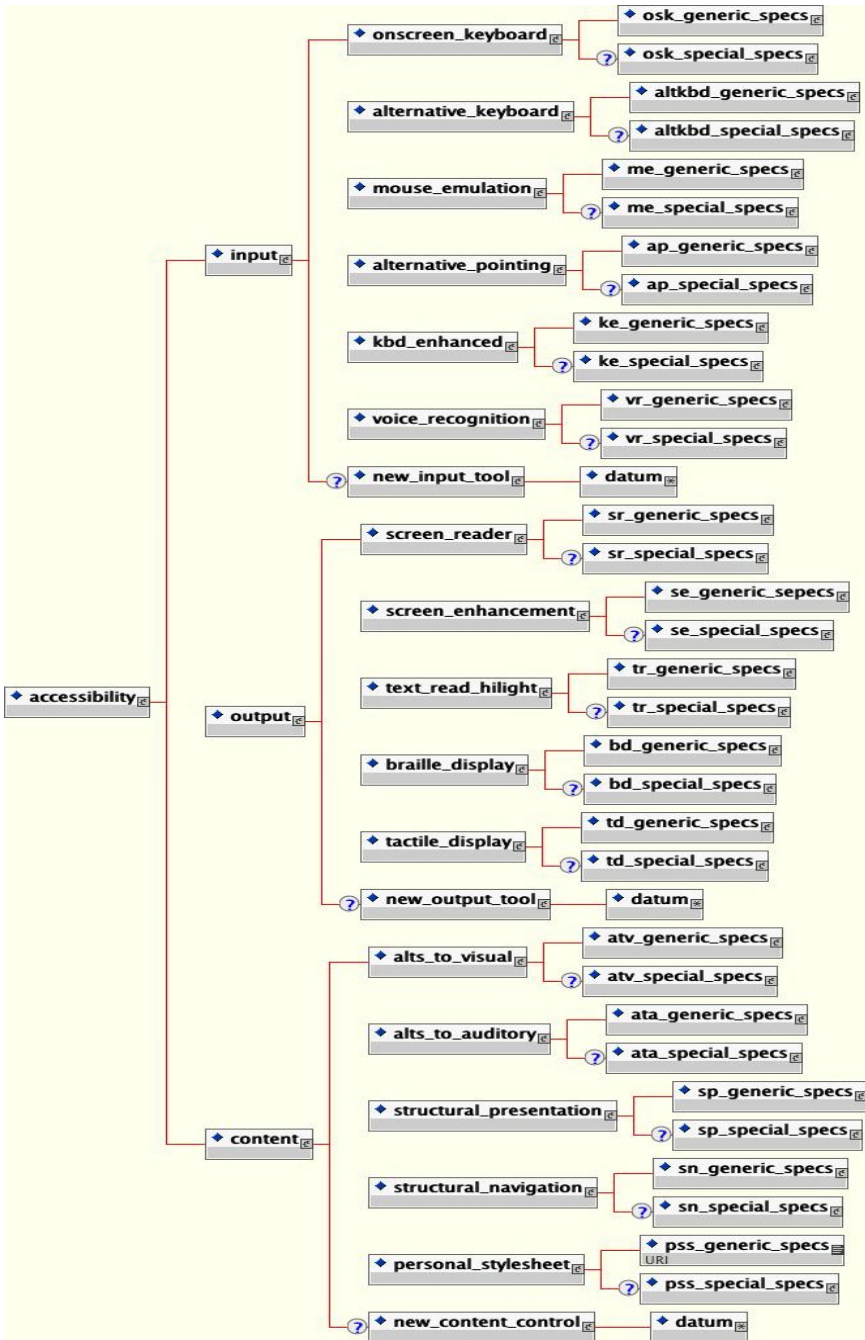


Fig. 1. A high level diagram of the draft preference specification XML DTD.

3 Web-4-All

Libraries, schools, colleges, universities, government offices and Internet Cafes all provide access to computer workstations that are used by multiple users each with their own personal setup preferences or requirements. Depending on the technical support available, user's presently make do with the workstation default or spend a great deal of time and effort adjusting the workstation to an approximation of their requirements. Many users with disabilities cannot use these workstations, even when they are "accessible" workstations, because the technology they need is not available or the technical support to set it up the way they need it is absent. In addition institutions offering and maintaining public workstations are often reluctant to include assistive technologies in the setup because the technologies conflict with one another or with other software and hardware on the system. The ATRC in cooperation with a number of partners has developed and is refining a system whereby users can carry with them their desktop preferences (including system preferences, browser preferences and assistive technology preferences) and automatically configure public terminals to suit their preferences and access requirements.

Web4All [2] is a program developed by the ATRC for Industry Canada [3] to address the need for accessible Community Access Point sites. Community Access Point sites are internet workstations dispersed to remote and under served areas of Canada to encourage citizens to utilize the Web. These sites are characterized by inconsistent technical support, and lack of knowledge about accessibility requirements. Web-4-All automatically configures public access terminals according to personal setup preferences (for the system, the browser and the assistive technology), as saved onto a smart card or other Open Card compliant device. The personal preferences are saved as an encrypted, compressed XML string and take up less than 2K. They are specified and saved onto the card using a personal preference wizard program. Once on the card, the user can take the card to any public access terminal with Web4All software, insert or swipe the card, and cause the system preferences, browser preferences and assistive technology preferences to be set exactly as they have specified. This is achieved through a software program called the Configurator. When the card is removed the workstation reverts back to the default and all assistive technologies are shut down to avoid conflict with other applications.

For the second version of Web4All the ATRC plans to expand the assistive technology classes covered to encompass technologies such as voice recognition and refreshable Braille. An API will also be published to allow assistive technology developers to create Preference Wizard and Configurator modules for their assistive technologies.

4 Barrier-Free Broadband Learning Environments

Currently, most post-secondary students make-do with instruction geared to the average learner or the perceived norm. This leads to a large segment of marginalized students who do not fit the norm. Students differ in their background knowledge, level of understanding of a topic, learning outcome goals, learning style, learning skills and accessibility needs. With dynamic web technologies, shared learning object repositories and properly structured curriculum, we have the opportunity to deliver

the approximation of personalized one-on-one teaching. The on-line education environment can be responsive to a number of learner needs and preferences. This can significantly enhance the effectiveness of the learning experience for learners and educators.

The Barrier-free Project, a multi-partner project lead by Canadian Learning Television and the University of Toronto, has explored the requirements and implications of truly learner-centric, on-line education delivery [4]. The team has created and evaluated media-rich learning content, that transforms in response to the specified individual needs of the learner. To achieve this the team developed the necessary tools including authoring tools, a player/browser, a preference wizard, and a dynamic learning object repository as well as learner preference specifications (XML-based).

Among the content types explored the team chose to target media-rich content such as video, as it presents the greatest challenge. Video content was digitized and tagged using available verbatim captions. Verbatim captions are a text transcription of the sound track, synchronized through time code to the video. Due to accessibility legislation, captions are available for many existing videos. The captions were used to mark up the structure of the video so that the learner could navigate through the video and search for specific segments. The captions were also used to link auxiliary materials such as definitions, exercises illustrating a concept, and associated web material. To accommodate learners who are blind and to provide additional commentary on the video, video descriptions were created. Video descriptions are spoken descriptions of the visual content fit into the pauses in the audio track. Alternative captions for more basic reading levels were also created. Thus a student viewing a video of a lecture given by an eminent physicist would be able to click on terms they do not understand and view definitions of the terms using the captions. To clarify a concept discussed they would be able to link to an interactive exercise that illustrates the concept. If the student has difficulty following a demonstration given by the lecturer they can turn on descriptive video which provides a sub-narrative in the audio pauses further describing what is happening. For additional help the student can turn on overlay captions that provide text labels of the objects and processes occurring in the demonstration. If they feel they have missed necessary background material they could search for video segments on the topic and navigate to the segments for review. Each of these learning scaffolds can be controlled by the learner. The learner can also create a learner profile that causes the learning content to be automatically displayed according to their personal preferences.

The project also explored the sharing and re-use of learning content. A shared learning object repository was created that allowed educators to retrieve desired learning content, adapt the content to the level, access needs and context of their target learner and deposit the adapted content into the repository for re-use.

These tools and processes were applied and evaluated in several institutions. The research questions addressed in the evaluations included:

- the impact of this learning approach on educators,
- the accessibility of the content to students with disabilities, and students who did not fit the profile of the average learner, and
- the effect of the learner scaffolds on learning outcomes for all learners.

Data gathering and analysis is in progress. Preliminary data shows that while the learning outcomes and learner response is very positive the approach requires a significant shift in teaching practices and resource allocations.

In phase 2 of the Barrierfree project the ATRC is investigating the implementation of the specification in personal web portal technologies. Thus the personal preference schema will be used to also configure the navigation tools, content organization, content presentation, personal bookmarks, and the content retrieval algorithm within a portal. This will be implemented using uPortal, [5] an open source portal initiative and used in post-secondary and government portals.

5 Conclusion

With a common specification for user preference settings and a tool to implement those specifications in public workstations, any user should be able to step up to a public workstation and replicate the desktop they are used to. The implementations of this common specification will reduce the need for technical support and reduce software conflicts with alternative access technologies. Most importantly they will provide a sustainable and realistic method of maintaining accessible public workstations in public institutions and businesses. Within a learning environment this specification will help to personalize the learning experience according to the needs and skills of each learner and thereby ensure that learners who do not fit the norm are not marginalized.

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EU Project SILC – Personal Bio-Sensor Based Alarm System

Peter Mayer, Georg Edelmayer, and Wolfgang L. Zagler

fortec – Research Group on Rehabilitation Technology,
Favoritenstrasse 11/366-1B, A1040 Vienna, Austria
{mayer, ged, zw}@fortec.tuwien.ac.at
<http://www.fortec.tuwien.ac.at>

Abstract. The aim of the project SILC (Supporting Independently Living Citizens) is to prolong the quality of life of older and infirm people by postponing the need for institutionalization. To achieve this aim, the consortium is investigating the feasibility, and develop working prototypes, of a portable wrist-worn life-signs monitor and communications link, giving the user the ability and confidence to continue to live in the community longer. The device will intelligently monitor the well being of the user and report alarms in the event of problems being detected. It will also permit two-way conversations with care providers, initiated either by the user or by the care provider. In this paper a general introduction and a status report on the development of the first prototypes will be given.

1 Introduction, State-of-the-Art, and Aim

There already exist devices on the market that help to increase safety and security of elderly people in certain situations. They all provide stand-alone solutions focusing only on one specific aspect of alarm giving or event detection or allow to measure single body parameters. Ideally SILC will supersede these devices and offer additional features. The recognition of one (or more) derailing body parameters is a unique feature of SILC not provided by other devices which offer only limited possibilities of detecting such events. Exemplary and without claiming to be complete such devices are listed below.

The main innovation of the SILC alarm device will be the inclusion of a set of biometric sensors together with additional features to make the device even more indispensable for the every day life of the future users.

1.1 Alarm-Button Devices

This is the device most frequently used by elderly people. A bracelet or pendant with an alarm button is worn by the user 24 hours a day (Fig. 1, left picture).

In case of help needed (e.g. accident) the user presses the alarm-button and a telephone connection to a Service Center (SC) is established where help can be summoned. This functionality will of course be integrated into SILC as it is a very

basic feature. The fact that users often do not press the alarm button because they see their (health) condition not serious enough or because they fear to bother the SC staff can result in critical situations not notified to the SC. Additionally some events like sudden unconsciousness will disable the user to press the alarm button in time. For these events, SILC will provide a solution with its detecting of body parameters and alarm giving if critical states occur.

1.2 Fall Detection

Recently fall detecting devices reached the market. Falls are one of the very critical events happening to the target user group of SILC. Falls in the elderly often causes serious injuries that renders the user unable to continue with his/her usual life. Therefore many elderly people live in fear of falling. Fall sensor devices are usually worn on the belt (see Fig. 1, right picture). If falls (or fall like events) occur, an alarm is sent to a dedicated SC to make summoning help possible. Although the detection of falls is much easier if the sensor is located on the body, SILC targets a detection of falls via sensors worn on the wrist. Intelligent algorithms and combination with other sensors will enable the SILC device to distinguish between hard falls (hard impact of the user on the ground) and soft falls (slowly 'slipping' to the ground) which also can be critical.



Fig. 1. Left: Examples of wrist or neck worn alarm buttons (Attendo), Source: www.telelarm.de. Right: Fall Detector (Tunstall), Source: www.tunstall.de

1.3 Measuring Blood Pressure

As an example for a device that picks up body parameters a blood pressure meter shall be mentioned. Devices like the one shown in Fig. 2, left picture, measure the blood pressure on the wrist with the usual deflating and inflating of a cushion.

The device is intended to be worn only during measurement. Accuracy is proven to be good if the usual preconditions (user does not move, lower arm in horizontal position, correct positioning of cuff, etc.) are kept. Blood pressure is a parameter SILC does not intend to measure (because of the bulky apparatus needed), pulse shape and pulse variation will be monitored instead.

1.4 Blood Glucose Level Monitoring

Latest research on non-invasive blood glucose detection led to a first device that is said to be able to non-invasively determine a person's blood glucose level. The GlucoWatch (Fig. 2, right picture) can measure the blood glucose level every 20 minutes during a 12 hours period. As the electrodes that constantly are applied onto the skin seriously shift in their characteristic during usage, the user still has to calibrate the device at least once a day with the usual method. SILC will follow the development of these devices and might implement it as part of the modular sensor architecture once the technique is evolved well enough for broader use.



Fig. 2. Left: Example of Blood Pressure Meter (Omron), Source: www.omron.de, Right: Example of Glucose Monitor GlucoWatch (Cygnus), www.glucowatch.com

1.5 Activity Monitoring

A recently launched alarm device (Fig. 3) offers more sophisticated monitoring possibilities than the already mentioned ones. Worn on the wrist it allows for detection of changes in movement behavior of the user and additionally measures the skin conductivity.



Fig. 3. VIVAGO WristCare System (IST Oy), Source: www.istsec.fi

The device consists (similar to devices like in Fig. 1, left) of a wrist worn part (including a manual alarm button) and a base station. This base station is not only used to provide the PSTN connection to different kinds of Service Centers but also monitors the changes in the activity pattern of the user. If a significant change is

detected (over a period of 30 minutes), an automatic alarm is generated by the base station. Compared to SILC only two parameters (general movement and skin conductivity) are used to generate an alarm. SILC aims at the faster detection of specific parameter changes and not at monitoring of activity level trends.

2 The SILC Concept

SILC is modular with a wrist unit and a base station connecting to the service center. This structure offers the possibility to upgrade the device with other sensors as soon as they become available. By using a cordless RF-link external sensors can be connected with the SILC system.

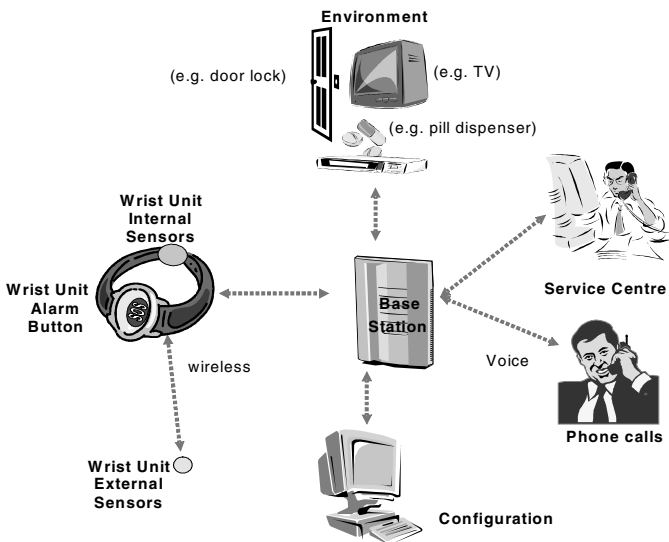


Fig. 4. System Concept of SILC

The goal is to monitor: (a) the heart pulse rate including the variation of the pulse, (b) the temperature on the wrist, (c) the spatial orientation and movement of the device (and thus of the user), (d) and in future other parameters like the glucose level with a new non-invasive method.

Additionally there will be: (a) a built-in cordless telephone, (b) a clock and alarm clock, (c) a simple Personal Digital Assistant (PDA) especially as a reminder for medication, (d) a remote control facility for various household appliances (TV, VCR, door lock, lamps ...).

The basis for every development within the project are the user requirements that have been collected at the beginning of the project. To ensure that the development

will follow real needs, continuous assessment of intermediate states of the modules or prototypes is performed by users.

To operate on a well defined base the SILC-Target User is defined as: (a) Elderly more than 65, (b) Living alone, (c) Health conditions that restrict the activities and/or disabilities, (d) Increased risk of falling or other accidents.

Following these indications, primary users for a user panel were selected by the SILC user partners. Rehabilitation professionals and service providers supplement this panel that represents the advisory body to the project and will assess and approve the project results. For the collection of user requirements questionnaires and in depth interviews were used. Possible usage-scenarios were developed to provide a very close real-life situation for the tests. The following graphic summarizes how the proposed SILC functions and features were rated.

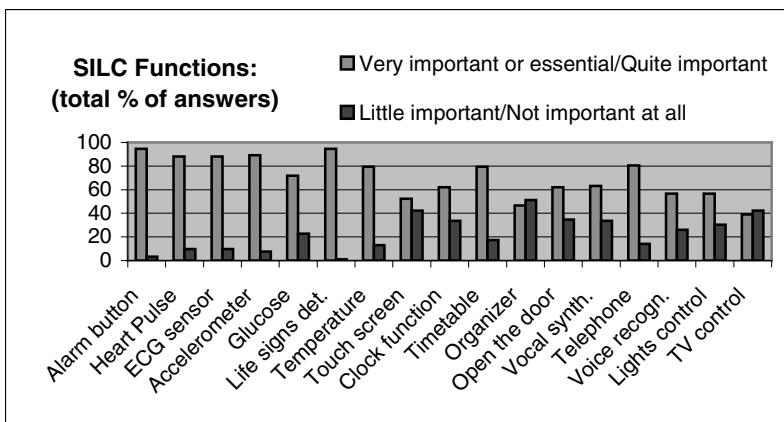


Fig. 5. Rating of proposed SILC functions by user panel

As can be seen, the alarm functions, means for life-sign detection as well as the possibility to make phone calls were the most appreciated features.

3 Prototype Development

Given a certain event that is to be detected, then the ‘perfect’ detection device will make no errors in detecting the event. In practice however, some events will be missed and non-events will be incorrectly classified as events. Clearly the severity of such false classifications can vary depending on the case between life threatening and just annoying in case of unnecessary alarms. To reduce false detections in the SILC device multiple sensor signals will be correlated and combined for a correct decision to send or not send an alarm.

Several sensors and sensor arrangements have been tested until now but only the tests with the full prototypes will show which sensors or sensor combinations will deliver satisfactory results.

3.2 User Interface

The User Interface (UI) for the SILC project is fundamental for the success and usability of the SILC system. At the first test stages mock-ups and simulations of the UI on a PC were used. For the first prototypes a special User Interface Evaluation Hardware will be used that communicates with a hand-held computer worn on the belt by the user. A BlueTooth module is implemented for testing the SILC communications system. The SILC UI (refer to Fig. 8) basically comprises of a central LCD (of about 25mm x 50mm) with textual and graphical information.



Fig. 8. PC demo of User Interface in the Wrist Unit

In the ‘normal’ state of the device a clock will be presented. In case of a telephone call (either transmit or receive) related (informative) texts will be presented. For maintenance and test purposes system values will be accessible. Around the display four buttons are located for navigating in whatever menu. A big SOS button will be located on the strap of the wrist device. As there is a reasonable demand for a less sophisticated version of the UI a version will be available having only two navigation buttons and a reduced set of presented functionality.

3.3 Base Station, Service Centre, Environmental Control

The Base Station (BS) plays an important role in the SILC system as it acts as a link between the Wrist Unit and the PSTN (telephone) link to a Service Center and as a basis for Environmental Control functions. An infrared transmitter like it is used for TV or radio remote controls will be implemented directly in the Wrist Unit, in addition an EIB (Konnex) interface (home automation network) and peripheral control modules (e.g. for door intercom) will be included in the Base Station. The environmental control link will be bi-directional such that also environmental alarms can be received (i.e. gas or smoke detector). The BS also provides a control panel for

the whole SILC system. A configuration interface allows helpers, health workers, social workers, or the Service Center via PSTN, to change settings and preferences, including those of the wrist unit.

Within the SILC project no own Service Center software is developed, nevertheless, care will be taken to make the interface to existing service providers as simple to implement as possible.

4 Outlook

The modules of the SILC wrist device and first Base Station implementations are planned to be ready in July 2002 to be evaluated in laboratory. The implementation of the first complete SILC prototypes (second half of 2002) intends to provide first possibilities for testing of the final functionality but will still be very different to the final prototype in size and weight. However, this first SILC prototype will already allow monitoring of critical body functions and alarm triggering as well as evaluation of the designed user interface in the wrist device.

The first prototypes will undergo a smaller user test starting in January 2003. Following this, a redesign will lead to the final prototypes that shall include all the proposed functionality in a miniaturized form.

5 Disclaimer

The SILC project is funded in part by the European Commission within the IST (Information Society Technologies) part of the Fifth Research and Technological Development Framework Program. The information in this paper is provided as is and no guarantee or warranty is given that the information is fit for any particular purpose. The user thereof uses the information at its sole risk and liability. The content of these pages in no way represents the view of the European Commission or its services.

Project Partners:

Austria: (Co-ordinator) fortec – Institute of Ind. Electronics and Material Science, Rehabilitation Technology; TECWINGS Industrialisierung und Elektronikproduktion GmbH; Joanneum Research, Institute of Noninvasive Diagnostics; Municipality of Vienna, Health Planning Department; Johanniter-Unfall-Hilfe in Österreich

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United Kingdom: Cardionetics Limited; Cloudworld Limited; Knowsley Metropolitan Borough Council Social Services

More information on the SILC project can be found via the project's homepage at <http://www.fortec.tuwien.ac.at/silcweb/SILC.htm>

Videophones: Useful Assistive Devices for Visually Impaired Persons?

Morten Tollefsen and Magne Lunde

Tangerudbakken 2D, N-0982 Oslo, Norway
morten@medialt.no, magne@medialt.no
<http://www.medialt.no>

Abstract. Videophones for people with visual impairments may sound like a contradiction of terms. In the “eye-phone” pilot project, our idea was to use the videophone as a communication channel to a sighted eye. An important question therefore was: What is the need for the human eye today and in the future? Visually impaired people have different expectations and needs, but when do they really need access to a sighted eye? Can existing information technology and dedicated devices solve most of the daily needs for blind and partially sighted persons, or do videophones offer new and/or better solutions to some of these needs? The “eye-phone” concept is selected to demonstrate a complete system: videophones and a sighted operator. The operators are usually located in a central, but the sighted person may instead be a personal reading assistant.

1 Pilot Project Activities and Results

To figure out the daily need for a sighted eye, we performed a three-step demand analysis. Sixteen blind and partially sighted persons were divided into 4 age groups. In addition we had a group of blind persons living without sighted persons in the household.

The persons taking part in the group-based interviews had no experience with videophones. Their needs were quite different of course, but surprisingly, identical in different age groups. Some examples include: determine if clothes are clean, mobility (e. g. where is the shopfront), reading post including advertisements and reading mobile phone displays. After discussing the needs, participants were asked to describe a device called the eye-phone. The keyword for most persons was: Mobile. The device should be mobile, and look like a mobile phone (at least not much heavier). Some participants also described a device or box, which could be used more or less like a hand held scanner. The last step was testing. The participants were asked to use the eye-phone to solve a typical problem. They were all very excited. After these tests they also believed a stationary videophone was useful, and all participants were interested in taking part in more comprehensive testing.

One advantage of a centralized service is increased availability. Visually impaired people can get assistance when they wish, not when it is possible to make an appointment with a sighted person. Most participants stressed the need for professional confidentiality, a point that is extremely important in a service like this.

The need analysis was used as a basis for testing available technologies. Several videophones were evaluated. Our main criteria were user interface, e. g. remote control (the distant operator must be able to control the camera on the user site). Tandberg 500 and 800 were used in our tests. The operator videophone was placed in a relay center for text telephone (a service for hearing impaired) and with a personal reading assistant. The text telephone relay operators are skilled in translating from text-to-speech-to-text and they are professional in their confidentiality. One difference to the operators' ordinary work, however was that they have to interpret some questions (e. g. do these garments match), in other words not just translation. Videophones on the user side were placed in the offices of MediaLT in Oslo and in Nannestad (30 km outside Oslo). The main focus in our testing was to determine which tasks it was possible to solve. Time, terminology etc. were less important. As many as 84,5 % of the tasks were successfully solved using the eye-phone.

2 A Two Year Main Project

Results from the pilot project were very promising. Therefore an application for a main project was submitted to the Norwegian Research Council. The application was accepted, and the main project started January 2002. The project period is two years.

The eye-phone project is a co-operation between MediaLT, Telenor, IT-Works, Tandberg, The Norwegian Blind Federation and The National Insurance Administration.

Activities in the main project include:

- More comprehensive testing (18 visually impaired will have a videophone at home or at work for 6 months). The relay central will be used at the operator side, but organizational models will have to be considered.
- If possible, test mobile technologies.
- Develop the user interface (our idea is that pressing one button should be enough to reach the operator).
- Map the eye-phone usefulness related to sight.
- Map the use of the service: when do people call, average conversation length, which tasks can/can't be solved, which tasks are most common etc.
- Propose systems for future funding of an eye-phone service.
- Continue the literature study (several special fields were identified in the pilot project).

Document cameras were not used in the pilot project, but we will use document cameras in the main project. We will also test different technologies, even though Tandberg is our main industrial partner. The pilot users are selected to represent different categories: age, sight, additional handicaps, gender etc. To make it possible to develop technology and services the users will be divided into three groups. The first group started to test the system in April 2002.

HMPH – “Habitat Mobile pour Personnes Handicapées” – Software for the Design of an Adapted Living Area¹

Jérôme Leloup and Pierre Gaucher

Laboratoire d'Informatique de l'Université de Tours
64, avenue Jean Portalis, 37200 Tours, France
Jerome.Leloup@etu.univ-tours.fr, Gaucher@univ-tours.fr

Abstract. The aim of the HMPH project is to specify the functionalities of a movable, opened and adapted living area, enabling a better autonomy by means of appropriate assistive technologies, home automation and electronic devices, linked by a home network. Moreover, it should be able to be inserted in a strongly medicalized facility, as well as in a familial area. To design the interior layout of this adapted living area in a minimal time, we propose a software tool that will allow making the layouts taking the constraints, needs and wills of the resident into account. The software and its prospects of evolution are presented, the first results can be seen at <http://www.e3i.univ-tours.fr/CNHL>.

1 Introduction

According to the last statistics, the rate of disabled and elderly people is constantly increasing. This induces several problems, including that of finding the best way to take care of them and overall the way to keep them at home. The aim of the HMPH project (initially CNHL [4]) is to specify the functionalities of a movable, connected and adapted living area, enabling a better autonomy by means of appropriated assistive technologies, home automation and electronic devices, linked by a home network. Moreover, it should be able to fit into a strongly medicalized facility as well as in a familial area and should give disabled and elderly people the possibility to live at home as long as possible with an increased autonomy. The same kind of research is presented in [1]. The design of such an adapted area calls for skills such as architecture, occupational therapy, home automation... According to [2], this leads to important design times (about 2 to 3 months). The use of a specific software environment, which will help during the conception, will tend to reduce these times. This software will enable the design of the layouts of the HMPH, taking into account the constraints linked to the disabilities (architecture, home automation, furniture, circulation...) and those linked to the needs and wills of the future resident. Using a software to design such an adapted area has been tested in [3] and should lead to significant results. This paper presents the first functionalities of the software, that

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automatically designs layouts by taking several constraints into account. It ends with a conclusion on the work done and the prospects of the project.

2 The Functionalities of the Software

2.1 Introduction

The software will enable a designer to design the layouts of an adapted living area for disabled people. We assume that the needs of the resident are at this step clearly identified. The software automatically places the rooms (and later the furniture) in order to obtain an assessed layout (a layout that respects the standards).

2.2 The Architecture of the Software

The software can be decomposed into several modules (figure 1).

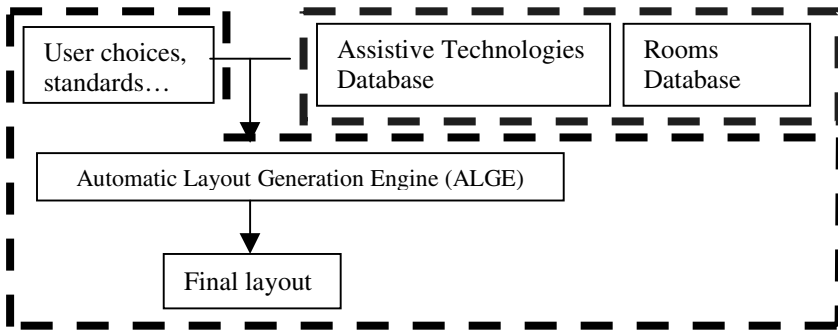


Fig. 1. Synoptic of the software

The databases contain information on the rooms and the available equipments and the CAD software computes the layouts with the ALGE. To create layouts of HPMHs with this software, the user follows several steps. First he chooses the rooms he wants in his living area and eventually creates preference rules for the layout. The software then generates several layouts and the user chooses those he wants to keep (he can keep them just as they are or modify them manually or automatically).

2.3 The Automatic Layout Generator Engine (ALGE)

The heart of the HMPH creation software is the Automatic Layout Generator Engine, inspired by genetic algorithms (GA). It enables the generation of several layouts matching the user's desires as best as possible. The layout generation algorithm, as a genetic algorithm, follows several steps (initial population generation, layouts assessment, generation of a new set of layouts). Contrary to GA, the cross over

operator isn't used because it doesn't give good results in our case. However, several mutation algorithms are available:

- Improvement mutation: mutations on each room aren't done randomly, but by searching the best place to move the room in order to get the best assessment.
- Totally random algorithm: randomly generates new coordinates, new orientations and new dimensions for each room on the basis of the selected models...
- Random algorithm taking constraints into account: as the previous one, it randomly changes the characteristics of each room. However, the directions of the moves are determined beforehand by taking the user's preferences into account.

Once a layout is selected by the user to be the final one, it must be validated to test whether it respects the standards or not (ie broad enough corridors...). The validation algorithm tests all rooms in regard to the others. If the distance between two rooms is too small, it will try to modify the rooms in order to get a validated layout. If several modifications are possible to get a validated layout, the algorithm will apply the one that gives the best evaluation in respect to the preference rules.

3 Conclusion and Prospects

To reduce high conception times and costs, we chose to develop a software that will be able to automatically create layouts for an adapted living area, including several constraints. The first results are significant (cf. <http://www.e3i.univ-tours/CNHL>) and the software rapidly gives assessed and relevant layouts. Moreover, it already includes a 3D virtual visit of the living area. Finally, the study on how to arrange each room in the living area with appropriate Assistive Technologies and home automation systems is in hand.

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“Bonkers”. Increasing Literacy Skills: An Eclectic Electronic Teaching Approach Gone “Bonkers”

Diana P. James

Assistant Professor, Communication Disorders Clinic
West Texas A&M University, Canyon, Texas 70119
djames@mail.wtamu.edu

Abstract. This position paper accounts the vision of a former public school speech-language pathologist and present day university clinical director. The vision is for the application of interactive exciting software technology to increase the literacy skills of children and youth with language and literacy disorders. Miss Bonkers, the bouncy and excited teacher and heroine in Dr. Seuss’ *Hooray for Diffendoofer Day*, provides her students with eclectic teaching and learning strategies. Multimedia software is the “Miss Bonkers” of computer learning. Multimedia software provides the student with exciting interactive learning possibilities. This clinician argues that the implementation of various inexpensive multisensory software, offered by publishers such as *Dorling-Kindersley Family Learning*, *Disney Interactive*, and *MacMillan* would aid in the rehabilitation of those children and youth identified with communication disorders- specifically those with the following problems: expressive language delay, reading/ reading comprehension disorder, spelling/writing failure, learning a second language, and attention deficit disorder [4].

1 Introduction

The critical shortage of experienced Speech-language Pathologists throughout the United States, has brought about extraordinary caseload size necessitating change from traditional speech therapy models to creative technology assistive programs. Caseloads are filled with children having chronic histories of otitis media and other congestion disorders. An association of chronic otitis media has been linked to articulation delay and the lack of phoneme awareness. This inability to discriminate sounds in language leads to delay in reading skills, then to poor self-esteem, and risk for failure. Interactive multimedia is suggested as a strategy for correcting reading delay. Of particular value is the capacity of instructional technology to address the unique needs and learning styles of each individual identified for enrollment in the computer laboratory due to poor reading ability. By changing the views of traditional Speech-language therapy and service delivery, administrators and therapists can enhance effectiveness of instruction, provide quality education, and empower students to achieve success with literacy through technological advances.

2 The Rationale for Multimedia Software

The use of technology, specifically multimedia software programs, within the general classroom setting should be viewed as an opportunity to maximize academic success of all students. All students include: those identified with special needs (physical, mental and emotional) and those who have “slipped through the cracks” of the identification process. Technology is for all, but perhaps the most important reason for teaching with multimedia software is the opportunity to individualize the learning situation in order to reach those students with special learning deficits, special learning styles, and special physical, mental, social and emotional concerns.

Students with disabilities are prime candidates for technological solutions with the teacher being challenged to find the technology, assess its appropriateness to the student’s individual needs, and advocate for its implementation [5]. When computer technology is used in conjunction with methods such as the integration of whole language along with grouping students by like learning styles, and individualized teaching modes--then learning can be enhanced with proper use of the technology. Caution must be taken to understand the student’s primary need and insure proper teacher training. Well-prepared teachers can help children overcome the disabilities which are preventing academic success and which could affect overall future success. Furthermore, advancing the overall usage of technology into the general curriculum is an expectation of local and state educational leaders.

3 Technologies for Improving Reading Ability

Certainly one of the most crucial of the language skills is phonemic awareness. The normal development of phonemic awareness and word identification is critical to the acquisition of decoding and word finding skills. Technological strategies or software programs that use methods that combine sound to letter correspondence linked to spelling then reading may produce better decoding ability in children and youth [2]

Multimedia technology supports school-aged children in learning simple and more complex language and literacy skills. Technology also assists children by providing visual mental models that increases memory and organization. Multimedia technology also allows a different kind of interaction with the printed word. Moeller and Hupert [11] explain the differences between print and multimedia.

1. The role of the printed text in multimedia is not the main conveyor of the message but also acts a support to other visual and auditory media messages.
2. Multimedia allows the user to hear the text being read aloud while looking or tracking the text that is being read. The presentation of written words and sounds effectively promote decoding skills.
3. Multimedia with visual, and auditory stimulation help children and adults to advance complex reading skills. When pictures are combined with text or video images, the result is better comprehension of text material.
4. Multimedia also aids students of all ages to form “mental models” that help to organize, store, and remember information. Interactive and exciting multimedia applications help all learners to create mental models to draw from.

Multimedia software applications can offer enormous instructional opportunities to increase a student's literacy skills. In their text, *Language and Reading Disabilities* Kamhi and Catts [3] explain the stages of reading development. Programs such as Dorling-Kindersley's *Reading Explorer Deluxe*, and *I Love Phonics* can be used to advance the stages of logographic, alphabetic, and orthographic reading ability.

In a study to improve reading speed and comprehension of English as Second Language (ESL) students, Culver [6] implemented a computer reading program to determine the exit and entrance scores of ESL college students to find out if their reading speed and comprehension would improve. The results showed some improvements for the majority of students in the target group with an overall increase of 3.9 grade level in reading rate. The results show important information about the effect of increasing reading speed on student comprehension because of employing computer technology. Finally, the use of multimedia may help school-aged children to increase their reading ability but technology also requires learning computer skills. Learning to navigate through a multimedia software program is an additional benefit gained from using multimedia applications to increase literacy skills.

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Access Music

Introduction to the Special Thematic Session

Ben Challis

School of Engineering, Leeds Metropolitan University, Leeds, UK
b.challis@lmu.ac.uk

1 Background

Music is a powerful way of conveying emotion. Its strength perhaps lies in the fact that we can all make music in one way or another. From the day we are born we are encouraged to do just this. Our parents sing to us, we are taught to clap and sing along to music at school, some of us learn to play musical instruments and eventually there will be those of us who move on to make a career in music. Traditionally, to pursue such a career would require considerable study into the theory of music and the practical aspects of performance. More recently there has been a move towards making music production more accessible to novices. Rapid increases in the availability of affordable music technology aimed at the home-user market have changed our attitudes towards who can and cannot become involved in music making. Computer-based applications allow us to learn how to play an instrument, to record and edit our own performances, to write and print music notation and even to create new and unusual synthesised sounds. Professional quality music can be recorded, mixed, mastered and transferred to CD from within the home-environment. Not that long ago, each stage of this process would require separate expert technicians.

In terms of how inaccessible music has been in the past, the speed of these developments has been exhilarating with new and exciting products being released in quick succession. However, the same music technology that makes music accessible to so many people is often inaccessible to those people who have special needs. The majority of music software is highly graphical such that a blind person simply cannot use it. Complex interaction is often required such that manipulating the mouse and keyboard might prove too difficult for someone with limited dexterity. Even the simplest of music making programs may exclude children with learning difficulties from experiencing the simple pleasures of interacting with sound. In tackling the central issues in general access to information it is perhaps often forgotten that the ability to express feelings and emotions through creative means is fundamentally important to us all. Helping to increase access to these areas could bring a rich form of communication into the lives of many people.

2 Music and Technology in Education

The richness of the musical experience that we experience during our school years is highly likely to influence any choices that we make in pursuing further development in this area. Tasks that many of us perceive as simple, such as striking a xylophone or blowing into a recorder, could be prohibitively difficult for some people to achieve. It cannot always be that technology will provide an adequate solution to such problems but it might be that technology can be used to provide more appropriate alternatives. Motion sensors, switches, pressure-pads and other novel interaction devices can all be used to initiate and shape music such that everyone can interact with sound in a meaningful way. Facilitating this level of interaction should be a fundamental aim but we should also prepare for the likelihood that some people will need to move on and develop skills through unrestricted means. Creativity does not have boundaries so true access to music cannot be prescriptive in terms of output. Whilst it might be acceptable to use assistive technology to 'guide' people through their first experiences of music the long-term aim should be to allow greater levels of control of the performance such that assistance does not become prescription.

Academic courses in Music Technology are currently very popular in the UK. Interestingly, UK government legislation is also in the process of being implemented to ensure that educational institutes make all courses truly accessible to people with special needs. As a result of this, many institutes will now have to reassess how to deliver such courses where much of the commonly used technology is often quite inaccessible. In the short-term this will result in considerable reflection on whether a particular piece of music software or hardware is in favour because it is efficient for teaching or demonstrating certain musical concepts or because it has been promoted heavily through clever advertising. There is often an expectation from new students that the software they will be taught with is the same software that they have been reading about in magazines. Personal experience has shown that popular software can sometimes be highly inaccessible.

3 Future Perspectives

One day, companies who produce commercial software will learn to appreciate the need for making their products available to everyone. Current commercial trends seem to favour a move towards the 'virtual' music studio. This approach is innovative and most musical equipment can now be emulated in software. If such virtual devices were designed to be accessible they could be inclusive enough to be useful; currently this is not the case. For the time-being, access issues like these will probably remain the focus of small research projects tackling individual problem areas. When research becomes this specific it can be difficult to find the appropriate audience with which to share results and findings. Those of us connected with research into access to music need to seek to build international links such that a permanent forum for this field can become a reality.

Spoken Music: Enhancing Access to Music for the Print Disabled

David Crombie¹, Sijo Dijkstra¹, Edmar Schut¹, and Natasha Lindsay²

¹ FNB, Dutch Federation of Libraries for the Blind,
Molenpad 2, 1016GM, Amsterdam, Netherlands
projects@fnb.nl
<http://projects.fnb.nl>

² Dept Electronics & Electrical Engineering, University of Glasgow
Rankine Building, Oakfield Avenue,
Glasgow G12 8LT United Kingdom
97027471@student.gla.ac.uk

Abstract. The traditional approach taken to the provision of music for the print disabled by major organisations has been largely concerned with Braille music. Reading Braille music is a specialised skill and not all visually impaired people can do this. There are some technologies available which allow the print-disabled to service themselves but there remains a lot of work to be done in this area. FNB has developed a new approach, called *Spoken Music*. The Spoken Music system can cope with a range of music, from elementary to professional levels, which can be very complex indeed. Opportunities for collaboration clearly exist as organisations move towards common standards (such as DAISY) and as digital distribution channels multiply.

1 Introduction

FNB has developed a system whereby music is spoken onto tape or CD under similar rules to those used for Braille music notation. A learner hears a short piece of the music which is then read in every detail. An advanced version of what is now called Spoken Music [1] is now in its last stages of testing and evaluation. Using the file which set the printed music (with some adaptation) and synthetic speech, a Spoken Music file can now be produced in any language for which there is synthetic speech software. This permits the automated production of multilingual Spoken Music. Such software, producing a digital file which can easily be sent to other libraries, is a major breakthrough for visually impaired musicians who cannot read Braille notation and yet need to read written scores. Given the ageing population there are likely to be more people becoming visually impaired. There is no reason why those that read music should be cut off from it.

1.1 Traditional Approaches

The traditional approach taken to the provision of music for the print disabled by major organisations has been largely concerned with Braille music or large letter music. Although there are Braille and audio transcription services available through libraries and specialist Braille production organisations, the availability of Braille music is still limited even with the recent availability of software solutions, such as Toccata [2] or PLAY2 [3], which assist with the production of Braille music. As the production process is extremely labour-intensive, the cost of production is high. This is one reason why only certain pieces may be held by libraries, or scores may be available only to loan. The conversion of text to Braille is, even with modern computers, much more expensive than the cost of the original text. Converting printed music into a form that can be read by visually impaired musicians can cost as much as ten times more than text conversion.

1.2 New Approaches

As noted, there are some technologies available which allow the print-disabled to service themselves. These include music notation packages which can be used by the print impaired with the aid of assistive technologies such as screen readers. For example, the Wedelmusic system (*vide infra*) is designed to distribute interactive music via the Internet and represents a multimedia approach to music that provides both print and Braille scores. There are also some developments in the field of independent use of software such as music Braille transcription programs but there remains a lot to be done in this area. Having said this, the forthcoming *Music Network* initiative, covering all aspects of music coding, should prove valuable.

The *Miracle Project* [4] was born from the need to provide music Braille users with a wider variety of scores, and to reduce duplication of effort in Braille music production. Several major Braille music producing libraries, FNB (Netherlands), SBS (Switzerland), ONCE (Spain), RNIB (UK) and Stamperia Braille (Italy), formed a consortium to produce an online central catalogue of Braille music. The rules followed were those laid out in the *New International Handbook of Braille Music Notation* [5]. To avoid the duplication of entries, a uniform cataloguing system was agreed upon. This was based on the *New Grove International Dictionary of Music and Musicians* [6] and *Smiraglia Rules* [7] for cataloguing music.

The catalogue exists to store the digitalised scores of each organisation which can be downloaded by any of the participating organisations. The downloaded file can then be made into a hard copy for end users, with a digital version available for any subsequent requests for the same score. The Miracle Group has declared its intention to implement the system.

The *Wedelmusic Project* [8] was designed to distribute interactive music via the Internet while protecting publishers' rights from copyright violation. The system provides innovative support for preparing performances, studying music, analysing music, learning instruments, and distributing music at a relatively low cost. At a basic level, Wedelmusic also represents a multimedia approach to music that provides both print and Braille scores.

The tools developed within Wedelmusic for visually impaired are of clear benefit. Where a sighted user would use a graphical interface, the computer uses synthetic

speech to convey the symbolic content of the music score they are using. This allows the visually impaired user to navigate through parts, notes etc, much in the same way as a sighted user would with a graphical interface. The user can read the music scores and can also use the Wedelmusic Editor to create their own scores. Moreover, visually impaired users can transcribe print music to Braille and read the symbolic notation with a Braille bar.

2 Development of the Spoken Music Concept

Around eight years ago the clients of the Music Department at FNB asked for an alternative approach to learning music. Many of the potential clients could not read Braille music and large print was proving to be somewhat impractical for many people.

2.1 Principles of Spoken Music

One of the guiding principles of FNB is that the print disabled should have access to the same information as the sighted, and that only the format in which the information is presented should change. For Spoken Music, this means that everything on the page of a music score must be represented in a spoken format. Furthermore, this spoken format must be applicable to all types of music and instruments. Initially this may not seem to be a difficult task, but on further inspection a number of unique problems arise.

Spoken music is presented as a played fragment of music, a few bars long, with a spoken description of the example. The musical examples are made on a computer and as far as possible with a non-interpreted version of the music. All notes are played at the same volume, at the same velocity, and each note of a certain duration has exactly the same duration. The musical example is there to provide the user with a context for the spoken material, making it easier to understand and play. Furthermore, when a sighted musician reads a piece of music, several pieces of information are assimilated simultaneously. For instance, when we see a note on the page we see which note it is; the duration of the note; the phrasing and dynamics associated with the note and so on. All of this happens in an instant. We cannot, however, represent all of this information simultaneously in a spoken format. We therefore had to find a way to order the information. The system had to be designed in such a way that the listener could build up an unambiguous representation of the original scores.

The most important part of the information is the name of the note. All the other information should be centered around this. Some of the additional musical information should be placed before the name of the note: some of it should be given afterwards. The guiding principles are the way in which the musical information will be processed; the duration of the musical information; and the importance of it. For instance, we must indicate which octave the note belongs to before we say the name of the note so that the listener can become aware of the position of the note and prepare some motor movements before playing the note. When, for example, a dynamic sign and a bow is mentioned at the same position in the score, the one with the longest duration should be mentioned first. Some information is not of equal

importance for all the readers. Fingering is additional information, and is mentioned after the note and its duration.

Naturally, it is preferable not to describe every facet of every note as some data is implicit. Having established a basic set of rules it was then necessary to consider ways of limiting the volume of information without losing any critical data. This led to the use of abbreviations. For example, we do not need to include the octave information for every note. If the interval between two consecutive notes is a third or less, then the octave information can be excluded. In the same way, if the following note is a sixth or more above the current note, we have to include octave information. If the following note is a fourth or fifth above the current note, and the notes belong to different octaves we do need to include octave information. The abbreviations adopted were the same as those employed in Braille music. Similarly, we do not need to include the note duration for all notes.

When making a transcription of homophonic music the order in which the notes are mentioned follows the order in which they should be played. The representation of polyphonic music presents another challenge for the Spoken Music format. For instance, a piano part may include several notes to be played simultaneously. However, we cannot read the names of these notes at the same time. We must consider the order in which we arrange the notes to be presented and how to indicate which notes are to be played together. The convention here is to present the notes in each bar from the lowest voice upwards, with a statement indicating which notes are to be played simultaneously. *Figure 1* below contains a sample score.

Adagio sostenuto M.M. ♩ = 52-60

Ⓐ *Si deve suonare tutto questo pezzo delicatissimamente e senza sordino.*

Ⓑ *simile*

Ⓒ *sempre pianissimo e senza sordino*

4

FP

Fig. 1. Sample score by Ludwig van Beethoven taken from Op.27 N^o 20 (Sonata quasi una Fantasia), widely known as the Moonlight Sonata

2.2 Corresponding Spoken Content

The beginning of the spoken part contains a description of what piece is being read, and the generic musical information:

The title is: Sonata quasi una Fantasia.

Opus 27 No 2.

Author: Ludwig van Beethoven.

This excerpt contains 6 bars and consists of 2 fragments.

The excerpt is read in eighth notes, except where otherwise indicated.

The signature is 2 halves time.

4 sharps.

The following information contains the detailed musical information. This example of spoken content relates to bar five of Figure 1. The line numbers are for reference only and are not included in the spoken content.

- | | |
|---|--|
| 1. @f. | 12.fourth octave c sharp 2 nd finger. |
| 2. bar 5. | 13.e 3 rd finger. |
| 3. second octave c sharp whole with fifth and eighth. | 14.triplet third octave g sharp. |
| 4. in agreement with | 15.fourth octave c sharp. |
| 5. triplet third octave e 1 st finger. | 16.e. |
| 6. g sharp 2 nd finger. | 17.in agreement with |
| 7. fourth octave c sharp 5 th finger. | 18.rest half. |
| 8. triplet third octave g sharp 1 st finger. | 19.rest quarter. |
| 9. fourth octave c sharp 2 nd finger | 20.pianissimo fourth octave g sharp dotted 5 th finger. |
| 10.e 3 rd finger. | 21.g sharp sixteenth. |
| 11.triplet third octave g sharp 1 st finger. | 22.End of piece: Sonata quasi una Fantasia. |

Looking at the spoken content we can see how the music is described following the abbreviation and navigation rules described above in section 2.1. We can see how the information is structured in general. For example, lines 1 and 2 tell us that a new fragment begins at bar 5. Within the fragments each bar the lowest voice is presented first, followed by the voice above and so on. The beginning of the next voice is indicated by the instruction “in agreement with” as in lines 4 and 17.

As already mentioned there is a distinction between what information can be included before and after the note is named. We can see from the example that the octave to which the note belongs is given before the note is named – see lines 3, 5, 7 and 9 for example.

We can also see that when the note duration is different to that indicated at the beginning of the spoken description, it is always stated after the note is named. For instance line 3 states that the C# is a whole note after the note is named. In the same way line 20 tells us after the G# is named, that it is a dotted quaver. Conversely, lines 5, 8 and 11 state triplet before the note is named. Dynamics on the other hand must be placed before the note is named. For instance in line 20 the pianissimo instruction is given for the G#. On the other hand fingering instructions are placed after the note is named. One such example is the fingering instruction in line 5.

2.3 Initial Evaluation

The initial Spoken Music system was tested by visually impaired musicians who gave valuable feedback and provided a number of key suggestions for improvements. The initial evaluation raised some interesting points and the positive features of Spoken Music were found to be:

1. the detailed description of the sheet music
2. the combination of played excerpts with the spoken description
3. the independence gained from using the system – less reliance on teachers
4. the process makes it possible to read and play at the same time, which is impossible whilst reading Braille
5. spoken music is easier to learn than Braille music

However, the system also had some problems, chiefly:

1. speed of descriptions was too fast
2. speed of played excerpt too fast/ too slow
3. some musicians need only spoken descriptions, while others need only the played excerpts
4. navigating on tape was difficult
5. cueing caused quick wear of the tapes
6. fragments of music were too long or too short

After the initial development phase, FNB started to produce music books on demand. The spoken excerpts were read by trained (volunteer) readers. The music examples were played on a digital piano and recorded and compiled on a computer. Tapes were then prepared by recording the sequenced and fragmented music together with the spoken parts. This meant that all tapes were in Dutch – the language of the volunteer readers.

3 Development of Solfège Production Software

It was felt that a multilingual application was needed to extend the service, and this contributed to the development of a new software package, namely Solfège. This program automatically produces MIDI and spoken output from coded music files. The spoken output uses synthetic speech and can therefore be applied to different languages, with the use of a conversion program. The languages currently available are Dutch, English and German, with French, Italian and Spanish converters in production. In addition, a detailed and comprehensive *User Manual* [9] has been developed which covers all aspects of the production of Spoken Music, currently available in both Dutch and English.

This software solves the language problems, but it also solves many of the issues raised by the initial evaluation. For example, with the Solfège software it is now easy to change parameters concerning the speed of the audio descriptions; to alter the speed of the sound examples; and to change the length of the sections.

The automatic production of MIDI excerpts and synthetic speech means that the production of Spoken Music is much quicker and far less expensive. We can also now reach a larger client base with the introduction of multilingual synthetic speech. We

do not need to train readers or perform time consuming editing of music and spoken segments. At this time, the program works with manually transcribed files containing the musical information. In future, it may be possible to plug-in a scanning component, thereby speeding up the production process even further.

3.1 Technical Analysis of the Solfege Software

For the production of spoken music books in different languages, a tool was needed to produce the spoken and played excerpts on the base of one digital source file.

The tool had to be able to produce all the files; put them in the right order; and transport them onto tape or CD. It also needed to invoke a speech synthesizer to read out each fragment and a MIDI-player to play it. Spoken and played fragments were interleaved. A method was needed by which the user could express aspects of the protocol in relation to the score. This was done by a simple text editor. With this editor the user could add and alter protocol markings, such as the division into fragments and the addition of annotations (like for example dynamics and articulations) to enforce correct reading (or playing). This leads to the technical architecture in Figure 2 below.

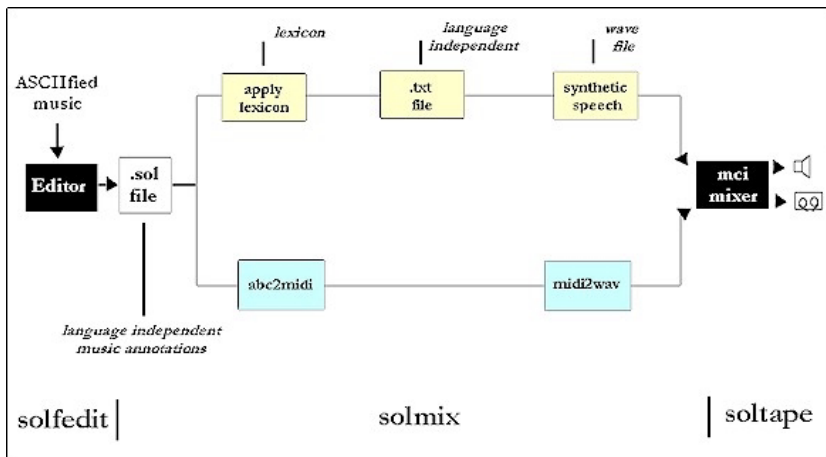


Fig. 2. Architecture of Solfege Production Software. The *Editor* produces *.sol files* with language independent music and relevant annotations. This file is the basis for two simultaneous conversion processes. The first process has two steps: an *abc to midi* conversion, followed by a *midi to wav* conversion. This process produces *.wav files* containing the musical excerpts. For the second process, a *lexicon* is applied to the *.sol file* thus producing a language dependent *text file*. This text file is converted into a *.wav file* using a *speech synthesiser*. Finally, a *mixer* combines the musical and the spoken *wav files*

We can distinguish three different roles or processes: transcriber, producer and a tape operator. Of course, this does not preclude one person having different roles. In view of this separation we established the following three programs in the Solfege suite:

1. *Solfedit*: ABC editor with navigation facilities. Later, when moving to another internal format, such as NIFF, a new editor takes its place
2. *Solmix*: a facility to assemble the output of Solfedit and produce wave-files with a mix of music and text. Solmix makes use of language specific materials such as a vocabulary. It checks and compiles such information into a datafile that allows for efficient access. It provides information on the estimated durations of the fragments in order to distribute the material over a minimal amount of tapes or CDs
3. *Soltape*: a batch oriented program to produce the actual tapes or CDs. It verifies the presence of the wave-files and operates the recording unit. It issues a warning when it is time to change tapes or CDs.

4 Current Situation

For the last three years, FNB have been producing an average of 40 to 45 book titles a year. This has resulted in the production of over 250 tapes per annum, with each tape lasting 90 minutes. This is a substantial amount when taking into account the extremely intensive process of producing Spoken Music books. The books are produced with trained volunteer readers, making the production of Spoken Music language dependent. One way to produce a more flexible production system is to increase automation. This automated process means that with less effort, more music books can be produced for a wider group of visually impaired musicians. Indeed, a pilot production study is also underway in the United Kingdom. At this time the use of tape has been discontinued and Spoken Music books are now available on CD, which solves several navigation issues as information can be ordered in separate tracks. In future, there may be a migration to DAISY [10] formats, further improving navigation and enhancing opportunities for collaboration.

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A Music Score Recogniser for the Blind

Angelo Da Ronch¹ and Adriano Blason²

¹ LADSEB-CNR, Padova, Italy

`angelo.daronch@ladseb.pd.cnt.it`

² New Systems s.r.l., Gorizia, Italy

Abstract. A music score recogniser for the blind is described. It is being developed at the Institute of Systems Sciences and Biomedical Engineering of the Italian Research National Council (LADSEB-CNR), Padua. The computer software application performs processing and pattern recognition on scanned printed score images; the results are stored both in a *MIDI* file to be played by a standard acoustic device and in a text only file, in order to permit both sighted and blind users to edit its contents.

Introduction

The main steps of the music score recogniser here described may be summarized as follows:

- 1 Image Scanning
- 2 Image Alignment
- 3 Staves and Measures Detection
- 4 Musical Symbols Recognition
- 5 Interactive and Output Formats Coding

1 Image Scanning

The first step of the program consists of the use of a scanner in order to store the optical image into the computer. All the control actions on the scanner parameters are performed by the program itself in this way: the pixel response is set constant to the B/W type; a first scan is made on the full available window with a spatial resolution of 300 dpi (dots per inch). Before continuing, the program measures the average staff height, say H , in dots; the expected value for an optimal processing is about 95 dots. If H differs from that by more than 10%, a new scan is run, at the space resolution obtained from:

$$R = 300 * 95/H \tag{1}$$

The adopted file format is the well known *TIFF*, with no compression. The image is loaded on the computer dynamic memory in a two dimensions bit map, where each bit represents a dot or pixel: 1 for black, 0 for white; clearly, the two coordinates, say X and Y , have integer values.

2 Image Alignment

The staves form the crucial space reference in the score. Normally, the average orientation of their lines does not get strictly parallel to the X axis of the scanner: so it must be measured. With no action on the image, the resulting slope should be kept into account in the subsequent processing algorithms. A proper software rotation of the whole image permits an evident simplification.

2.1 Slope Measurement and Image Rotation

A convergent procedure was chosen among some tested approaches. The black pixels are added by horizontal lines into a histogram, say $IST(Y)$, several times "as if" the image was turned by different angles; at each time, a pixel alignment parameter is extracted by measuring the "alternate component" in $IST(Y)$, regarded as a wave form. The highest value of such a parameter is searched by applying the gradient method to the set of already found values; the corresponding slope is taken as the average staff one. The function, adopted for the mentioned measure, is the sum of the absolute values of the fourth order differences:

$$\Delta 4 = \sum (|6 * IST(Y) - 4 * (IST(Y-2) + IST(Y+2)) + IST(Y-4) + IST(Y+4)|) \quad (2)$$

If the just found angle is not zero, the image is turned around its center by the opposite value angle, say α , by applying to each dot the usual rotation formulae:

$$X_n = X_o * \cos(\alpha) - Y_o * \sin(\alpha), \quad (3)$$

$$Y_n = Y_o * \cos(\alpha) + X_o * \sin(\alpha), \quad (4)$$

where (X_o, Y_o) is the original position, (X_n, Y_n) the destination position.

3 Staves and Measures Detection

In the musical scores, the intersection of different objects is a quite normal event: it means that each black pixel may belong either to only one object or to more of them. Several approaches are possible in order to keep into account this fact. In the present work the adopted procedure [2] may be summarized in this sequence of actions (see Figure 1):

- localize staves and measure bars,
- store their mean coordinates,
- erase them from the image.

After these actions, the remaining objects result as isolated sets of black dots and will be extracted from the image, such as they are, for recognition purposes.

3.1 The Staves

In consequence of the image rotation, the lines of these objects result to be nearly parallel to the X axis: the histogram $IST(Y)$ is then built up again by adding the pixels by horizontal lines. In such a function, the staves give place to remarkable peaks: the inspection on $IST(Y)$ keeps into account this property and the rule of being formed by groups of five equidistant lines. For these strong self-correlations, the detection of staves is a simple and reliable operation, by extracting the values of $IST(Y)$ higher than a proper threshold. The average vertical positions and widths of the found lines are stored in the structure $List$. The left and right borders of each staff are also searched and stored.

The selective erasing of staff lines must be sharp enough to achieve two opposite kinds of goals: save the graphical connection of the objects, in order to localize them exactly; erase as much as possible the staff contribution, because it is an error element for the recognition.

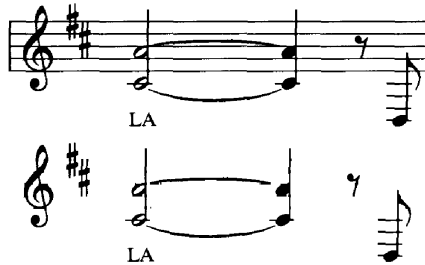


Fig. 1. The effect of erasion of staff and measure bars from the image

This operation requires rather careful criteria. First, the scanned images of the lines appear as black paths with a certain amount of local random variability in slope and vertical width. Second, as already said in general, the staves cross almost all the other present objects; when these are different enough from the staff line in the crossing zone, it is possible to detect them in a clear way, by simple measurements of local position and size; in the contrary case, such as for half notes or G-clefs, a certain part is just superimposed to a staff line: the problem can be solved only in a more complex way.

The procedure considers the lines one by one, reads their positions from $List$, explores the space which surrounds them up and down and stores previously their parts to be erased in terms of vertical borders for each abscissa into the couple of vectors: $ZYL(X)$, $ZYH(X)$. A conventional value, say $SAVE$, is given to $ZYL(X)$ where the image must not be erased; in the following, only non $SAVE$ elements will be referred to.

For each line, a regular scan is done between the horizontal borders. Mainly, at each X , a set of reliable acceptance intervals for the two vertical borders is obtained from the latest values of ZYL , ZYH ; it is used to decide whether

a local elementary column of black dots belongs or not to the line. The initial values of the mentioned intervals had been extracted from $IST(Y)$, computed only for a small zone around the initial part of the line.

The line erasing consists of changing to white the black dots between each pair $ZYL(X)$ and $ZYH(X)$. Before this operation, the detection of the intervals shared with other objects is performed, in order to save them. To do that, the vectors ZYL , ZYH are divided into groups of X -contiguous elements. On the basis of the range of the musical objects, a group may be erased if it is longer than 20 dots. For the other cases, the image around the group position is compared with expected patterns, e.g. full note and G-clef: if a matching is successful, the group is saved from erasion just by setting its ZYL elements to the value $SAVE$.

3.2 The Measure Bars

The measures offer a redundant information in the musical language. Their localization is useful in a recogniser, just to detect some eventual recognition errors by testing the metrical coherence. The search of their well known patterns is sped up by building first $IST(X)$, the histogram of black dots by vertical columns, from the zone of the image containing the current staff. The maxima in IST lead directly to those abscissae in which the measure bars may be found. Around such X values some tests are led out, in order to keep into account only isolated vertical bars, extended just to the staff height. In this way, the other objects revealed by IST , such as stems of notes, may be ignored.

4 Musical Symbols Recognition

In the actual step the objects are detected in terms of connected sets of black dots and recognised in their natural sequence: staff by staff and from left to right. For the absence of staves and measure bars from the image, the procedure consists of the iteration of this loop: scanning the staff space up to the next black dot; storing it and the ones connected to it into a proper bit map; erasing all of them from the original image; recognising the object; storing the so obtained results in the file of the corresponding symbolic names.

4.1 Two Recognition Procedures

The normal way to recognise a graphical object, once extracted from the background, is based on its comparison with a set of homologous reference images, available in the database of the program, together with the symbolic names; the best matching reference image gives its name to the object. Of course, the result is valid only when the entering object is "represented" in the database. With respect to that, two kinds of images are used in the musical notation: one image for one symbol, some elementary symbols joined together (mainly, they form clusters and chords of notes). Due to the large variety in shape of the second kind objects, their inclusion in the database, as they are, is simply unrealistic.

Rather, they shall be subdivided in a proper way, so that the obtained "elements" form a reasonably small class in the database. As a consequence, it is also necessary to detect to what of the mentioned kinds each object belongs, in order to properly deal with it. This is performed in two different ways: a cluster is identified by comparing the two overall dimensions with expected values; for all the other objects the recognition is run, ignoring at first the number of musical symbols they are intended to contain: if no matching is found good enough, the object is processed as belonging to the mentioned second kind. These two procedures are described in the next two sections.

4.2 Single Symbol Objects Recognition

The size of the objects is used also in this step, in order to pre-select the reference images with an expected good result from the comparison: to this purpose, the images are grouped into a certain number of classes, each for a range of surfaces (width by height). Each unknown object is compared only with the elements of its surface class.

The comparison consists of matching the two images dot by dot, by the "exclusive OR" function; the resulting image is stored and examined. To perform such a process in the correct way, it is necessary to resize the unknown object, so that its frame gets equal to the one of the reference image. The required scale factors for the two coordinates will be used as "penalties", in terms of differences from one. From the mentioned match image the amount of black dots is extracted: referring to the correspondence between dot colors and bit values, it has the meaning of sum of differences between the two compared images. From such a number, three error indexes are obtained, dividing it by these quantities:

- 1: the (common) total surface,
- 2: the number of black dots in the resized unknown image,
- 3: the same number in the reference image;

together with them, three other parameters are considered:

- 4 and 5: the two mentioned resize penalties,
- 6: the difference in the height/width ratios.

From the testing experience, two kinds of threshold were stated out:

- 0.6 for each of the first three parameters,
- 2.0 for the sum of the six parameters.

Two possible events are issued from the application of these thresholds:

- at least one of the used reference images passes all the tests with success: the one with the lowest errors sum gives its name to the unknown object; if the corresponding music symbol is a note or an accidental, its pitch is found from its vertical position in the staff; finally, it is stored in the file of symbols and the process terminates;
- in the contrary case, the unknown object is again examined, as it will be described in the next section.

4.3 Multiple Symbols Objects Recognition

This process is applied to the already selected clusters of notes and to the objects rejected as just seen (Figure 2). Of course, also this step may reject some objects. The feature which is supposed to be common in any case is the presence of vertical stem(s) of notes. These elements are sought first. To do that, the histogram $IST(X)$ is evaluated on the actual image: in it, high and steep peaks reveal the presence and the abscissae of the stems.



Fig. 2. Examples of the three main multiple symbols objects: a chord, a note with ledger lines and a cluster

A single stem indicates a chord or a note with additional ledger lines; two or more stems reveal a cluster. In the first case the heads of the notes are looked for; in the second, also the cross-bars must be found, in order to give the proper duration to each note. To find the heads, the reference images of the quarter and half notes heads are moved throughout the unknown image, next to the stems' abscissae, local maxima of likelihood are looked for and compared with pre-fixed thresholds. The cross-bars are normally thick enough that they may be detected with a certain ease around the stems terminations which result vertically opposite to the heads of the notes.

5 Interactive and Output Formats Coding

The natural result of a score recogniser consists of translating the identified musical contents in a code suited both to the acoustic output and to a music editor. In the present case, a further condition is the accessibility of the editor by a blind user.

For these reasons, the music editor "Terpsychore", developed at the University of Padua [7], was integrated in the recogniser package. In fact, the main aspects of this editor are: it may compile a *MIDI* format file, for acoustic playing purposes; the source file of the musical symbols is of the text only type, so it may be managed by the help of acoustic or tactile screen readers; finally it contains some useful procedures for the control of the syntactic coherence.

6 Discussion

The program here described is still under development: mainly, the polyphony automatic detection shall be built up and a text recogniser, developed at

LADSEB-CNR [8], is available for integration in the package. Also the reliability of the procedures needs some improvements: the actual error rate, about 1%, is an encouraging but not yet sufficient result.

From the beginning, a particular attention was given to two objectives: the use by blind people shall be as friendly as possible; each new version must be tested by sighted and blind users with different skill degrees, in order to collect their suggestions for upgrading purposes.

In order to achieve these goals, besides the described fact that the scanner is called and driven by the software, the same program may run in two main modes, the alternatives being stored in a *INI* type file:

- an interactive mode for development purposes: the partial results may be shown in several ways and with different degrees of detail;
- a totally automatic way, for easy use by the blind: once put the score on the scanner and ran the program, the piece is played directly on the computer acoustic device with no further actions.

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Visualization of Music Notation for Partially Sighted Persons

Tatiana Evreinova and Roope Raisamo

TAUCHI Computer-Human Interaction Unit
Department of Computer and Information Sciences
FIN-33014 University of Tampere, Finland
+358 3 215 8569
{e_tg, rr}@cs.uta.fi

Abstract. The goal of this work is to find an inexpensive solution that would allow real-time imaging of music notation through spatial-temporal color coding. The device consists of four light emitting diodes, which are coupled with eyeglasses. Software and pilot evaluation of the method of imaging were performed. The average value of recognized test notes among noise ones was 87.24% at exposition times 640-1280 ms and dispersion was 14.4%.

1 Introduction

Musicians who are partially sighted persons have difficulties in using music sheets in Braille during rendering. Another issue is that Braille is very difficult for perception if the person has low tactile sensitivity, for instance, when he/she plays on the string instruments. Therefore, musicians must start to learn Braille as early as possible.

2 Method Design

Each music token is displayed with the help of a spatial pair of four light emitting diodes (Fig. 1), which are coupled with the glasses. They have three levels of brightness (0, 1/2, 1) and three colors (background as gray, red and green). A temporal pattern consists of eight light units. The light units within the temporal pattern are not divided by intervals. Diffused luminescence does not require recognition of clear shape of characters and does not create obstacles for direct gaze. Indicators provide only direction detection of the light sources and are coupled into groups, based on functional similarity and frequency of using. ASCII equivalents and their combinations were used as intermediate code between graphic imaging of music symbols and color patterns. Total number of coding combinations was 326.

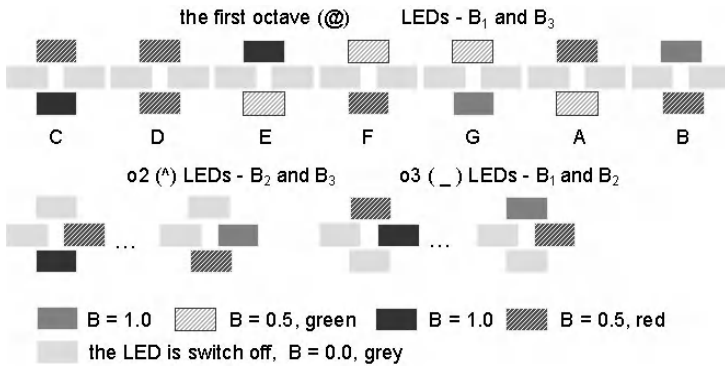


Fig. 1. Spatial-color coding of notes for imaging of three octaves

3 Test Designing and Results of Pilot Evaluation

We have recorded an amount of detected test notes among other music symbols (noise) presented within a test sequence to the subjects. All test sequences were composed equally of ten test-notes and ten noise symbols. When increasing the exposition time up to 960 ms the amount of recognized test symbols has grown to 94 percents (Fig. 2). To decrease the amount of errors we plan to develop color code with adaptive exposition duration of light units in the color patterns.

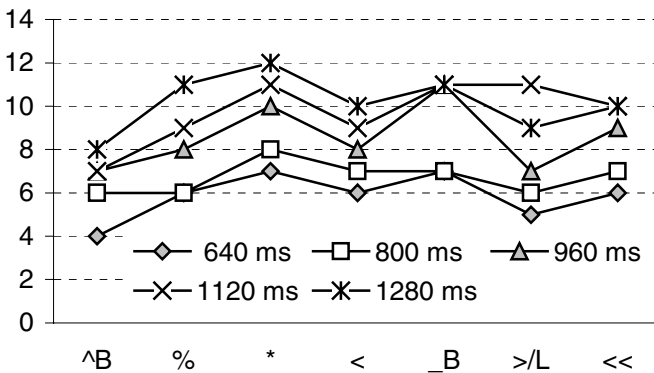


Fig. 2. Color pattern recognition at exposition times 640-1280 ms for "E" note

The proposed method could be useful as a peripheral display in wearable computers for people with special needs.

Accessing the Software Studio

Damian T. Murphy and Mark A. Hildred

Music Technology Research Group, Department of Electronics, University of York,
Heslington, York, UK, YO10 5DD
{dtm3, mah104}@ohm.york.ac.uk

Abstract. The pairing of modern computing power and the software studio environment potentially offers the disabled musician access to creativity as never before. Limitations identified through the use of switch control for both specialist music applications and overlay software have resulted in novel hardware solutions being investigated. MIDIcreator has been used to link a reduced control set interface with a standard software studio application, allowing navigation and control of audio functions.

1 Introduction

The use of powerful and inexpensive computer technology has seen a shift in how modern popular and electronic music is written and produced. The traditional studio setup has effectively been replaced by a similar software environment, facilitating the ever more easy creation and arrangement of many musical styles through the use of a wide range of instrumentation and processing options.

The significant advantages and flexibility of the software studio are offset however by the limited provision for “hands-on” user control. Typically the mixing desk control surface of the traditional studio consisting of many tactile functional elements is traded for mouse and QWERTY keyboard interaction. The limitations of this already non-ideal user interface become further compounded if disabled musicians are to be allowed equivalent access to the creative opportunities these software applications provide.

Research undertaken by the Drake Music Project has examined the problems faced by disabled musicians who use switch control when working with such composition and arrangement software [1]. This has concentrated on either specialist software such as *E-Scape* - a music composition application designed for switch users - or the use of overlay software together with standard existing composition applications.

Despite specialist systems being found to offer advantages in terms of interaction, feedback and immediacy of use, most disabled users prefer to have access to industry standard software. The additional functionality on offer enhances creative potential, and allows the disabled musician to interact with the wider musical community through the common use of professional, industry standard software with the perceived acceptance that this is seen to bring. However the success or otherwise when using an overlay based solution seems to depend highly on the tenacity and

ability of the user, the design of the overlay system and the suitability of the target application.

2 Software Navigation and Control Using *MIDIcreator*

The complexity of navigating the software interface is usually enhanced through the addition of specific control surface hardware, often following the design of a studio mixing console, communicating with the host application via MIDI.

MIDIcreator is an interfacing system that can take up to 8 switched and 8 proportional control inputs and translate them into combinations of MIDI events or controller messages. The control sensor inputs currently available for *MIDIcreator* range from gesture detection devices using ultrasound or varying capacitance through to pressure based switches for handheld or floor use. Additional control surfaces can also be designed and built, and as such *MIDIcreator* is highly appropriate for the rapid prototyping and development of alternative control and interfacing solutions.

An investigation into how *MIDIcreator* can be used to provide interaction with a standard software studio application (*Steinberg Nuendo*) through a suitably reduced control set has been carried out. The proposed solution uses only three proportional controllers to offer interaction with the following functions across 16 audio mixer channels: channel select, volume, pan, mute, effect send 1 level and effect send 2 level. Controller 1 changes the value of the selected function, controller 2 cycles through the six channel functions, and controller 3 moves through the 16 audio mixer channels. The *Nuendo* GUI provides visual feedback to aid navigation and this can be enhanced further through the use of *MIDIcreator* switch controlled LEDs.

3 Conclusions and Further Work

This investigation has shown that it is possible to provide interaction with the software studio using a restricted set of MIDI based controls. This can be expanded according to the training and experience of the user, potentially allowing the disabled musician to explore audio remixing and live sound control work, both supporting and offering an alternative to more traditional MIDI based composition strategies. Further work will expand the number of functions that can be realistically manipulated, and investigate how the generic interfacing method used at this prototyping stage (a standard slider) can be replaced with a more specifically designed sensor applicable for both the task at hand and the needs of the individual user.

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Opening Doors to Information Technology – Section 508 of the US Rehabilitation Act of 1973

Helen Chamberlain

General Services Administration, Center for IT Accommodation, USA
helen.chamberlain@gsa.gov

1 Introduction

Section 508 of the US Rehabilitation Act of 1973 has the potential to make the biggest impact on reducing barriers to technology for many people with disabilities. Although it only applies to the U. S. Federal government, its impact is being felt in the U. S. state governments, the private sector, and around the world.

Section 508 was signed into law on August 7, 1998. The purpose of Section 508 is to ensure that technology does not stand as a barrier to employment and the full productivity by people with disabilities. Section 508 is not about assistive technology; its purpose is to improve access to “mainstream” technology, (making it easier to provide assistive technology)

There are 54 million (20.6%) persons in the United States alone that have some level of disability. Over 70% of working age persons with severe disabilities have minimal or no employment and the U. S. Federal government currently employs approximately 167.900 persons with disabilities.

More then two-thirds of Americans have some type of access to the Internet and in less then a decade, email has become a fundamental communication tool. In 1998 the U. S. Postal Service delivered 101 billion pieces of paper mail; estimates of the number of email messages transmitted that year range as high as four trillion. The number of electronic mailboxes worldwide reached almost 570 million in 1999. According to a report put out by UCLA (University of California at Los Angeles), by 1997, some 19 million Americans were using the Internet. That number tripled in one year and then passed 100 million in 1999. In the first quarter of 2000, more then five million Americans joined the online world, roughly 55,000 new users each day. Every 24 hours, the content of the Worldwide Web increases by more then 3.2 million new pages and more then 715,000 images. Last year alone the number of hits on U. S. web pages passed the one billion per day mark.

The types of products covered by Section 508 include:

- Software applications and operating systems
- Web based information and applications
- Telecommunications functions
- Video or multi-media products
- Self contained closed products
- Computers

Also covered is compatibility with adaptive equipment people with disabilities commonly use for information and communication access.

The main beneficiaries of Section 508 will be those who have historically had the most access barriers. This includes people who are blind, and with an increased use of sound files and videos, people who are deaf. There are approximately 10 to 11 million blind and visually impaired people and 22 million deaf or hard of hearing people in the United States.

What effects will the implementation of Section 508 have? Section 508 can lead to improvements in:

- Better employment opportunities in the U. S. Federal government for persons with disabilities
- More effective job functions for those currently employed by the Federal government
- Greater opportunities for persons with disabilities working in the private sector
- More opportunities for persons with disabilities who are unemployed
- And unproved access to Federal government services for persons with disabilities

The U. S. Access Board was created in 1973 to develop guidelines and standards, provide technical assistance and training, conduct research, and handle compliance and enforcement for issues regarding accommodating persons with disabilities. In 1999 the U. S. Congress assigned responsibility to the Access Board to amend Section 508 of the U. S. Rehabilitation Act for Electronic and Information Technology (EIT) to reflect technology advances and change in EIT. The final standards were published in December 2000 and became enforceable in June of 2001.

The U. S. Access Board and the General Services Administration were tasked by the President of the United States to provide technical assistance with regard to the requirements of Section 508.

Further information on Section 508 can be obtained by going to www.section508.gov or www.access-board.gov

Below is an overview of the Rehabilitation Act and Section 508 in particular.

2 The US Rehabilitation Act of 1973 Established Policies to ...

(1) Empower individuals with disabilities to maximize employment, economic self-sufficiency, independence, and inclusion and integration into society, through—

1. Statewide workforce investment systems implemented in accordance with title I of the Workforce Investment Act of 1998 that include, as integral components, comprehensive and coordinated state-of-the-art programs of vocational rehabilitation;
2. Independent living centers and services;
3. Research;
4. Training;
5. Demonstration projects; and
6. The guarantee of equal opportunity; and

(2) Ensure that the Federal Government plays a leadership role in promoting the employment of individuals with disabilities, especially individuals with significant disabilities, and in assisting States and providers of services in fulfilling the aspirations of such individuals with disabilities for meaningful and gainful employment and independent living

In 1998, Congress amended Section 508 of the Rehabilitation Act to require Federal agencies to make their electronic and information technology accessible to people with disabilities. Inaccessible technology interferes with an individual's ability to obtain and use information quickly and easily. Section 508 was enacted to eliminate barriers in information technology, to make available new opportunities for people with disabilities, and to encourage development of technologies that will help achieve these goals. The law applies to all Federal agencies when they develop, procure, maintain, or use electronic and information technology. Under Section 508 (29 U.S.C. ' 794d), agencies must give disabled employees and members of the public access to information that is comparable to the access available to others.

3 Section 508 Overview

3.1 General (Subpart A)

The standards define the types of technology covered and set forth provisions that establish a minimum level of accessibility. The application section (1194.2) outlines the scope and coverage of the standards. The standards cover the full range of electronic and information technologies in the Federal sector, including those used for communication, duplication, computing, storage, presentation, control, transport and production. This includes computers, software, networks, peripherals and other types of electronic office equipment. The standards define electronic and information technology, in part, as "any equipment or interconnected system or subsystem of equipment, that is used in the creation, conversion, or duplication of data or information."

Subpart A also explains what is exempt (1194.3), defines terms (1194.4), and generally recognizes alternatives to what is required that provide equal or greater access (1194.5). Consistent with the law, the standards exempt systems used for military command, weaponry, intelligence, and crypto logic activities (but not routine business and administrative systems used for other defense-related purposes or by defense agencies or personnel). The standards also exempt "back office" equipment used only by service personnel for maintenance, repair, or similar purposes.

The standards cover technology procured by Federal agencies under contract with a private entity, but apply only to those products directly relevant to the contract and its deliverables. An exception clarifies that the standards do not apply to technology that is incidental to a Federal contract. Thus, those products that are not specified as part of a contract with a Federal agency would not have to comply with the standards. For example, a firm that produces a report for a Federal agency under a contract would not have to procure accessible computers and word processing software even if they were used exclusively for the contract; however, compliance would be required if such products were to become the property of the Federal agency as contract

deliverables or if the Federal agency purchased the products to be used by the contractor as part of the project. If a Federal agency contracts with a firm to develop its web site, the standards would apply to the new web site for the agency but not to the firm's own web site.

3.2 Technical Standards (Subpart B)

The standards provide criteria specific to various types of technologies, including:

- Software applications and operating systems
- Web-based information or applications
- Telecommunication products
- Video and multimedia products
- Self contained, closed products (e.g., information kiosks, calculators, and fax machines)
- Desktop and portable computers

This section provides technical specifications and performance-based requirements, which focus on the functional capabilities of covered technologies. This dual approach recognizes the dynamic and continually evolving nature of the technology involved as well as the need for clear and specific standards to facilitate compliance. Certain provisions are designed to ensure compatibility with adaptive equipment people with disabilities commonly use for information and communication access, such as screen readers, Braille displays, and TTYs.

Software Applications and Operating Systems (1194.21): Most of the specifications for software pertain to usability for people with vision impairments. For example, one provision requires alternative keyboard navigation, which is essential for people with vision impairments who cannot rely on pointing devices, such as a mouse. Other provisions address animated displays, color and contrast settings, flash rate, and electronic forms, among others.

Web-based Intranet and Internet Information and Applications (1194.22): The criteria for web-based technology and information are based on access guidelines developed by the Web Accessibility Initiative of the World Wide Web Consortium. Many of these provisions ensure access for people with vision impairments who rely on various assistive products to access computer-based information, such as screen readers, which translate what's on a computer screen into automated audible output, and refreshable Braille displays. Certain conventions, such as verbal tags or identification of graphics and format devices, like frames, are necessary so that these devices can "read" them for the user in a sensible way. The standards do not prohibit the use of web site graphics or animation. Instead, the standards aim to ensure that such information is also available in an accessible format. Generally, this means use of text labels or descriptors for graphics and certain format elements. (HTML code already provides an "Alt Text" tag for graphics, which can serve as a verbal descriptor for graphics). This section also addresses the usability of multimedia presentations,

image maps, style sheets, scripting languages, applets and plug-ins, and electronic forms.

The standards apply to Federal web sites but not to private sector web sites (unless a site is provided under contract to a Federal agency, in which case only that web site or portion covered by the contract would have to comply). Accessible sites offer significant advantages that go beyond access. For example, those with "text-only" options provide a faster downloading alternative and can facilitate transmission of web-based data to cell phones and personal digital assistants.

Telecommunications Products (1194.23): The criteria of this section are designed primarily to ensure access to people who are deaf or hard of hearing. This includes compatibility with hearing aids, cochlear implants, assistive listening devices, and TTYs. TTYs are devices that enable people with hearing or speech impairments to communicate over the telephone; they typically include an acoustic coupler for the telephone handset, a simplified keyboard, and a visible message display. One requirement calls for a standard non-acoustic TTY connection point for telecommunication products that allow voice communication but that do provide TTY functionality. Other specifications address adjustable volume controls for output, product interface with hearing technologies, and the usability of keys and controls by people who may have impaired vision or limited dexterity or motor control.

Video or Multimedia Products (1194.24): Multimedia products involve more than one media and include, but are not limited to, video programs, narrated slide production, and computer-generated presentations. Provisions address caption decoder circuitry (for any system with a screen larger than 13 inches) and secondary audio channels for television tuners, including tuner cards for use in computers. The standards also require captioning and audio description for certain training and informational multimedia productions developed or procured by Federal agencies. The standards also provide that viewers are able to turn captioning or video description features on or off.

Self-Contained, Closed Products (1194.25): This section covers products that generally have imbedded software but are often designed in such a way that a user cannot easily attach or install assistive technology. Examples include information kiosks, information transaction machines, copiers, printers, calculators, fax machines, and similar types of products. The standards require that access features be built into the system so users do not have to attach an assistive device to it. Other specifications address mechanisms for private listening (handset or a standard headphone jack), touch screens, auditory output and adjustable volume controls, and location of controls in accessible reach ranges.

Desktop and Portable Computers (1194.26): This section focuses on keyboards and other mechanically operated controls, touch screens, use of biometric form of identification, and ports and connectors.

3.3 Functional Performance Criteria (Subpart C)

The performance requirements of this section are intended for overall product evaluation and for technologies or components for which there is no specific requirement under the technical standards in Subpart B. These criteria are designed to ensure that the individual accessible components work together to create an accessible product. They cover operation, including input and control functions, operation of mechanical mechanisms, and access to visual and audible information. These provisions are structured to allow people with sensory or physical disabilities to locate, identify, and operate input, control and mechanical functions and to access the information provided, including text, static or dynamic images, icons, labels, sounds or incidental operating cues. For example, one provision requires that at least one mode allow operation by people with low vision (visual acuity between 20/70 and 20/200) without relying on audio input since many people with low vision may also have a hearing loss.

3.4 Information, Documentation, and Support (Subpart D)

The standards also address access to all information, documentation, and support provided to end users (e.g., Federal employees) of covered technologies. This includes user guides, installation guides for end-user installable devices, and customer support and technical support communications. Such information must be available in alternate formats upon request at no additional charge. Alternate formats or methods of communication, can include Braille, cassette recordings, large print, electronic text, Internet postings, TTY access, and captioning and audio description for video materials.

Access: The North American Experience of Legislating Attitudes

Zachariah Cameron

Rm#T130, Steacie Science Library
York University
4700 Keele Street
Toronto, Ontario M3J 1P3
Canada
{zcameron, ability}@yorku.ca

Abstract. The past century and particularly the past four decades saw great improvements in science and technology. Many such improvements have promoted Accessibility. This apparent symbiotic relationship is not all that it seems. Technological advancement is a necessary but not, in itself, a sufficient catalyst to Accessibility. In the twentieth century the situation of people with disabilities saw very slow socio-economic progress, largely through the efforts of humanitarian agencies. In the 1960's the humanitarian organizations were joined by the rights based organizations and together they were responsible for a significant surge toward equal access. It was, however, not until broad based legislation was put in place in the form of the "Americans with Disabilities Act" that attitudes and equality began to change in a real and broad based manner. It is in the dialogue on disability, access and compliance that we see this change.

The century just closed was one of great turmoil, of great suffering, of great advancement, of great tragedy and of great humanitarian endeavour. At the beginning of the twentieth century the Red Cross was a young organization of an entirely new sort in that it was secular and stateless pledged simply to help when, where and whomever needed without consideration of race, creed, nationality, sex and so forth. There were, to be sure, other organizations of a humanitarian nature that existed before the nineteenth century and many others that sprang up in the twentieth, which were of a less universal but still effective reach. The March of Dimes springs immediately to mind along with Doctors Without Borders and Easter Seals. And never has there been a century so in need of their services.

In North America and, I think, in many other places further afield the situation of people with disabilities at the turn of the twentieth century was bleak. Those who received treatment were not always the lucky ones. The horrors of mental institutions of the time are well known, well documented and well gone. At the very least, gaining a disability generally meant losing ones livelihood and there was no social safety net.

Things changed very little and very slowly over the course of the first half of the century. Images of the United States president that always excluded his wheelchair indicate what were at least the perceived limits to the awareness and acceptance by the population at the time. The needs of returning veterans fueled some progress in

care and treatment as well as new prosthetics but curiously this influx did not manifest itself in the form of desires and demands for the rights of the individual.

In the areas of Accessibility, Access technology and the development of the human spirit that such endeavours imply we find that a great deal of what has happened has occurred in the last forty years. It is similarly very evident that there have been tremendous advancements in technology over that period and it might be argued that there is a cause and effect relationship here.

This apparent symbiotic relationship is not all that it seems. Technological advancement is a necessary but not, in itself, a sufficient catalyst to Accessibility as has been demonstrated many times at ICCHP in previous years. It often happens that technological advances do not get taken up and used in a practical way to improve the situation of people with disabilities.

In the decade of the 1960's things began to change. The Red Cross was now at the end of its first century and full of experience and joined by a number of other humanitarian groups. Moreover the position of humanitarian concerns began to take a larger and often louder place in North American society. This apparent ground-swell of compassion extended to the animal rights movement, the environmental movement, the peace movement and a host of others.

At the same time as this humanitarian imperative blossomed there was a similar renewal of interest in and struggle for human rights. This often proved to be the louder and more volatile of the two leading occasionally to violence and death. The struggle for desegregation of schools and services heated up in the United States leading to huge marches. In Canada, in a typically low key Canadian variation, the native population increased pressure to redress the wrongs done to them and to reclaim some of their heritage.

These two forces may seem on the surface to be pretty much the same. It is important to understand that they are different. The humanitarian side of the equation is one that seeks to relieve or to avoid suffering. In my usage I extend this to compassion that goes beyond the merely human realm. One need not imply moral or political rights to render assistance where needed. In the aftermath of a hurricane or plague the question of rights would be completely misplaced. You may rage against the storm but you do not question its right to blow.

In contrast the rights based approach is based on the notion that the individual, in a collective sense, has certain rights by virtue of being a human in a given society. This approach offers equal rights by virtue of species membership as the prime argument and, strictly speaking, requires no compassion.

These two forces have often manifested themselves, one or the other, in human history. In the context of this paper the Native American giving aid to malnourished early explorers and settlers provides a sample of humanitarianism and on the rights side of the equation there can be little better example than the United States Declaration of Independence. When these two forces mix together as they did in the North America of the 1960's the result is a very potent cocktail. There was a broad based, non-aligned movement toward peace and compassion and a broad based, non-aligned movement toward securing the practical expression in society of the civil and human rights that society espoused. Clearly there was some overlapping of membership in the two groups but the end result was a powerful force for social and political change.

In such a mix the humanitarian side provides energy and practical activity while the rights side provides the power. It is this power that draws in others in the society

by showing the correctness and justification for a course of action. In short, it is the right thing to do.

During this same period, roughly the third quarter of the twentieth century, advances in medical science resulted in the survival of many individuals who would not have been expected to survive just a few years earlier. Amongst these were a good many healthy and athletic individuals who as a result of severe trauma in accident or war found themselves unable to function as before. Many of these people, new to disability, were anxious to get back into the mainstream of life and provided active consumers of new prosthetics and technology. They were also vocal speakers in favour of their right to an active life within the 'main stream' of society.

Along with tremendous advances in wheelchair design and prosthetics the micro-processor began to really make its presence felt in the 1970's. The Apple computer and the Echo speech card promised exciting new possibilities to those of us involved in disabilities issues at the close of the 1970's. It remains exciting in the same way a Model T Ford excites automobile enthusiasts.

In spite of continued pressure from an increasing number of support groups on both sides of the border, progress was still slow in the United States and Canada in this decade. In 1978 Frank Bowe began the forward to his book *Handicapping America: Barriers to Disabled People* with "America handicaps disabled people. And because that is true, we are handicapping America itself."¹[2] In Canada Joan Brown titled her 1977 book on policies for disabled people in Canada *A Hit-And-Miss Affair* indicating the scattered and occasionally effective approach to services and support for people with disabilities in Canada at the time.

Transportation for people with disabilities started to come online in major centers. In some places like Toronto it was quite a fight and in this instance the local transit authority, while putting their name on the project, would not operate it directly themselves until several years and a couple of bankrupt sub-contractors had passed.

In the nineteen eighties in North America an increase in awareness built up amongst the community of people with disabilities and their supporters. Through magazines and print media and conferences gradually the voices of people with disabilities started to be heard. They also began to lobby government in the United States for Access legislation that would ensure that people with disabilities not be unnecessarily shut out.

The 1980's were the decade of the United Nations in terms of the profile of people with disabilities. In 1980 the Canadian government struck the "Special Committee on the Disabled and Handicapped" in anticipation of the United Nations International Year of Disabled People in 1981. The United Nations then announced the "World Programme of Action Concerning Disabled Persons" and finished out the decade (and more) with the United Nations Decade of Disabled Persons (1983-1992).

While this did raise the profile of people with disabilities it failed to translate into a general, societal awareness. Buoyed by the United Nations support and efforts people with disabilities and their supporters found new energy to push forward as well as finding new hope that these efforts would be rewarded. Legislators on both sides of the border became, to a greater or lesser extent, aware of the issues and slowly became aware of some of the steps that could be taken to improve matters.

¹ Frank Bowe, *Handicapping America: Barriers to Disabled People*, (New York: Harper & Row Publishers, 1978) page 1 of forward.

All too often in the hearts and minds of many in the national governments and across North America in businesses, large and small, in homes and in civic government there was a failure of understanding and perception. People with disabilities were seen as a special interest group, an 'other', for whom, in some quarters, it was not at all clear that they had the right to life let alone the rights to liberty and the pursuit of happiness. This, of course, is an allusion to the United States "Declaration of Independence" but the lack of vision, or perhaps distorted vision, the earlier comments imply, could be found throughout North America and I suspect far beyond our shores.

A second, less morally bereft but almost equally powerful barrier producer, is a variation on the NIMBY (Not In My Back Yard) syndrome. This has an important difference however as it is a passive process rooted in the failure of individuals, who may otherwise be quite supportive, to consider the barriers they erect in the built and social environment. Individuals simply fail to consider the effect of the tall step in front of the restaurant or post office or the automatic doors that don't work or don't exist at the entrance to a public building. A variant on this is the situation where people do see the need but everyone wants someone else to pay for the needed modifications.

In 1990, with the passing of the ADA (Americans with Disabilities Act), the ground was prepared for the next surge of growth in the awareness of disabilities issues and for deepening the roots of the understanding and acceptance of the rights of individuals with disabilities. It also signaled the beginning of a great divergence between the United States and Canada in support, awareness and attitude in regards to people with disabilities and their access to basic human rights.

It is often said that you cannot legislate morality or attitudes. What is particularly interesting about both the ADA and the American Rehabilitation Act, beyond strict legal implications, is what it has meant in the generation of discussion, news coverage and thinking about Access issues. What this has meant is a much higher incidence of articles in newspapers and magazines. People are more aware and much more supportive as a result. It is as if people see that it is the law and feel that it must be right and take on new attitudes or morality as a consequence.

I don't wish to imply that the changes were rapid, that in 1989 life was nasty, brutish and short and in 1991 a new social contract had transformed life into sweetness and light. The process has been gradual but the pace did pick up through the 1990's as improvements build upon themselves.

The measure of these changes cannot be taken directly. No one thought to try to gauge the level of public awareness or the attitudes of the public to disability and associated rights in the built and socio-economic world. Even today little of that type of data is collected. In this lack we find our key to open a window onto the rapidly changing nature of awareness and attitudes in the southern part of North America.

It is in the questions people ask as well as the questions people fail to ask that we most clearly see the nature of and changes in attitude. The questions not asked can be as enlightening. The fact that no one thought it important at, or around, the time of the passage of the ADA to survey in any breadth or depth the position of people with disabilities, attitudes toward them, access to the rights guaranteed them by the United States Constitution and the Canadian Charter of Rights and Freedoms, is indicative of an absence of a sufficiently broad based and serious interest to bring that about.

Other questions common at the time coming from areas of government, business, education and the general public showed a range of attitudes from uncertainty through apprehension to antagonism. People asked,

- "Why bother?"
- "Are there enough people to make it worthwhile?"
- "Can we afford it?"
- "Who are you to tell me how to run my company?"

I strongly suspect that behind at least some of the resistance was the fear that acknowledging the rights of others might mean relinquishing some for oneself.

Up to this point Norm Coombs and Dick Banks in their courses on Access Technology from RIT (Rochester Institute of Technology) could answer the 'Why?' with

- "Because it is the right thing to do."
- "Because it is cost effective."

After 1990 they could add

- "Because it is the law."

After 1990 and with increased speed as the decade wore on these questions began to fade. They will likely never disappear, as there will always be those who through fear or ignorance oppose the extension of rights and have little compassion.

The questions we heard coming out of the United States were now of the nature of how:

- "How can we make a computer lab accessible?"
- "How can we accommodate a person who cannot use a mouse?"
- "How can we assist a person whose vision is deteriorating?"

We heard people in business say that they had never really considered accessibility before and would not likely have done so if not for the legislation. The fact that some of these business people were pleasantly surprised in the performance of people with disabilities whom they hired is a striking indicator of a shift in attitude from one of which they had never been consciously aware to a new more conscious awareness of an attitude of something close to equal acceptance.

The passage of Section 508 of the American Rehabilitation Act gave impetus to this change in attitudes and added questions about how to comply with the dictates of the Act.

In Canada the period after 1990 saw little change on our side of the border though we were acutely aware of the developments with our neighbours to the south. The same old questions about cost and numbers and the unilateral rights of business owners continued to arise. Also on the increase was the desire for change.

In Canada we have taken a somewhat less proactive and supportive stance toward Access. We have both federal and provincial charters of rights. Both of these, it is worth noting, are also fairly recent developments on the Canadian political scene

having arrived in the latter half of the twentieth century. This is generally the only line of defence for people who wish to seek a remedy for being discriminated against due to disability. The process of going through the human rights court is a long one usually taking several years. Moreover it requires considerable financial resources to see such a case through to the end. In many cases such a case will not be brought or has no chance of completion before the death of the complainant.

The federal government was clearly in no hurry to bring in legislation similar to the ADA in order to make manifest the rights enshrined in the Canadian Charter of Rights and Freedoms. There may be some connection between this and the fact that the charter was only eight years old in 1990 and the courts were still working out what it meant in practice. Discrimination against people with disabilities was proscribed in the work environment but was still quite legal outside of the workplace. In the province of Ontario, which is home to over one and one-half million people with disabilities, the ODA Committee (Ontarians with Disabilities Act) was formed in 1994 to lobby the provincial government for legislation similar to that in the United States. The next year during a provincial election campaign Mike Harris, the leader of the Conservative party, promised that in his first term he would enact an ODA.

The promised bill did not materialize on schedule. It took almost seven years of constant struggle and pressure by the ODA Committee before a bill was passed at the end of 2001 just before Premier Harris left politics. In the process the efforts of the ever growing numbers of people and of local chapters in the ODA Committee across a large province had some effect in raising the awareness of Ontarians and to a certain extent of Canadians. There are now many more people aware of the current state of accessibility in Canada and of the lack of political will amongst many of our politicians to deal with the situation directly and ensure that the daily operation of the country live up to the grand words of the Charter of Rights and Freedoms. A further benefit has been the increase in the numbers of activists and the development of leaders amongst the community of people with disabilities and their supporters.

In the end very little has changed on the Canadian side of the equation when compared to the sea change brought about in the United States by the ADA and the American rehabilitation Act. The ODA was passed very late in 2001 but in our system that means very little. The provisions of a bill must be enacted separately and generally at the will of the ruling party. Two-thirds of the provisions of the ODA remain unproclaimed and there are no estimated dates for when the remainder might be brought into play.

Ontario's 'Decade of the Disabled, 1986 to 1995, saw only a continuation of the slow progress seen in the latter part of the century. The close of that decade saw some of the legislation supporting physical access repealed.

An Angus Reid opinion poll taken for the Royal Bank in 2000 found 64 percent of the population believed that a person with a disability was less likely to be hired than a person without a disability and the same qualifications. While 72 percent of Canadians believed that companies should reduce barriers in the workplace this is a substantially lower figure than what I have heard from the United States. The number of people who say they work with someone with a visible or non-visible disability is 35 percent but given that 47 percent say they would try to hide a non-visible disability it begs the question, "How do you know if you are working with someone with a non-visible disability?". The fact that less than half, 44 percent, say their workplace is accessible means that potential employment opportunities are similarly diminished.

Across Canada we still have a hodgepodge. The province of British Columbia for instance recently dropped funding for the BC Library Services audio book programme. Within provinces support both moral and practical varies widely. While there are some areas of active support in the federal government there is no set vision or driving force for support across the country.

In the United States we need only look at the directive that all government offices, and by extension their suppliers, must act in accordance with the ADA and the Rehab. Act to see the difference in effect. It is the law. Everyone is doing it. No unbearable burdens are created by reasonable accommodation. This is what leads to real changes in attitude. Still, when we saw the pictures of Judith Heumann, Assistant Secretary for Special Education and Rehabilitative Services in the Clinton administration, with no attempt to disguise her wheelchair it was tempting to wonder if the North American public was ready for a Prime Minister or President with a known disability.

The United Nations, Red Cross, Easter Seals and various other groups can do a great deal to support and further awareness and the rights of all people but it takes legislation to create a substantial change in behaviour in large masses of people. This modifies the world in which we live and work and it changes the dialogue we have with and about our world. Human beings are creatures of language and changes in language change the way we think and behave. Attitudes are thus modified by modifying behaviour. We are what we do.

This story very much continues to develop at the time of this writing, but awareness, as both cause and effect, is a steady feature of these developments. It is, therefore, an important entity to know how to nurture and magnify.

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Supplementary material, largely in the form of links to related information, will be made available at <http://www.yorku.ca/zcameron/Attitudes/>.

An Open Machine Translation System for Augmentative and Alternative Communication

Constantinos Viglas and Georgios Kouroupetroglou

Department of Informatics and Telecommunications
National and Kapodistrian University of Athens
Panepistimiopolis, Ilisia, GR-15784, Athens, Greece
Tel: +30 10 7275617, Fax: +30 10 6018677
{cviglas, koupe}@di.uoa.gr

Abstract. In this paper we describe the characteristics of an open system we designed and implemented that adds Machine Translation (MT) capabilities into Augmentative and Alternative Communication (AAC) applications. In particular, we present the basis for an open MT framework that can easily integrate with component-based developments especially regarding interpersonal communication and information presentation, either in stand-alone or web-based applications. We concentrate on the system's core, an expandable database of multimedia elements, which offers uniform management of multiple representations of concepts in both natural languages and symbolic communication systems, allowing concept-by-concept omnidirectional translation. Applications of the system are also presented, along with brief pointers on current work for possible extensions and improvements.

1 Introduction

Users of AAC systems have experienced many benefits over the years, especially with the introduction of modular computer-based aids [7],[8] in the Computer Mediated Interpersonal Communication (CMIC) domain. Although such devices offer expandable vocabularies, speech output, and customizable interfaces, they don't do as much in allowing the disabled to communicate transparently with other people (disabled or not) regardless of the communication system they use. Unlike the common translation problems, when it comes to AAC additional effort is required. Our solution is realized by the design and implementation of an open and scalable system whose properties, characteristics, and applications will be presented hereafter.

2 Interpersonal Communication and Machine Translation for Assistive Technology

Machine Translation (MT) and Natural Language Processing (NLP) are being used in a number of computer-based applications [1],[2] and often cross the domain of Interpersonal Communication [6],[13],[14]. Nevertheless, they need to be properly

adapted to form a translation system for the average AAC user of an alternative communication system.

2.1 Contemporary Communication and Translation

Interpersonal communication as far as assistive technology is concerned, relies heavily on the use of alternative communication systems known collectively as symbolic communication systems (such as BLISS, MAKATON, PCS, etc.) [5]. They use graphic symbols (available in all sorts of formats ranging from cards, boards and tablets), to portable libraries of symbols in the form of computer viewable graphic images) in order to depict concepts and convey meanings from and to their users. However, little has been done to provide standardized and compact ways of dealing with symbolic systems and communication aids as a whole, covering aspects like learning graphic symbols, using symbols with a communication aid for everyday communication needs, either in face-to-face situations or remotely (e.g. over the telephone or a computer network). Another of their prominent characteristic is that they offer speech output (either synthetic or digitized) since most disabled are incapable of producing intelligible speech. However, if the disabled wish to converse with other people (disabled or not), some kind of automated process leading to a common transcription is necessary be that speech, text or plain graphical symbols. Moreover, such a transcription is needed for the disabled to access and retrieve information offered in mediums like the World Wide Web (WWW), according to the Web Accessibility Initiative (WAI) regarding access to information [18]. To communicate or review information in a form or language different from what one uses is a complicated issue that becomes more challenging for AAC. A more flexible approach should provide translation and transcription between the various languages, symbolic systems and the representations of the associated symbols and concepts.

On the other hand, research on MT has produced a number of significant results over the years [4], with its realizations focusing mainly on bi-lateral natural language translation, although there have been multilingual, language independent systems built around specific lexicons [3],[16], with efforts ranging from simple word-by-word systems to more complex ones providing correct translation of sentences and phrases in terms of overall meaning, grammar and syntax in the target language. MT has already found application in both stand-alone and web-based translation systems (e.g. SYSTRAN [17]) that provide either off line or “real-time” translation of documents. Moreover, MT has found new ground of application in conjunction with NLP, especially concerning specific or restricted vocabularies leading to major applications of translation of scientific and technological writings through lexical analysis of written text in the language of interest. Under similar notions other areas of application have been multi-lingual document generation in a given language using large lexical knowledge acquisition. Systems under both of the latter two cases have been built for medical purposes [12],[16].

2.2 Requirements and Specifications for an MT Framework for AAC

Our goal is to integrate MT techniques into contemporary Computer Mediated Interpersonal Communication (CMIC) aids. The modular character of such devices

resulting from their Component Based Development (CBD) nature, call for a scaleable degree of MT integration. At the same time, desirable qualities that need to be satisfied from a software engineering point of view include expandability, adaptability, reusability and accessibility. Further requirements and properties for the implementation of a specific MT framework, would satisfy some –if not all- of the following: support for direct translation mode (i.e. a word-by-word or symbol-by-symbol translation), language and media independence (all possible representations for a given language like text, pictures, graphics, or voice should be addressed), effective information presentation regarding data transmission and bandwidth overload in all communication modes (e.g. local, face-to-face, remote, real time, or asynchronous), usage of restricted or expandable lexicons, context of translation, adoption of analysis, augmentation, and/or synthesis stages, consideration for possible solutions to lexical ambiguity and synonym meanings, potential applications, etc.

In the light of the above, in principle we aim to provide an open and compact environment that handles natural languages, symbolic systems, symbols and related vocabularies in a uniform manner, so as to prove beneficial for an adaptable communication aid, and to go beyond simply providing symbol libraries of communications systems associated with a couple of -usually hardwired- natural language interpretations. This system can be the cornerstone of the whole communication process interconnecting various up to now isolated entities, allowing system integrators to build customizable systems in a cost-effective way, ultimately supporting omni-directional translation between the concepts of all interconnected languages. Moreover, our system would be incorporated into modular communication aids that target on the international market, dealing with not converging user needs in various counties, with different cultural backgrounds and different languages. Therefore, multilinguality (with reference to both natural languages and symbolic communication systems) in all levels of encoding and presenting meanings, definitions and information is imperative. Adaptability is also desirable, in terms of selecting the proper language or communication system and associating it with user specific and context dependable vocabularies, meeting the changing-with-time user needs. Last but certainly not least, to maintain effective communication between partners that “speak” different languages a common ground needs to be determined based on a common interconnecting mechanism that relates languages and corresponding meanings using proper techniques to overcome mismatching vocabularies [4], thus enabling correct concept-by-concept translation. Moreover, translation should not only be limited to verbal terms, but allow for transcription rather than just translation between multiple output modalities and media representations, such as speech, audio, visual, text/printed, etc.

2.3 System Realization

The design specifications, made it clear that we needed a structured means of organizing, storing, managing and retrieving the information, mechanisms and media involved. Hence, the choice to build it around a properly engineered database that can hold data of a more diverse nature than just the graphic symbols that make up a symbol library and their associated meanings in a given natural language.




<i>Symbolic Communication Systems</i>			<i>Natural Languages</i>			
BLISS	Makaton	Picture of an apple	Greek	English	Spanish	French
			<i>Written form</i>			
			ἰῆῆῖ	apple	manza na	pom me
			<i>Oral form</i>			
			1	1		1

Fig. 1. Example representations of the concept “apple” in various languages and systems

Database Structure and Design. Databases have always been considered the best way to store information in a well organized, structured and efficiently accessible manner even over computer networks and the Internet in particular (via client-server or web interfaces). The database design is based upon previous experience and implementations as well as contemporary studies, experience and domain knowledge [3],[10],[11],[12],[15]. Primarily, we were concerned with the aspects of the database design that deal with media representation, since a variety of media need to be considered (e.g. speech, text, icons and pictures, video, etc., depicted in Fig. 1) and associated with the various languages and systems.

Translation is facilitated by the database by means of relating the corresponding words and symbols of the various languages and systems via the entity of *Interlingua concepts*, namely by the definition of an independent, stand-alone, natural-like language (the Interlingua) that primarily gets all supported concepts defined, categorized, marked for synonyms, and indexed. After defining the required languages and symbolic systems into the database (through the corresponding *Language* entity), utilizing the proper structures to best incorporate their properties and values, concepts are also defined for each language or system including any associated corresponding media representation is needed. The Interlingua concepts are then mapped onto the elementary communicative blocks of the defined languages (i.e. their words) and symbolic systems (i.e. their graphic symbols) with which they share the same meaning. In this way we ensure a simple first degree of concept-by-concept translation. In this way all languages (even artificial ones) that have a formal definition can be included, and their properties can be encoded into the meta-entities of our translation capable database (provided that these meanings can be associated to Interlingua concepts). By way of inclusion of *language representation* entities, we made sure that all modalities for a given concept would be addressed for both natural languages (e.g. text literal, definition, phonemic transcription, any regional related pictures or videos, etc.) and symbolic systems (the graphic symbol, tutoring pictures or animations, etc.). Other entities and internal mechanisms allow the definition of groups of concepts into user-oriented modifiable vocabularies that adapt to the user’s abilities and needs evolving with time and place (proper selection sets can be accommodated by the definition of categories based on a variety of criteria such as graphical, thematic, grammatical, contextual, etc., per language or system). The open

design of the database also includes *meta-entities*. They are generic in nature, may relate to specific languages and systems and include non-communicative items (NCI) per language, various language element categorizations, and linguistic information (such as grammar or syntax rules that can be utilized for MT and NLP purposes to address for instance synonymity, context and ambiguity). Additional structures include built-in rules and procedures, triggers and views that have to do with database integrity and customisation.

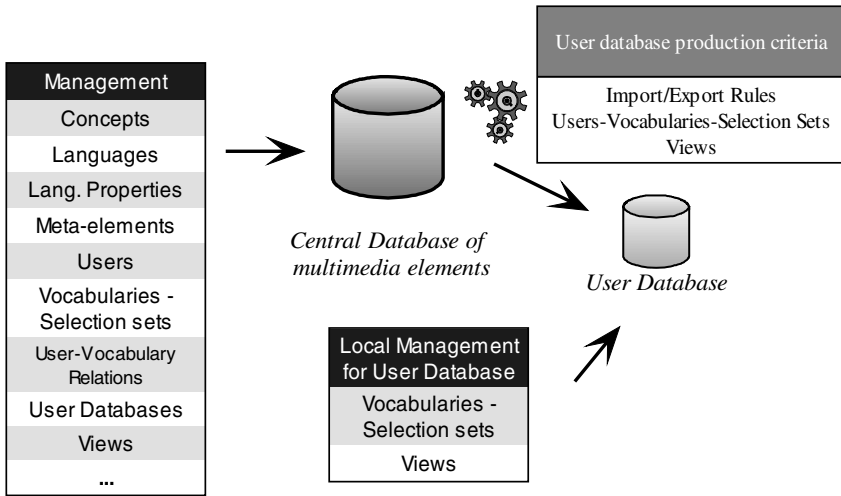


Fig. 2. Management options and production of user databases. Management is downsized for the user databases, which constitute a subset of the central database

Implementation Issues. The system we developed is to be used especially by computer-based interpersonal communication aids to which will be a major component. It has taken into account software building technologies particularly regarding database connectivity and web-enabled access. In this respect, the implementation of the database is very straightforward using a contemporary DBMS. Storing and manipulation of data is ensured via proprietary software tools that deal with adding, deleting, updating and reorganizing data in a transparent and secure way (see Fig. 2 for available management options). Connectivity and presentation is attainable for local and web access using ODBC or JDBC drivers, while adopting CBD recommendations so that the developed database can integrate in a modular application environment. Particular measures were taken in order to accommodate all media related information in a text form, namely storing all binary object related data concerning image or sound files as pointers to local storage directories and not as embedded binary objects. Such a technique allows transparent modification of the binary objects without affecting database content, as well as transparent transmission of concept codes when communication and translation is needed.

The database itself may co-exist in a number of instances varying in location, size, content and utilization, but still bearing the same internal structure of entities and relationships. A main instance can be a central or reference database, bearing literally

any available information on the structures and entities incorporated. When used as a module for CMIC component-based systems it can produce new customized databases (referred to henceforth as “user databases”) to be used in specific interpersonal communication applications. “User databases”, are smaller parts of the central database, user specific (personalized) database versions according to specific needs and requirements reflected into interpersonal communication aids (concerning natural language and symbolic system to be used, vocabulary and selection sets definitions, gender specifics for user personalization, etc.). The “user databases” can be stored locally alongside the application that uses it, and can be easily adapted to reflect evolving user needs by proprietary tools that modify vocabulary and selection sets for a local user, and proper import/export mechanisms in conjunction with the central reference database, when languages or systems need to be added modified or removed, or whole vocabularies need to be adapted with the provision of new or modified concepts.

Table 1. Number of concepts defined for some of the Natural Languages and Symbolic Communication Systems included in the database (the Interlingua has 2064 distinct concepts)

Natural Language	Number of defined concepts (with synonyms)	Symbolic System	Number of defined concepts
Greek	2718	BLISS	2063
English	2726	MAKATO	500
		N	
French	73	PCS	119
Spanish	73	ASL	70

2.4 Field Tests

The presented framework has been field tested in a number of cases related directly or indirectly with interpersonal communication. A central version of the database acts as the core of an on-line translation dictionary for natural languages and symbolic communication systems (called the PolyLexicon), and can operate either locally or over the Internet, using a web interface offering: full database search abilities for concepts in various natural languages and symbolic systems, and concept based translation capabilities between symbolic systems and natural languages (Fig. 3 depicts the access for translation workflow used in the PolyLexicon, while Table 1 offers a comprehensive summary of the defined concepts per natural language and symbolic system in the database). A (“user”) database module for interpersonal communication aids has been implemented and successfully utilized under the ULYSSES framework for building component-based CMIC applications [7], for both face-to-face and remote communication allowing even for vocabulary synchronization between the conversation parties [9],[15]. Another domain of application had to do with teaching symbolic systems, since the framework can provide with translation from the symbolic system’s graphical symbols to natural language equivalents and vice versa, thus being a valuable tool to both teachers and learners (the application is simple, yet web based, using a user database to teach the BLISS system to Greek disabled students).

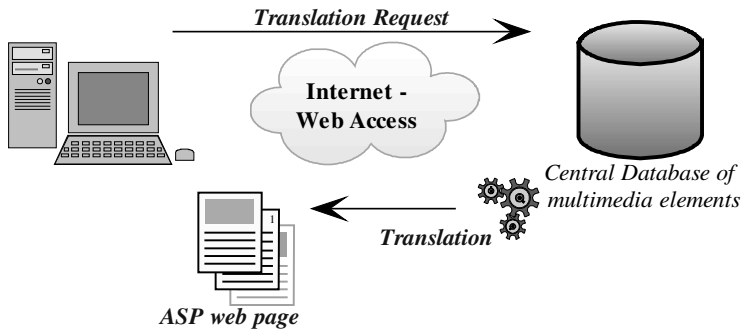


Fig. 3. Sample translation over the web. A request is made and the results come through accessing the central database and presented in a dynamically generated web page using ASP

3 Conclusions – Plans for Further Work

We have demonstrated an open system that was built to serve as the basis of a concept-by-concept, omni-directional MT system between natural languages and symbolic communication systems, through the unified management of multiple representations of concepts via a properly constructed expandable and customisable database. It is web enabled, and can easily become integrated as a component of modular applications. Currently, we investigate the potential of augmenting the database design, in order to include further linguistic metadata so that translation can be more effective regarding synonymy, multiplicity of meanings and definitions in relation with context information, and grammar/syntax rules for the purpose of semantically correct sentence translation. Another area of investigation deals with embedded database-driven user interfaces –at least- in all defined natural languages within the database, so that online content (utilized by presentation applications like the translation dictionary) can be automatically presented in the proper interface language.

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Capabilities and Limitations of the Disabled in Remote Access to Information

Ryszard Kowalik

Technical University of Gdansk, Faculty of Electronics
Ul. Narutowicza 11/12, 80-952 Gdansk, Poland
Kowalik@pg.gda.pl

Abstract. The article discusses ways in which the disabled can remotely access sources of information. It presents devices and aids designed to enable groups of disabled users to remotely access the Information Centre, define the information they need, and receive and record it in a way that best serves the handicapped inquirer's needs.

Over the centuries, until contemporary times cities were built as if people with disabilities never existed. They were formally recognised as part of the community as late as the 20th century. People then discovered that a number of barriers prevented those with disabilities from getting around town and engaging in life activities. That led to some of those barriers being removed at great cost. A lot has been done: some underground crossings now have wheelchair ramps or lifts, there are buses and trams with specially lowered floors, some street crossings have audio signals apart from the regular traffic lights. Then the realisation came that not all barriers can be removed. There are at least two reasons. Firstly, the society cannot afford the high costs. Secondly, by removing what is considered a barrier by some handicapped, we may be making things even more difficult for others. For example, the blind do not have any difficulty operating intercom buttons while people who have lost the use of their hands do. Sensor based buttons work perfectly for people with manual impairments but are not usefull for the blind. Luckily, cities offer a variety of accommodations allowing people with disabilities to find an appropriate route that will ensure access to an institution or public office. To find the route, however, one has to know all of the city's inconveniences and facilities. This information should be stored in one location and made available to people with disabilities, taking into account the type of disability.

For a disabled person to fully use the information stored in the information system's database, they have to successfully complete four tasks:

1. connect to the information system;
2. say exactly what information they need;
3. receive the requested information;
4. record it in a way that will allow multiple uses of the information.

All aids people with disabilities use to remotely access information, must be analysed from these four perspectives to ensure that a particular disability will not prevent the use of the information system. For example, a deaf person can easily place a telephone call to the information centre and put their request, although great

difficulty. They cannot, however, receive the information. On the other hand, a person with a manual impairment can easily ask a question over the phone and listen to the answer. What they are unable to do, or at least with great difficulty, is enter the number, record the information for future use or even place the handset next to their ear.

The needs, mentioned above, was the basis for designing Gdansk's Computer Information Centre for People with Disabilities, called Gdaskon. The needs of the disabled who can get around town on their own were analysed and the following 6 groups of the handicapped were distinguished. These are: the blind, visually impaired, deaf, hard-of-hearing, those with manual and physical impairments. The needs of the latter are most difficult to fulfil. An analysis of one of Gdansk's districts followed, to check for any inconveniences or accommodations there might be for people with disabilities. The information was then input into Gdaskon's database and covers the various streets and public service buildings. The database and an electronic street plan will help the computer select the easiest route that will accommodate a particular disability. Examples of the destinations could include an all night pharmacy or a post office with facilities for the disabled, e.g. lower counters or a sign language interpreter.

We are convinced that an Information Centre designed to meet the various needs of people with disabilities will help them to achieve a higher degree of independence and facilitate their integration into the community.

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IMPACT: An Example of Information, Awareness, and Legislation, Leading toward a More Accessible Workplace

Charmaine Mueller Iversen

Founder/Manager, IMPACT¹
United States Department of State
2201 "C" Street, NW, Room 2635, Washington, DC 20520 USA

Abstract. The foundation of IMPACT, the Department of State's IRM Program for Accessible Computer/Communication Technology, was information, awareness, and legislation, with customer service serving as the ever-important cement. Advocacy of accessible Department IRM technology, information, and programs to Department customers, including employees with disabilities, was the initial goal of IMPACT. Sharing information about technology, as well as employees' workplace concerns fostered an understanding of basic access issues and promoted positive customer awareness. IMPACT also provided the Department with the opportunity to be proactive, rather than reactive to legislative requirements. Section 508 of the Rehabilitation Act of 1973, as amended, mandates that U.S. government agencies comply with certain accessibility requirements, and IMPACT is the Department's Section 508 resource. While IMPACT continues to serve as a customer-driven vehicle to champion accessibility through a foundation of information, awareness, and legislation, that service increases, exponentially, as our customers take back to their organizations information that will assist with their implementation of Section 508, leading to a more accessible workplace.

1 Introduction

The United States Department of State Information Resource Management Program for Accessible Computer/Communication Technology (IMPACT) demonstrates how information, awareness, and legislation can lead toward a more accessible workplace. IMPACT advocates the accessibility of Department programs, IRM technology, and information to employees and U.S. citizens, including individuals with disabilities.

Announcement of the IMPACT initiative coincided with National Disability Employment Awareness Month in October 1997. Although IMPACT's mission is conceptually consistent with earlier endeavors of serving as a forum for the advocacy of accessibility, awareness and information then partnered with legislation as the advent of Section 508 amendment requirements approached. IMPACT was

¹ The author is a program manager at the Department of State. Any views expressed herein are solely those of the author, and not necessarily those of the United States Government or the Department of State.

designated to serve as the Department's Section 508 resource to provide requirement awareness and information to bureaus to facilitate their compliance.

2 Legislation Overview

The goals of equal opportunity and access for people with disabilities have been attained over many years through statutory requirements, including The Rehabilitation Act of 1973² and the Americans with Disabilities Act of 1990.³ While Section 508 was originally added to the Rehabilitation Act in 1986, on August 7, 1998 the Workforce Investment Act of 1998, which included the Rehabilitation Act Amendments of 1998, was signed into law. These amendments significantly expanded and strengthened the technology access requirements in Section 508, created binding, enforceable standards, and incorporated these standards into Federal procurement regulations. Section 508, as amended, also establishes a complaint procedure and reporting requirements which also strengthen the law. Section 508 of the Rehabilitation Act of 1973,⁴ as amended, requires that when Federal agencies develop, procure, maintain, or use Electronic and Information Technology (EIT), they must ensure that the EIT allows Federal employees and members of the public with disabilities to have access to and use of information and data that is comparable to the access to and use of information and data by other Federal employees and members of the public without disabilities.

Standards published by the Architectural and Transportation Barriers Compliance Board (Access Board) on December 21, 2000⁵ define EIT and the technical and functional performance criteria necessary for EIT accessibility. Covered under these regulations which became effective June 21, 2001 are EIT products, whose function is to acquire, store, manipulate, manage, move control, display, switch, interchange, transmit, convert, or receive data or information (such as copiers, computers, software, hardware, fax machines, and kiosks). Also addressed are component specific requirements (mechanical controls and software) for compatibility with assistive technology, as well as functional performance criteria. Comparable access may require use of alternate formats including, but not limited to, Braille, ASCII text, large print, recorded audio, or other electronic formats, as well as use of alternate methods such as voice, fax, relay service, TTY, captioning text-to-speech, synthesis, and audio description. All web sites, either hosted on the Internet or an internal intranet, also must be in compliance with these regulations. Federal agencies are not required to "retrofit" existing technologies. Systems in existence prior to June 21, 2001 are excluded until they are revised.

There are rules and exceptions that are not included in this overview. Complete regulations and additional information can be found on: www.usdoj.gov/crt (U.S. Department of Justice), www.section508.gov (Federal Information Technology Accessibility Initiative), and www.access-board.gov (U.S. Access Board).

² Codified at 29 USC §§ 701 et seq. www.dol.gov/dol/oasam/public/regs/statutes/sec504.htm

³ Codified at 42 USC § 12101 et seq. www.usdoj.gov/crt/ada/pubs/ada.txt

⁴ Codified at 29 USC § 794d www.ed.gov/offices/OSERS/RSA/Policy/Legislation/rehabact.doc

⁵ Codified at 36 CFR § 1194

3 Information and Awareness

Information and Awareness are vital partners in providing assistance to Bureaus within the Department. The Department's Chief Information Officer (CIO) hosted an IMPACT meeting where an Access Board member briefed bureau representatives about Section 508. The meeting was videotaped for Department distribution. An inter-bureau IMPACT Section 508 task force, comprised of employees from several disciplines, functions, and management levels addressed Section 508 policy, Internet/intranet accessibility, EIT, compliance, and procurement issues. Teleconferencing was also used to facilitate a real-time global dialogue and encourage dissemination of this information to all Department locations. Serving as a resource to assist Department bureaus to meet Section 508 compliance requirements, IMPACT ensures that all Department bureaus receive on-site, e-mail and/or telephone assistance to address accessibility topics, as well as Section 508 policy and technology concerns. Inquiries may be sent to a Section 508 e-mailbox 24 hours a day. These inquiries are tracked in a database until research has been completed and the customer has received a response. Information is then incorporated into a Frequently Asked Questions document.

The IMPACT Outreach Center provides telephone, email, and in-person Section 508 consultations as well as assistive technology demonstrations, website accessibility evaluations, and informal training to Department employees. IMPACT websites are located on the Department's Internet and intranet. Section 508 and accessibility-related literature are also available on disk, in Braille and large print.

To further support the Department's commitment toward an accessible workplace, articles were written for Department publications to provide accessibility awareness and information about Section 508 requirements. Opportunities were provided for Section 508 technology, procurement, and policy training. To reach a broad audience, panel discussions and training workshops regarding Section 508 and accessibility were also included as part of Department-wide conferences. Vendor technical presentations were hosted, not as product endorsements, but to provide options regarding tools and leading edge technology for accessibility in areas such as web development and video production. Interaction with other Federal agencies was invaluable as an opportunity to share questions, concerns, and accomplishments.

4 Conclusion

Endeavors toward providing information, awareness, and assistance to meet legislative requirements, in addition to a genuine desire to offer customer service, have been IMPACT's foundation toward supporting the Department's commitment to provide a more accessible workplace. Legislation can be an undeniable motivator, but IMPACT's non-confrontational approach, coupled with the willing participation of Department colleagues and customers alike, provided a positive atmosphere conducive to legislative compliance leading toward a more accessible workplace.

IT-Certificates to Foster the Vocational Integration of People with Disabilities: ECDL® PD

Introduction to the Special Thematic Session

Andrea Petz¹ and Denise Leahy²

¹integriert studieren / integrated studying, University of Linz,
Altenbergerstraße 69, 4040 Linz, Austria
andrea.petz@jku.at

<http://www.integriert-studieren.jku.at>

²Trinity College, Dublin 2, Ireland
denise.leahy@cs.tcd.ie
<http://www.tcd.ie>

Abstract. In this Special Thematic Session, we want to discuss the possibilities of using standard or special certificates for IT-skills to foster the vocational integration of people with disabilities. One part of the STS will present first results of the above mentioned project. The STS should discuss how and why access to such certificates can become a tool for supporting the integration of people of all social orders and what difficulties may occur. Researchers, teachers and experts in the field of IT training and certificates are invited to contribute to this STS.

1 Basic Information

The ECDL®/ICDL®¹ enables people to demonstrate their competence in computer skills. Its aims are:

- to raise the general level of competency in IT
- to improve productivity at work
- to enable employers to invest more efficiently in IT
- to ensure that best practice and quality issues are understood and implemented.

The ECDL®/ICDL® is awarded on the successful completion of seven tests assessing the candidate's competence in using the computer:

1. Basic Concepts of IT
2. Using a Computer and Managing Files
3. Word Processing
4. Spreadsheets
5. Databases
6. Presentation
7. Information and Communication

¹ ECDL®/ICDL®: European / International Computer Driving Licence™.

The ECDL®/ICDL® offers the basic opportunity to make IT accessible for people with special needs:

- The ECDL®/ICDL® is product independent
- The ECDL®/ICDL® is organization independent
- The ECDL®/ICDL® is an international promoted standard
- The ECDL®/ICDL® is designed to be open to anyone.
- The ECDL®/ICDL® offers maximum flexibility in time management and organization.

Nevertheless there are problems bringing up barriers. The Project ECDL® PD, which will be discussed as an example in this STS, aims to lift these barriers.

2 Papers of This STS

- ECDL® PD – Using a Well Known Standard to Lift Barriers on the Labour Market
Author: Andrea Petz; integriert studieren / integrated studying, University of Linz, Altenbergerstraße 69, 4040 Linz, Austria
email: andrea.petz@jku.at / Homepage: www.integriert-studieren.jku.at
- KISS – Keep It Short and Simple?
Author: Andrea Petz; integriert studieren / integrated studying, University of Linz, Altenbergerstraße 69, 4040 Linz, Austria
email: andrea.petz@jku.at / http://www.integriert-studieren.jku.at
- Many Ways to ECDL
Authors: Magne Lunde, Morten Tollefsen; MediaLT,
Tangerudbakken 2D, N-0982 Oslo, Norway
email: {morten, magne}@medialt.no, http://www.medialt.no
- ECDL: Learning Materials, Individual Training and Distance Education
Authors: Magne Lunde, Morten Tollefsen; MediaLT,
Tangerudbakken 2D, N-0982 Oslo, Norway
email: {morten, magne}@medialt.no, http://www.medialt.no

Paper I: ECDL® PD – Using a Well Known Standard to Lift Barriers on the Labour Market. IT is of increasing importance in society and of much higher importance for the integration of people with disabilities. The enhancement of basic computer knowledge is therefore of general importance and ECDL® PD addresses this target group. Certificates like the ECDL®/ICDL® are a useful tool – especially at the labour market – to support the holder in showing his/her skills on one hand and on the other hand to support the employer in the selection process of employees.

This paper discusses how and why access to such certificates can become a toll for supporting the integration of people of all social orders, what difficulties may occur and with which strategies ECDL® PD wants to overcome them.

Paper II: KISS – Keep It Short and Simple? In September 2001, the European Commission decided to fund a pilot project called ECDL® PD – brought forward in Leonardo da Vinci II Programme – which aims at adapting the widespread and well known ECDL® certificate to the needs of people with disabilities. The ECDL®

should not only become a tool for people with disabilities, but also for the ascending number of other underprivileged people on the labour market (e.g. older people, people with poor education, immigrants...) – a certificate designed for all.

The everyday language of one of the target groups, the deaf and hard of hearing, is in structure and terminology very different from the language used by hearing people. The ECDL® Syllabus, the questions and tests and the learning and teaching materials are full of technical and computer terminology and complex structures, too – and therefore not usable for the majority of this target group. This paper explains the “simple language” – concept, mentions our approach of adapting the ECDL® materials to “simple language” without changing level and quality and finally discusses first results of the project ECDL® PD.

Paper III: Many ways to ECDL®. In 2001 MediaLT went through the ECDL® Syllabus and MQTB² to analyze the appropriateness of these documents and to make sure that the questions do not exclude visually impaired (e.g. that the questions and answers are not attached to a specific solving – method). The paper discusses assumptions, approaches and findings of this study.

Paper IV: ECDL: Learning Materials, Individual Training and Distance Education. On the labour market, insufficient IT – skills are on one hand a huge barrier for people with special needs throughout Europe. On the other hand, there is lack of accessible courses, the assistive technology (e.g. for visually impaired people) is very expensive and only few course providers are experienced in servicing people with disabilities.

In a project funded by Norwegian research council, Microsoft and Telenor, MediaLT A/S, several Norwegian organizations for the blind and Datakortet A/S work together to develop learning materials and a well – suited ECDL® distance education programme. This paper discusses the assumptions, approaches and findings of this project.

² MQTB: Manual Question Test Base – a directory with all available exams (and questions)

ECDL for Visually Impaired Persons: Learning Materials, Individual Training, and Distance Education

Morten Tollefsen and Magne Lunde

Tangerudbakken 2D, N-0982 Oslo, Norway
morten@medialt.no, magne@medialt.no
<http://www.medialt.no/>

Abstract. Accessible learning materials, adapted training and a suitable certification scheme are important parts in the Norwegian ECDL project. Training and learning materials are discussed in this paper. Both individual training and distance education are parts of the project. Syllabus and the certification scheme are discussed in a separate paper.

1 Introduction

Insufficient training in using computers and standard software is a problem in Norway, Europe and in the rest of the world. This is the case in general, but is particularly noticeable for blind and partially sighted persons. One of the main reasons for this is that visually impaired computer users are dependent on complicated assistive devices like Braille displays, artificial speech and screen enlargers. Few course vendors offer accessible training, because they usually do not have the necessary expertise to teach students using assistive devices and screen readers.

ECDL (European Computer Driving License) is a standardized course in practical computer usage. MediaLT A/S, Datakortet A/S and several Norwegian organizations for the blind work together. The goal is to develop a suitable certification scheme, accessible learning materials and a training model. The ECDL syllabus is not modified.

The project is funded by the Norwegian Research Council, Microsoft, Telenor and two Norwegian departments.

2 Learning Materials

Learning materials can be divided into three categories in this project:

1. Set books and supplementary literature
2. Tactile graphics
3. Software

2.1 Set Books and Supplementary Literature

Set books for the ECDL have to cover the syllabus, and Datakortet A/S approves the literature in Norway. Unfortunately, accessible Norwegian computer books are a commodity in short supply. We therefore had to rewrite standard books. This process consisted of including keyboard commands, describing pictures/figures, writing alternative techniques, etc. We decided to rewrite the books to be usable for both the visually impaired and blind, and the set books therefore are not screen reader dependent. After some research however, we decided to include a few Jaws functions. The main advantage to using this approach is that the books have a larger target group. The most obvious disadvantage is that it is necessary to develop supplementary literature for different screen readers and assistive devices.

The seven set books are produced both in DAISY format [1] and HTML. Three of the DAISY books include the full text and the remaining four are digital audio books only. We have selected different approaches to be able to get feedback on advantages and disadvantages with the different formats. The books have been used in our individual training, the pilot distance education course and by some persons not taking part in our courses (about 20 persons). The following points summarize our experience using DAISY and HTML books in the ECDL project:

- The playback software (LpPlayer) is not suitable for reading full-text DAISY books (synchronized text and audio) by Braille or artificial speech users. The main reason for this is the user interface. LpPlayer however can be used for searching, bookmarks, listening to recorded audio, navigation etc.
- Full-text DAISY books are appreciated by partially sighted persons using standard monitors or screen enlargers. Full-text books are also said to be beneficial to dyslectic users.
- When using recorded audio, most students prefer to use a dedicated DAISY player (e. g. Plectalk TK300B).
- Navigation (go to page, browse headings, go to bookmark etc.) is easy and efficient in DAISY books, both when using a PC and a dedicated player.
- Adapted HTML books are easy to read, but these books have one big disadvantage: It is not possible to set bookmarks or write comments using a standard browser.

The production of full-text DAISY books is expensive using today's tools. This may change of course! Our experience is that recorded audio is beneficial in a course like the ECDL, and that full-text DAISY is a useful format. DAISY is based on HTML, and therefore it is easy to include a plain HTML version when producing full-text books.

As mentioned above, we have written supplementary literature. This is important, at least when deciding not to produce screen reader specific books. The feedback indicates two important additions to the set books: application specific screen reader functionality and recommended setup for different software (including "How to do" chapters). Our students claim that Norwegian manuals for assistive devices are very insufficient, but we have not been able to inquire whether this is the case.

Set books (HTML), compendiums, set of exercises, trial exams and software are collected on a single, easy to use HTML CD. We have included autostart on this CD, and therefore it is relatively easy for the students to start using the product.

2.2 Tactile Graphics

Windows is a visual user interface. Our experience is that blind persons need to learn “what Windows looks like” (build a mental map). This understanding is important, e.g. to be able to locate/navigate to specific elements like the menu, status bar, title bar, etc. in an efficient way, when using Braille displays or artificial speech. In our opinion, tactile graphics is the best method to help blind persons to be able to build a mental map of the user interface. The utility value of complex, tactile graphics is limited however, and therefore the pictures have to be simplified. When using tactile graphics as a learning tool, it is also very important to avoid the “what’s this game”.

Several techniques can be used to produce tactile graphics [2]. We have used two different approaches:

- 3d tactile models
- Swellpaper

The tactile models should be used together with a teacher. Two different models are developed. This is done to be able to test different approaches, therefore the two designers have not been in contact. For the time being, the models have been named after their designers.

The G-model. The G-model is designed by Gunnell Pettersson as part of her major subject.

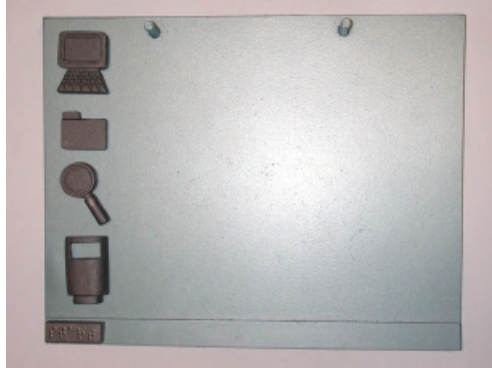


Fig. 1. G-model, Desktop

The G-model is 26x20,8 cm. This small model is easy and inexpensive to produce. Materials include metal, plastic and magnets. A button plate forms the desktop, and applications can be placed on top of the desktop. The model is not very flexible, but can be used to show most of the basic windows concepts. The model is portable, and some teachers have suggested that the model can be used as a toy (e.g. in the kindergarten). The idea is to let the children become familiar with icons, windows etc.

The T-model. The T-model is planned by Morten Tollefsen and designed by Thormod Lunde.

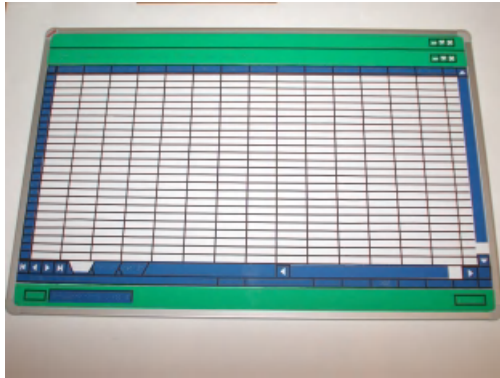


Fig. 2. The T-model, Microsoft Excel

The T-model is 90x60 cm. This model is very flexible, but more expensive to produce. The desktop is formed from magnetic whiteboard, and magnetic film is used to show windows, dialogue boxes, the taskbar, etc. Several materials are used, e.g. plastic, wood and magnets. Icons are cut out of wood as shown in the picture below. Our experience is that it is important to use materials which feel attractive. In order to make icons less expensive, they could be made of plastic or plastic clay. We have not performed scientific tests with the model, but the feedback indicates that the T-model is very useful.



Fig. 3. The T-model, 4 Icons

Swellpaper Compendium. The compendium “What does Windows look like” is written to show the most important windows elements: desktop, start button, start menu, task bar, system tray, icons, title bar, menu, toolbars, status bars, dialog boxes, tabs, buttons etc. Thirteen swellpaper pictures are explained in Braille and standard print (for sighted teachers). The compendium can be used for self studying, and we have used the pictures in our courses for about one year. As opposed to the tactile models, the pictures in the compendium are static. This limits the possibility to show functions like drag and drop. If the students know about terminology, it is possible to explain the dynamic concepts (pointing, clicking, drag and drop etc).

Tactile Graphics and Feedback from the Students. It is difficult to measure how useful the tactile graphics is. The feedback from our tests indicate that the models and the compendium are helpful. We have seen clear progress concerning navigation after using the tactile graphics. This of course is most noticeable with beginners, but even more experienced users claim that they have learned something important from the pictures/model. We also believe that the graphics are helpful to learn terminology. Knowing terminology is important both in the training and when visually impaired people communicate with sighted computer users.

2.3 Software

In addition to the standard ECDL software (word processor, spreadsheet etc) we use two categories of applications: Software for distance education and ECDL dictionary with examples.

We have tested several systems for speech based chatting over the internet. MediaLT use this technology in our distance education courses as well as an addition to individual training. The first usable product was called Lipstream, but after using Lipstream for about 6 months the company offering the service failed. After trying four other systems, we found a product called ChatterBox, and this program works satisfactorily. The sound quality is good, and the product has other functions like file transfer, text chat, built in browser etc. We can put up different classrooms and perform teamwork. ChatterBox is stable regarding screen readers and standard applications.

To be able to show students how to solve different tasks, and eventually figure out what’s going wrong, we need software to remotely control PCs. We have selected to use VNC [3]. Combined with ChatterBox this allows a very good communication with the students. It is not possible to use VNC for a blind teacher, but this works fine for the students (screen readers and magnifiers work as if the students had performed the tasks).

Our ECDL dictionary explains important computer words. This small program is developed by MediaLT. To each word, e.g. windows elements, it is possible to include an example. Our idea is mainly to give examples of windows elements and how to use these elements (list boxes, combo boxes, buttons, tree structures etc.). The examples are separate binaries, allowing other companies to develop the examples. The dictionary can be updated from the internet. This software is designed to be standard and very simple, and therefore it is also a suitable tool for beginner training.

3 Individual Training: Our First Pilots

To test our literature, tactile graphics, software and training methods, we started an individual pilot course with two participants, one blind and one partially sighted. We also needed to try the manual tests developed in collaboration with Datakortet A/S. After the first pilots, we have continued with four other individual persons (they have not finished all seven modules at the moment, but that is the goal for all of them).

The points below summarize our findings from the first pilot courses:

- ECDL is not easy for visually impaired, but the syllabus doesn't have to be changed when offering manual tests.
- The basic training in using assistive devices has not been sufficient. Usually about 20 hours of training is given when people get screen readers or other assistive devices in Norway. Most of our pilot users (including the persons in the distance education group) do not even know basic functionality of their special hardware or software.
- The DAISY books and other learning materials are appropriate. As mentioned above, we have developed special compendiums for different assistive devices.
- The HTML Help system and Windows Explorer are not familiar, even to skilled visually impaired computer users (this observation is also based on our other training activities, but has been confirmed in the ECDL project).
- Powerpoint (module 6: Presentation) is no more difficult than Excel or Access.

The first blind student completed all seven modules in October 2001. In April 2002 the other pilots have completed from 1 to 5 modules. When we started with our first pilots, we used this module sequence: 1, 7, 2, 3, 4, 5, 6. The reason for taking module 7 as early as possible was because communication with the students is much more flexible when they can use e-mail and the internet. Our experience is that the module sequence above is suitable, therefore we have not tested other alternatives. The first blind pilot student was very focused on working as closely as possible to the techniques of sighted users. In our training we have not been totally focused on hotkeys (which is the tradition when teaching blind persons in Norway). The blind student did however realize that hotkeys and alternative procedures were essential to complete the ECDL. The student had to fail one of the tests (module 2) before realizing that working as a blind person is different than working with applications as a sighted user. This student was very interested in being able to collaborate with sighted colleagues. The student therefore wanted to know procedures which were not possible to solve using a Braille display or artificial speech, e.g. how to move controls in a Access scheme using the mouse. This person is perhaps not typical. However the student points to something important: blind persons profit by being able to collaborate with sighted users. Therefore they probably need to know both to solve a task using assistive devices and how sighted persons work.

We have used distance education elements in our individual training, especially speech technology over the internet. This has freshened the teaching. The students think this is exciting and fun. Another advantage is that it is easier to offer a few hours of training (usually we work a full day). Most of the students receive two days of training per week. Besides this, they are practicing on their PCs at home or at work.

To be able to fix a price for individual modules and a full ECDL, we have tried to determine the training hours needed. This is very difficult, and is of course dependent on the students assumptions. The table below shows a typical training plan for the students in our individual courses.

Table 1. ECDL modules and estimated training hours

Module	Training hours	Finished (months after the start)
1: Basic Concepts of IT	15	1
7: Information and Communication	30	1
2: Using a Computer and Managing Files	30	2
3: Word Processing	30	2
4: Spreadsheets	40	3
5: Databases	40	3
6: Presentation	40	4
Total	225	

The training plan above can be a guide for the blind as well as the strongly visually impaired. Our experience indicates that the partially sighted, using screen enlargers, have at least as many challenges as the totally blind users. This is surprising. Our explanation is that the screen enlargers do not have the same cursor tracking capabilities. Another factor probably is that the partially sighted users tend to stretch their vision too far.

4 Distance Education Pilot Courses

We believe that it is necessary to define a demand for qualifications in using helping aids and computers to accomplish the ECDL as a distance education course. Our definition is called “The Start Package”. The main elements in this package are:

- Basic PC components and adjustments (e.g. display contrast).
- Assistive devices and basic functionality.
- GUI and basic operating system functionality (e.g. how to use the windows elements: buttons, list boxes, start menu etc.).
- Internet, especially basic mail functions.

The start package is fairly detailed, and the details are outside the scope of this paper. Pilot users not having the knowledge mentioned in the start package are offered training in addition to the ECDL.

The experience with distance education and visually impaired is not comprehensive in Norway, at least in a course like ECDL. This probably is the situation in the rest of the world as well. Because of this, MediaLT organized an internet based course in FrontPage, an experience which we believe is important in the ECDL pilot courses. The participants in the FrontPage course were ten expert

users from Norway and Sweden (6 blind, 2 partially sighted and 2 with normal vision). Feedback from the 10 students can be summarized in the following points:

- Distance education based on internet speech technology (LipStream) is usable.
- Visually impaired users and persons with normal sight can participate in the same course.
- Screen readers and simple sound cards (one wave output channel) are a problem because the artificial speech is not working when somebody talks (this problem is most noticeable when practicing). When using modern sound cards with multiple wave channels, and newer operating systems, this is not a problem.
- Available literature in an accessible format is a problem. In this course, we were able to find material on the internet which supplemented the lectures.

As mentioned above, LipStream went bankrupt. The points of view from the FrontPage course can be forwarded to the current speech system. (The feedback in the ECDL distance education course indicates similar points of view).

MediaLT is going to organize two distance education pilot courses in the project. The first started in January 2002 (5 participants: 2 blind, 2 partially sighted and 1 with normal vision). The second group will start during the Autumn 2002, and is intended to be a standard course (that means we'll test the complete educational package and not in the same manner expect the students to be pilots). In April 2002, the five first pilots have completed three modules (1, 7 and 2).

In addition to the developed learning materials, the form of instruction in the distance education course includes:

- Joint meetings (totally 4 or 5 two-day meetings during the whole education).
- Follow-up using phone and mail.
- Joint internet teaching (using speech technology).
- Correction of trial exams.
- Distant control and observation of the students computers.

Feedback from the students is of course both important and necessary in the distance education pilot course. This feedback will be utilized to continue on with the next distance education students, which is designed to be a standard course.

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ECDL[®] PD – Using a Well Known Standard to Lift Barriers on the Labour Market

Andrea Petz and Klaus Miesenberger

integriert studieren – integrated studying (I³S³) – University of Linz
Altenbergerstraße 69, 4040 Linz, Austria
andrea.petz@jku.at, k.miesenberger@aib.uni-linz.ac.at
<http://www.integriert-studieren.jku.at>

Abstract. In September 2001, the European Commission decided to fund a pilot project called ECDL[®] PD¹ which aims at adapting the widespread and well known ECDL[®] /ICDL^{®2} certificate to the needs of people with disabilities. The ECDL[®] / IC DL[®] should not only become a tool for people with disabilities, but also for the increasing number of other underprivileged people on the labour market (e.g. older people, people with poor education, people with a weak social background, immigrants...)

This paper consists of two main parts: Part I introduces the certificate ECDL[®]/ICDL[®] in general; Part II explains the idea ECDL[®] PD and presents first results.

1 ECDL[®]/ICDL[®] in General

1.1 History, Development, and Prospects

In fall 2001, ECDL[®] Foundation launched “ECDL[®] Advanced” in Denmark, Ireland and Austria. The ECDL[®] Advanced is a developed version of the classic ECDL[®]/ICDL[®] which aims to establish a standard in advanced computer knowledge. Seven years ago, no one would have thought about that - or about 1,6 mio. participants in 60 countries worldwide.

The ECDL[®] Foundation works to promote a pan-European certificate of industry-standard computing skills. It is set to become the most widely recognised qualification in the field of work-related computer use, partly because it is targeted at the full spectrum of the population, and partly because of the support and monitoring of the organisations behind it.

The ECDL[®]/ICDL[®] is open to everyone: from large multinational organisations and government bodies to the individual computer user. The Foundation was established by the Council of European Professional Informatics Societies (CEPIS), to support and co-ordinate the work of the ECDL[®]/ICDL[®] organisation in each country.

¹ ECDL[®] PD: European Computer Driving Licence for People with Disabilities

² ECDL[®]/ICDL[®]: European / International Computer Driving Licence TM

It all started in Finland 1994, when Finnish Information Processing Association evaluated the needs for basic IT-Knowledge within Finnish industrial labourforce. A certificate called “Finnish Computer Driving Licence” was introduced, which should guarantee (and certify) the knowledge of basic computer skills necessary for everyday work.

In 1995, CEPIS (Council of European Professional Informatics Societies) installed a “task force” to examine a way to raise the level of IT skills in industry throughout Europe – supported by funding of the European Commission. This task force found the Finnish model to be most effective and carried out Pilot Tests (1995 and early 1996). A last test was launched with the first version of an European Computer Driving Licence (ECDL®/ICDL®) in August 1996 in Sweden. Since 1997 ECDL®/ICDL® was installed throughout Europe – and subsequently rolled out internationally. The CEPIS “Task Force” was rebuilt to an organization of its own - ECDL® Foundation with the mission to [1]:

- “raise the level of knowledge about Information Technology (IT) and increase the level of competence in using personal computers and common computer applications for all the citizens of the world.
- disseminate, promote and evolve ECDL®/ICDL® as a globally accepted IT skills certification programme that prepares all people for participation in the Information Society.
- develop partnerships with professional computer societies in all countries to administer ECDL®/ICDL® in order to facilitate full access to the programme by the local populace.
- drive awareness amongst the general public and corporate, institutional and governmental decision-makers of the vital role of ECDL®/ICDL® in promoting core IT knowledge and providing an essential certification that is becoming the defacto global IT skills standard.”

1.2 Statistical Background

There are 60 countries participating worldwide – with 1.6 mio participants. The number of test centers steadily increased since 1997. In December 2000, there were about 7000 accredited test centers worldwide. [2]

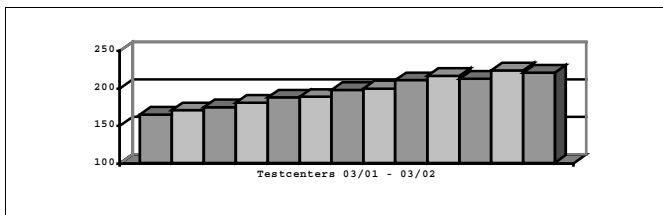


Fig. 1. Growth of the number of accredited ECDL®/ICDL® test centers in Austria [2]

The number of applicants to the ECDL®/ICDL® test increased at the same level. In September 2001 we had 1.523.987 individuals with a skills card worldwide.[2]

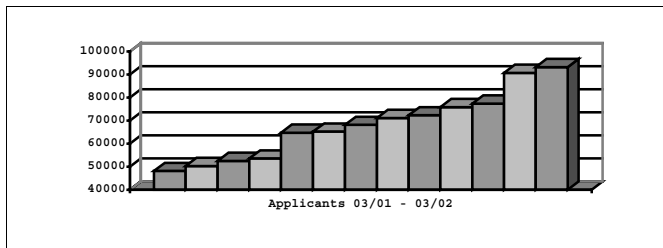


Fig. 2. Number of applicants in Austria since March 2001 [2]

There are numbers concerning the distribution of the age on the group of ECDL®/ICDL® applicants in Austria, but there are no further demographic studies available to the public.

It would be of great interest to get the number of people with disability who are interested in achieving the ECDL®/ICDL® – not to mention numbers concerning different disabilities.

1.3 Advantages & Limits

The main advantages of the ECDL®/ICDL® (especially concerning the IT-work with/for people with special needs) are the following:

- The ECDL®/ICDL® is product independent
It does not ask for knowledge in handling a certain piece of hardware or software but for skills in managing practical tasks with suitable computer applications. Any system configuration can be used to fulfil the tasks asked for. Therefore hard- and software, organisation of courses and exams, etc. could be organised and presented in a way which enables people with special needs to pass the ECDL®/ICDL®. The level of the ECDL®/ICDL® standard will not to be changed by setting up accessible environments.
- The ECDL®/ICDL® is organization independent
Colleges, schools, training companies, special organizations, institutions et al. may offer courses designed to lead to the passing of the exams and the awarding of the certificate. No accreditation of the courses, which may take any form, is required. It is envisaged that in addition to day and evening classes at colleges and training companies, the contents of the syllabus will be incorporated into school and university curricula. To ensure access to the greatest numbers, they will also be made available via distance learning. This flexibility is a prerequisite to ensure the accessibility of the ECDL®/ICDL® for people with special needs.
- The ECDL®/ICDL® is an international promoted standard

It is valid and promoted in all the countries where the foundation is represented. The more the ECDL®/ICDL® is promoted and known in general the more it could support the integration of people with special needs.

- ECDL®/ICDL® is open to anyone, regardless of age, education, experience or background and in the future also of the special needs of the applicant.
- ECDL®/ICDL® offers maximum flexibility in time management and organization. The modules may be taken in any order and over any period of time - even all at once – offering maximum flexibility. When all the modules have been successfully completed, the logbook (“skills card”) is exchanged for the certificate. Users may, if they wish, just walk in off the street and take the tests.

The ECDL®/ICDL® enables people to demonstrate their competence in computer skills. Its aims are:

- to raise the general level of competency in IT
- to improve productivity at work
- to enable employers to invest more efficiently in IT
- to ensure that best practice and quality issues are understood and implemented.

The syllabus is designed by a panel of European experts. It is regularly updated to ensure its relevance to the working world and the advances in technologies and practices. In the same way a panel should be established taking care of the accessibility of the syllabus for people with disabilities. Unnecessary barriers should be avoided without compromising the level of skills and knowledge requested.

Accreditation of testing centres is strictly controlled to ensure compliance with the syllabus and the appropriateness of the testing regimes by regular, rigorous audits which guarantee standards and conformance. This already established structure of quality control should be used to offer additional information on accessible centres and training opportunities for certain groups of people with special needs. The contact to the ECDL®/ICDL® testcentres should also be used to collect interested people and their needs and to rise the awareness to integrate people with disabilities into existing courses. This long term, quality and flexibility orientation of the ECDL®/ICDL® asks for ongoing engagement in keeping the ECDL®/ICDL® accessible for people with special needs - and for an organisational integration into the ECDL® foundation.

The ECDL®/ICDL® is awarded on the successful completion of seven tests assessing the candidate’s competence in using the computer:

1. Basic Concepts of IT
2. Using a Computer and Managing Files
3. Word Processing
4. Spreadsheets
5. Databases
6. Presentation
7. Information and Communication

The product independent structure of the ECDL®/ICDL® offers the basic opportunity to make IT accessible for people with special needs and to give access to the advantages of the ECDL®/ICDL® outlined above. Nevertheless there are problems bringing up barriers which will be discussed later.

2 ECDL® PD - ECDL® for People with Disabilities

2.1 Project Outlines

IT is of increasing importance in society and of much higher importance for the integration of people with disabilities; the enhancement of basic computer knowledge is therefore of general importance and ECDL® PD addresses this target group.

Certificates like the ECDL®/ICDL® are a useful tool - especially at the labour market - to support the holder in showing his/her skills on one hand and on the other hand to support the employer in the selection process of employees.

The more a certificate becomes an accepted and intensively used standard, the more it may tend to become a handicap for those who are not able to access it. Often locations of training and exams, learning materials, the dependency of the certificate on certain systems which are not accessible, ... simply the neglect of the special needs of people with disabilities build up barriers. Although people with disabilities have or are able to acquire the skills asked for in an accessible environment they are not able to access the certificate and are put on a disadvantage.

ECDL® PD, the European Computer Driving Licence for People with Disabilities, intends to make the ECDL®, an evolving standard certificate in Europe, accessible. The ECDL® should also be used as a tool to increase the basic computer skills of people with disabilities and to support their integration into the labour market.

2.2 Who Will Benefit of ECDL® PD?

- The individual:

ECDL®/ICDL® is designed to help people at work and at home. It will confirm to potential employers that the person has a professionally recognised, relevant and up-to-date qualification and it will assist in raising familiarity with the technology and its uses. This is especially useful for employees, job seekers and students at the entrance to the labour market. By being able to show the same level of qualification the ECDL®/ICDL® should help people with disabilities at the labour market.

- the employer:

ECDL®/ICDL® helps provide proof of competency in the computer skills of potential employees. People with disabilities will be taken into account more often when they can prove their qualification. Similarly, a company looking to train up its workforce will want to ensure that the money they spend on courses is going to be well spent. Offering the chance that also employees with disabilities can increase their knowledge fosters their position in their company and opens up career possibilities.

- the training provider:

Colleges and other training providers are well aware of the importance of Information Systems to the world of work - and increasingly to the individual in daily life. Indeed, many courses already incorporate elements of the teaching of basic and advanced computer skills - but there is no widely accepted qualification. Often training providers do not consider the integration of people with disabilities

because they are not aware of the possibilities. ECDL® PD wants to increase this awareness and increase the offers of accessible training.

- the certificate ECDL®/ICDL®:

The ECDL®/ICDL® syllabus is designed to cover the key concepts of computing, its practical applications and their use in the workplace and society in general. ECDL®/ICDL® is, per definitionem, open to anyone - regardless of age, education, experience or background and now also of the applicant's special needs.

2.3 Limits for the Use of ECDL®/ICDL® in Integration

There is a lack of knowledge on how to:

- Handle the situation of integrating people with disabilities into standard courses and on how to organise accessible courses.
Standard courses offered are most of the time not accessible to people with special needs. Applicants with special needs are therefore often not accepted at ECDL®/ICDL® test centres and sent home without any further information on training opportunities.
- Set up accessible environments which can be handled by people with special needs according to the product independent and flexible organisation of ECDL®/ICDL®. Certain parts of the Syllabus seem to be inaccessible at a first glance.
- Edit and prepare information and training materials.
The ECDL®/ICDL® and the unique chance to use it as a tool for integration is not known to people with special needs. Special courses and training materials are very expensive and the demand is very low at regional or local level

2.4 Our Tasks within the Project

1. Evaluate the ECDL®/ICDL® Syllabus and the ECDL®/ICDL® MQTB³ for 4 different groups of people with disabilities:
Blind and partially sighted; Deaf and Hard of hearing; People with Mental Disabilities and People with Physical Disabilities. Our aim should be to find ways on how the requirements could be fulfilled without changing the strict guidelines of the ECDL®/ICDL®.
2. Develop accessible versions of (approved) ECDL®/ICDL® training and teaching materials in different languages and for different groups of people with disabilities in print, electronic text and online format.
Existing training and information material should be brushed up and made available in the future based on the pilot materials. If people with disabilities are able to access materials in accessible formats via the ECDL® foundation this should help to make self learning and the participation in courses more attractive, effective and feasible.
3. Elaborate "Train the trainers" - materials and information materials concerning disabilities and the resultant special needs.

³ MQTB: Manual Question Test Base

The integration of people with disabilities in computer training courses ask for training of the trainers and teachers. The organisation of these courses should be facilitated by the training materials which should contain basic technical, medical, pedagogical, didactical as well as psychological information on how to handle the special situation. Check-lists for the integration into courses or for organising special courses should be added. These materials are to be seen as an addition to the training materials and help to promote the idea of integration in training organisations and to raise awareness that there are possibilities to put integration into practice.

4. Create Outlines for pilot courses, search for other examples and set up a collection of „case studies“ with the goal to develop a best - practice guide which should be made available as an addition to the Syllabus.
5. Set up pilot courses for a certain number of people with disabilities.
These courses, held by partners who are already running Training Centres or Special Institutions for people with disabilities should help to evaluate the results of the adaptation of the Syllabus and, when these partners are ECDL® Test Centres, the MQTB as well as training and information materials. These tasks have to be seen as an interactive process where the practical courses enhance the quality and usability of the materials and vice versa.
6. Establish Tools and the Organisational Framework to collect the information on people with disabilities who ask at training centres for training and can not be serviced. If training centres are not able to fulfil the requirements for certain clients it has to be guaranteed that these clients get the information and the contact to ECDL® PD.
7. Start an information and promotion campaign in Europe.
On the need to enhance the basic knowledge in handling the computer for people with disabilities to benefit from new IT in the evolving information society; the ECDL® will be promoted as an accessible and useful tool for this purpose.
8. Evaluate the accessibility of ECDL® Test Centres and integrate evaluation criteria into the standard description of approved training centres.
9. Integrate the work of ECDL® PD into the organisation of the ECDL® foundation.
Methods, tools and procedures should be established to guarantee that the special needs of people with disabilities are taken into account when they try to access the ECDL®.

2.5 Assumptions

For the analysis [3] of the Syllabus (and subsequently for the MQTB) we have made the assumption of full mental ability. We do not take into account multiple disabilities as in the case of a physical disability associated with a mental or learning disability.

There are three levels of disability:

- Low / medium level of disability:
low impact on computer test facilities but attention to ergonomic aspects (full use of arms and hands, no requirement of particular aid).
- Medium / high level of disability:
Necessity of input/output aids and attention to additional time required. Alternative systems of medium complexity, problems in quantitative productivity which the use of these systems might cause.

- High / very high level of disability:
very reduced physical capacity which requires personalised solutions mandatory in terms of aids, timing and assistance. Access workers or personal assistants can only help the candidate to position at the work station. After the beginning of the test, only the Test Centre assistant will be allowed to intervene. The personal assistant will help again after the test ended.

The applicants must dispose of assistive technology. It is necessary to provide the environment, in which the exam will be taken, to be ergonomically adapted, the verification of the requested aids necessary for the candidate and properly installed assistive tools.

2.6 Findings Concerning Syllabus and MQTB [3]

As the Syllabus is the blueprint of the relevant knowledge a person must possess in order to pass the ECDL[®] tests, and as it lists the main tasks to be translated into questions, that will be part of the questionnaires, there are no substantial changes to make. After these first looks, the following are to be taken into account:

- The necessity of a guaranteed minimum standard in architectural and ergonomic design and hardware of the Test Centre and the testing facility.
- The changed time frame for the work with alternative (assistive) systems. (The necessity of flexible time frames - written replies will, for some access aids, require longer times to elaborate).
- The ability to switch on the computer and the insertion and/or substitution of floppy disks and the operations concerning the use of the printer - or the availability of a personal assistant doing this following strict rules.
- The possibility to take personal equipment for testing, what would avoid further stress caused by the necessity to familiarise with a new computer.

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KISS – Keep It Short and Simple?

Andrea Petz

integriert studieren – integrated studying (i³s³) – University of Linz,
Altenbergerstraße 69, 4040 Linz, Austria
andrea.petz@jku.at
<http://www.integriert-studieren.jku.at>

Abstract. “An average sentence, in a German newspaper, is a sublime and impressive curiosity; it occupies a quarter of a column; it contains all the ten parts of speech – not in regular order, but mixed; it is built mainly of compound words constructed by the writer on the spot, and not to be found in any dictionary – six or seven words compacted into one, without joint or seam – that is, without hyphens; it treats of fourteen or fifteen different subjects, each enclosed in a parenthesis of its own, with here and there extra parentheses, making pens with pens; finally, all the parentheses and reparentheses are massed together between a couple of king-parentheses, one of which is placed in the first line of the majestic sentence and the other in the middle of the last line of it - after which comes the VERB, and you find out for the first time what the man has been talking about” [1].

1 The Starting Point

In September 2001, the European Commission decided to fund a pilot project called ECDL[®] PD¹ – brought forward in Leonardo da Vinci II Programme – which aims at adapting the widespread and well known ECDL[®]/ICDL^{®2} certificate to the needs of people with disabilities. The ECDL[®]/ICDL[®] should not only become an integrative tool for people with disabilities (Blind / Visually Impaired, Deaf / Hard of Hearing, People with Mental Disabilities, People with Physical Disabilities), but also for the ascending number of other underprivileged people on the labour market (e.g. older people, people with poor education, immigrants...) – a certificate designed for all.

The everyday language of one of the target groups, the deaf and hard of hearing, is very different from the language used by hearing people. There are differences in structure (e.g. sports: “You soccer?” instead of “Do you like/play soccer?”) and terminology (there are - for example in word processing - problems with the german term “kursiv” (slanted, italic), which is not understood clearly).

The ECDL[®]/ICDL[®] Syllabus, the questions and tests and the learning and teaching materials are full of technical and computer terminology and complex structures, too - and therefore not usable for the majority of this target group without training the vocabulary like learning a foreign language.

¹ ECDL[®] PD: European Computer Driving Licence™ for People with Disabilities.

² ECDL[®]/ICDL[®]: European/International Computer Driving Licence™.

2 Basics

2.1 Deaf and Hard of Hearing

Hearing loss can occur at any age. Hearing deficits in childhood can result in lifelong impairments in receptive and expressive language skills. The severity of the handicap is determined by several factors: [2]

- The age at which the hearing loss occurred
The age of a child when a hearing impairment arises (is diagnosed) is crucial to the development of the child's speech, language, cognitive, and psychosocial abilities
- The nature of the loss
eg. conductive hearing loss, sensorineural hearing loss...
- Its duration
- Frequencies affected
- Degree of loss
- The susceptibility of the individual child
eg. coexisting visual impairment, mental retardation, primary language deficits.

For a child with a sensorineural loss, the additional burden of a conductive hearing loss may severely degrade speech discrimination. Children who have other sensory, linguistic, or cognitive deficiencies are affected more severely by hearing loss than an otherwise intact child.

2.2 People with Mental Disabilities

It is very hard to qualify "mental disabilities". There are mental retardations of unknown cause, autism, social disorders, emotional disturbances, specific learning disabilities, diseases... [3] In most cases, these phenomena come together with other sensory, linguistic, or cognitive deficiencies and have one or more of the following symptoms (more or less distinct) in common: lifelong impairments in receptive and expressive language skills, problems analyzing complex linguistic structures and the disability to follow specific tasks without distraction which aggravates the gain of (not only on the labourmarket) useful degrees and certificates like the ECDL[®]/ICDL[®].

2.3 Secondary Target Groups

One task of the project ECDL[®] PD aims to check the ECDL[®] Syllabus and ECDL[®] MQTB³ for appropriateness for the four primary target groups. It is also apted for the ascending number of other underprivileged people on the labour market (e.g. older people, people with poor education, immigrants...). Most of them have similar problems analyzing and understanding the complex structure and technologically overloaded wording of up to date computer "slang".

³ MQTB: Manual Question Test Base. A directory of all exams (all existing ECDL[®] questions).

The ECDL®/ICDL® syllabus is designed to cover the key concepts of computing, its practical applications and the use in the workplace and society in general. ECDL®/ICDL® is, per definitionem, open to anyone – regardless of age, education, experience or background. This “design for all” of the certificate ECDL®/ICDL® does not yet cover the special need of a simple, easily understandable language – *for all* – in consideration of the same, high, accepted and intensively used standard – which must not be changed.

3 “Simple Language” in ECDL® PD – First Results

At a first glance, “Simple Language” sounds like simplification, lower level or the typical TV – Talkshow – slang. It is, in fact, much more. It encourages these people to get in contact with the hearing world by using simply structured sentences, “simple” words, “easy to get” explanations, pictures, images or videos in gesture language.

3.1 Findings

In addition to technical support, more time to answer the questions, personal assistance (gesture language interpretation) and sensitization of the personal environment and the public, the following careful modifications should be considered (especially for syllabi and written exams) without changing the given level: [4]

- Short, clear sentences, no involved sentences
- Give only information which is relevant for the current task
- Only essential technical terms should be composites or foreign words
- Distinct separation of (necessary) introduction and the problem to solve
- Definite questions, introduced with common interrogatives
- Structuring aids (eg. tables) to minimize the applicant’s text production
- Visualization aids (eg. images) to clarify needed concepts and contexts

We strongly recommend native speakers to do these “translations”.

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Many Ways to ECDL

Magne Lunde and Morten Tollefsen

Trolldalsvegen 7, N-2033 Aasgreina, Norway
{magne, morten}@medialt.no, <http://www.medialt.no/>

Abstract. In 2000, the firm MediaLT initiated a Norwegian project, where the goal was to adapt the European Computer Driving License (ECDL) for the blind and partially sighted, i. e. to develop and arrange a distant education course and a certification scheme. This short paper will cover the work related to adapting the certification scheme. Individual adapted training and accessible learning materials are discussed in a separate paper. We wanted to explore if the certification scheme discriminated the visual impaired, because the ECDL tests measured the method and not the ability to solve tasks.

1 Equal Level and Equal Opportunities

The work with the ECDL certification scheme had two main goals:

- The level should remain high.
- The certification scheme must give everyone equal opportunities.

Is it possible to combine these two goals? If the level of ECDL is maintained, will this exclude the visually impaired? Our hypothesis is that the answer to this approach is "no". This hypothesis was built on the assumption that there is an abundance of software, when it comes to alternative methods of solving a task. Further, in some cases the helping aids have embedded alternative functionality, which makes it possible for disabled persons to solve tasks that are impossible to solve by using standard software. Based on this assumption, we wanted to explore if the visually impaired persons' problems with passing the tests were connected to discriminatory wording of questions and other shortcomings with the certification scheme.

In other words, there are many ways to ECDL. Therefore it is important that the Syllabus and the Certification Scheme are not attached to a specific way towards the goal. It is the ability to solve a certain task that will be measured and not the method that is used.

2 Syllabus

The Certification Scheme is founded on the Syllabus. Based on this background, MediaLT went through the Syllabus [1], and the assessment of the Syllabus showed that it was possible for the visually impaired to solve all the tasks the Syllabus demands, apart from drawing (Item 6.4.1 in the Syllabus). Beyond this item were

challenges attached to skills described in the Syllabus solved in alternative ways. The challenges were connected to three main subjects:

1. Auto figures and clip gallery: At the present time, the visually impaired cannot use Auto figures and the clip gallery in an adequate way by themselves. They can learn the method, but have limited possibilities to choose the objects they wish. If alternative text explanations of pictures and objects were included in the software, it would be possible for the visually impaired to use Auto figures and the clip gallery. Certainly in some of the software, the properties give an indication of the content of the objects, but the visually impaired will have little control with the appearance. Items four and five in the chapter “test-adaptations” describe two ways to solve this challenge.
2. Move and place windows, objects, icons and controls: It is very difficult for the blind and partially sighted to have the necessary overview and control, when it comes to placing and relocation of windows, objects, icons and controls. The possibility for control also fluctuates with the helping aids. Item five in the chapter “test-adaptations” describes the main solution to this challenge, but in some cases this challenge can also be solved by item three.
3. Diagrams and graphs: The blind and partially sighted have little control with diagrams and graphs. Therefore it is important that the questions related to working with diagrams and graphs are not very detailed and complicated. If the tests are prepared with this in mind, it will be possible for the blind and partially sighted to demonstrate skills in this area.

3 The Certification Scheme

In December 1999, ECDL Norway appointed a national committee consisting of MediaLT, several Norwegian organizations for the disabled and centers of excellence. The commission was to develop guidelines for carrying out tests. In the summer of 2000, ECDL Norway had planned to offer only automatic tests. The graphic interface in the automatic tests would have eliminated several groups of disabled. On the advice from the national committee, ECDL Norway cancelled the plans, and now it is established in the guidelines that both manual and automatic tests can be used.

The guidelines [2] separate the three levels of adaptations:

1. Simple adaptations (automatic test)
2. Adaptations that can be done without approval from ECDL Norway (manual test)
3. Special adaptations which need approval from ECDL Norway after application via the test center (manual test).

Adaptations on levels 1 and 2 include use of special equipment (e. g adapted mouse, braille display, screen enlarging) and use of Norwegian dictionary for non-native users. Level 2 also includes 15 minutes extra time, the set of exercises in accessible format, use of deaf interpreters and vaste disposal in own room (with the test manager present). Adaptations on level 3 include assistance for practical help during completion of the test, oral examination with a secretary (applies only to module 1), extra time beyond 15 minutes and the test is conducted outside the test center on premises which are adjusted to the candidate’s special needs for adaptations.

4 Test-Adaptations

In 2001, MediaLT went through ECDL's manual tests, to assure that the way the questions were formulated did not exclude the visually impaired persons. The adaptation of the tests can be divided into five main groups:

1. Description of pictures: In the set of exercises, pictures were used to show the tasks the candidates had to perform. Therefore, a description of the pictures was added to the questions, to give the visually impaired access to the information.
2. Alternative methods for solving tasks: In cases where the solving of a task was related to a certain method, the questions were rewritten to give additional information, which made it possible to solve the tasks.
3. Exact placing of pictures and objects: In those questions where exact positions for pictures and objects were not stated, an exact description of where the pictures or objects should be placed was added to the questions. Exact positions are important to insure that the visually impaired can control the image processing.
4. Pictures from the clip gallery were replaced with pictures from file: Where the candidates were asked to place a picture from the gallery, an alternative was added to the questions, which gave them an opportunity to place a picture from a file.
5. When shortcomings with the helping aids made it impossible to solve a task, the candidates were given an opportunity to describe theoretically how it is done. The following was added to the questions: "If you use helping aids (e.g a braille display/synthetic speech) that do not work in relation to ..., can you explain how this is done?" This solution was chosen because it enabled the visually impaired to solve tasks like this together with a sighted person. If the visually impaired know the method, they can conduct the sighted person to carry out the task.

Items one, two and four were the main sections of the adaptation of the tests. Items three and five were seldom used.

5 Summary

In October 2001, a blind student completed all seven modules. He used the adapted tests, and confirmed that it is possible to combine the requirements regarding equal level and equal opportunities. This means that discriminatory wording of questions and other shortcomings with the Certification Scheme explains the visually impaired persons' problems in passing the ECDL tests.

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Studying and Academic Mobility – IT Support for Students with Disabilities

Introduction to the Special Thematic Session

Joachim Klaus

Universität Karlsruhe (TH)
Study Centre for Blind and Partially Sighted Students (SZS)
szswww.szs.uni-karlsruhe.de
klaus@szs.ira.uka.de

Globalisation and internationality, competition and knowledge, mobility and transnational experience - these are some of the keywords dominating our new millennium. Human resources, personal qualification and life long learning is our platform concerning these worldwide challenges. Our society pretends to be open, based on an social, humanistic and democratic structure, enabling to every individual to develop his/her personal and intellectual capacities and to present an adequate surrounding. Reality is far away: our daily experience around us and the news transported from everywhere of our globe – not only the difference between the northern and southern hemisphere, countries in west and east, but as well the exclusion of special groups like elder people, un- or semi-skilled people, women and handicapped characterise our actual situation. The scissors of those having access and those being segregated as fringe groups diverge and seem to be accepted as fatalistic.

In this atmosphere the new information and communication technologies are a new medium and concrete instrument to open totally new possibilities – in those areas, too. Internet, world wide web, e-learning, virtual campus, electronic portal, synthetic voice input and output, homepage, digital books, chat-rooms and virtual conferences the words inundate anglicism everywhere – all languages and infiltrate imperceptibly our daily actions.

The special thematic topic of the academic world, students with disability and IT supporting systems is to focus these different programs and assistive technology, but at the same time it is indispensable to transfer them into a cohesive unit and an integrated view. A technical product is always involved in a pedagogical social and psychological surrounding, one influences the other.

The different papers of this Special Thematic Session offer a variety of aspects regarding this broader view of integrated concepts, pointing out the advantages and limitations, chances and barriers of IT for people with disabilities. The internet has become a normal research and communication area in the academic world. Its accessibility for visually impaired people – for example the websites

with their visual attractions – is a great problem. Companies' and manufacturers' sensitivity and legal regulations are demanded. The interaction via media for deaf and hearing impaired opens exciting new perspectives, but the daily mobility in their community is abundant in barriers and hindrances. Just for those who do not obviously present their handicap the communication in the academic world is very often a personal psychological problem. Being impaired in mobility and having reached the academic door to study and to look for a correspondent profession is characterised by fights and special equipment, respectively ergonomic needs or special regulations for examinations. The documentation and evaluation of developments and programmes, the national and international exchange and transfer – like the ICCHP – is a helpful and as well economic need.

Developing Academic Skills among Print Disabled Students: IT Based Austrian-Wide Network for Service Provision

Andrea Petz, Klaus Miesenberger, and Bernhard Stöger

integriert Studieren – integrated studying (*i³s³*) – University of Linz,
Altenbergerstraße 69, 4040 Linz, Austria
k.miesenberger@aib.uni-linz.ac.at,
{andrea.petz, bernhard.stoeger}@jku.at
<http://www.integriert-studieren.jku.at>

Abstract. This paper presents the service provision system for print disabled students at Austrian Universities. An institute with full research and teaching tasks is established which in addition networks all small support units or centers at universities to enable a full scaled service provision. Students with print disabilities can decide whatever course they want to attend and wherever they want to study – a freedom which society basically guarantees to everybody.

1 Background and History of the Austrian-Wide Institute

i³s³ is the follow up organization of a model project for comprehensive service provision for blind and visually handicapped students established in 1991. Based on and pushed by assistive technologies, *i³s³* originally was part of the Institute for Applied Computer Science of the University of Linz.

i³s³ is at the moment an Austrian wide institute where 4 universities co-operate in a network of distributed competences; each center develops its special areas of services, research and teaching and provides them for the whole network. It is planned that all Austrian universities join the institute, contribute to and benefit from the network. All print disabled students in Austria should get access to this comprehensive service for developing the skills needed for studying and doing research.

The history of *i³s³* began at the first ICCHP (International Conference on Computers for Handicapped Persons), held in Vienna in 1989. At this conference, disabled people demanded to take concrete measures to improve their chances to get academic qualifications. As a response, Prof. Dr. Wagner (University of Linz) decided to institute the "Educational Endeavor Computer Science for the Blind" following the University of Karlsruhe, Germany, where special support for blind students exists since 1987. The scope of activity was very limited: First it supported only blind students, second it was confined to students of computer science and mathematics, and third its duration was limited to one year.

Neither the clients nor the founders of the Endeavor were satisfied with these restrictions: In a first step, the project was prolonged to 1995. Then, blind students of

all disciplines available in Linz were supported. From 1995, the Endeavor became a regular department of the Institute for Applied Computer Science at the University of Linz.

The need to extend the support to students outside Linz as well as the necessity to lift the restriction to blind and partially sighted students caused the last step of extension: in 2000, the department changed to an institute which operates as an inter university network. The clientship now embraces all Austrian print disabled students.

2 Arguments and Reasons for the Installation of an IU Network

Establishing such a network asks for an enormous effort in awareness raising, negotiations and discussions with the board of universities, political and administrative staff and teaching staff at university. The following comprehensive overview to the most important arguments used to push the idea should be seen as an input for the exchange of ideas and practice for learning from each other and improving service provision:

2.1 Integration – A Task for the Universities

An open and democratic society cannot and must not neglect the challenges of integration of people with disabilities. Consequently, integration has been acknowledged as a social concern.

On July 9th 1997, the Federal Parliament unanimously passed an addendum to Article 7 (1) of the Federal Constitution. It reads:

"Nobody may be discriminated because of his/her disability. The republic (federation, federal countries, and communities) confesses to ensuring equal treatment of people with disabilities in all areas of daily life."

Hereby, education, in particular advanced and higher education, has a special mission:

- Obstacles in access to education, by which possibilities and chances of life are selected, intensify exclusion.
- Enabling of and integration into education may, since it is socially acknowledged, help overcome prejudices.
- Every university is bound to follow this principle.

i^3s^3 offers the possibility to follow this mission for the print disabled efficiently and with effective exploitation of existing resources.

2.2 Integration – A Task for the Lecturers

The Law of Studies Organisation obliges the lecturers to enable everyone who has both the qualification for and the inclination to completing university studies to do so in a form adequate to the student's needs.

Hence i^3s^3 is primarily an institution that supports the lecturers in fulfilling this responsibility. Print disabled students shall be able to find comparable chances for success in their studies, independent of the discipline or the place of their studies.

2.3 High Expenditure for a Small Group

At all Austrian universities, print disabled students can be found. This implies that:

- know-how in dealing with this target group is lacking,
- efficient service is considered too expensive.

i³s³, as an inter-university institution, grants to the participating universities the possibility to offer effective service to the target group, including counselling, support, and integration into the labour market, imposing minimal load on the universities involved. Available resources are exploited wherever print disabled need them, independent of the location of studies.

Being an inter university institution, *i³s³* brings forward budget applications for resources directly to the Federal Ministry of Education, Research and Culture, such that the budgets of the universities involved are not charged. So, joining the *i³s³* does not cause any further costs for a university.

2.4 Socio-political Responsibilities at a Socio-political Level

An inter-university institute is imputed to the Ministry, which is the instance that is bound to the socio-political mission. Universities and their senates are to act according to strict economic criteria. Supporting the concerns of a minority is difficult: It leads to misunderstandings, and, since the university committees change rapidly, it is constantly in peril and needs to be often re-motivated.

By the *i³s³*, that concern will be long-term established at the right level. This is also valid for the financial point of view (see above).

2.5 Acquittal of the Legal Obligation to Employ Disabled Co-workers

All companies and institutions in Austria are obliged to fulfil a quota for the employment of co-workers with a disability. The *i³s³* supports this, because at least one half of the employees belong to the group of favoured disabled people, and this will remain so in the future.

2.6 No Experiments

The *i³s³* is not an inexperienced pilot project. Rather, it is based upon nine years of experience in service, research, development, and teaching.

It is integrated into the international community of institutions supporting print disabled people, as well as into the host of research organisations dedicated to the area. This guarantees that the work is always up to date.

2.7 Combination of Service, Research, and Teaching

The *i³s³* intends to long-term support the integration of print disabled students through efficient utilisation of new information technologies. By combining services with research in the field of applied computer science, the demands of teachware and

didactics of the various subjects can be constantly reflected, such that ways of communicating complex interrelations to the target group may be developed.

By courses offered all over Austria, print disabled students acquire IT skills that are above average. Paramountly, print disabled students become experts in the use of hard- and software systems especially developed for them. For this target group, IT is a cultivation, such as paper and pencil are for the fully sighted.

2.8 Co-operation with Publishers – Virtual Library

The most important aspect of service is access to studying materials, especially to literature. Contacts to publishers and authors are of conclusive importance. Confidence-building measures, reliability and exoneration from the organisation of distribution of electronic versions of literature and from getting the rights for digitisation should be undertaken as coordinated as possible.

Since its early years, *i³s³* is an institution committed to digitisation and to the utilisation of the Internet for providing teaching and learning materials. The existing virtual library of electronic documents shall be optimised and extended. It may be used by all institutions involved.

2.9 Projects in Research and Application

"Design for All", "Usability Engineering", and "Social Inclusion" are not only slogans: Rather, they are of importance in the announcements and in the evaluation criteria for projects in research and in application on a regional, national and international level. The *i³s³* can, in this still quite new area, already cast back to profound experience from more than 20 projects. For example, the *i³s³* acts as an evaluator and as a reviewer, but is also represented in expert committees for the European Communities and for ministries. For university institutions that participate in the *i³s³*, this implies the possibility for co-operation and for the utilisation of that know-how and that competence.

2.10 Administration

The administrative tasks concerning the *i³s³* are taken over by the University of Linz, thus charging the other universities only to a minimal extent. Via the inter university commission that takes over the responsibilities of the senate, every participating university may influence the work of *i³s³*.

3 Concept of Service Provision, Research, Development, and Teaching

The main part of the support activities is the digital preparation of all studying materials such as books, lecture notes, overhead sheets, exercises, contents of the blackboard and so forth for print disabled students. Beside digitization and meta-data

enrichment, the co-operation with publishers, authors and lecturers is most important to optimize the document delivery process.

The research and development work is based on practical experiences made in service provision. Research, project and development activities focus on issues related to the service provision system.

i³s³ also offers teaching and training in IT, social skills, preparing for university, job integration and other fields.

The organizational overview in the appendix should clarify the structure of this all over Austria operating institution.

3.1 The IT Infrastructure Needed for a Nation-Wide Co-operation

- workflow management system
- electronic catalogue
- virtual library
- access to wireless campus
- personal equipment of students and public work stations

3.2 Important Partners

Publishing Industry. It is of vital importance to co-operate with the publishing industry and to get integrated in the process of decision finding.

There are several estimations summarizing the need for more efforts in the field of services for print disabled people:

- Only 1-3 % of all teaching and learning materials are made available to print disabled people
- Most documents, which are transcribed into accessible formats, are used 0 - 3 times.
- An important number of publications and documents is transcribed two or more times at different locations (by private persons or professional organisations).
- Most of the time only text is made available; pictures, figures and complex structures in documents are not made accessible or usable.
- a mark-up of documents with well defined and long lasting metadata to make documents hardware and software independent as well as accessible and usable for many user groups in many different circumstances is still not used.

These estimations show that:

1. more documents have to be made available,
2. information on available documents should be distributed in a better way,
3. better co-operation and co-ordination of the production is necessary,
4. more efforts should go into access to non-textual parts of documents and
5. service providers should use well defined metadata for long lasting usability and multimedia presentations.

This summarises the most obvious challenges for future service provisions for print disabled people.

It also becomes more and more obvious that all these efforts converge with the needs of the publishing industry. Service provision for print disabled people are those parts in the publishing world which concentrated most on future technologies. As one librarian expressed it: working in the field of service provision for print disabled people introduces to the emerging future technologies that will be used in some years.

Assistive Technology. In the 80s PCs and digitization of documents became the key issue in offering better and faster access to documents to print disabled people. Today digitization is a key issue in all areas of society, be it business, administration, culture or leisure. A similar development can be seen in areas like electronic cataloguing, digital document management, copyright issues, meta-data enrichment of documents, virtual libraries, e-books and e-publishing. Therefore a strong convergence of interests can be found in fields and in the service provision for print disabled people.

Other Players in the Field. All these technology driven developments of the last years do not make services for print disabled people obsolete. Still only a small percentage of documents is available in accessible formats.

Still print disabled people have to overcome a lot of hurdles and to spend cumbersome efforts to get hold of accessible documents. Still most digital documents do not contain the meta-data and the information making them really usable for print disabled people. We also must not forget that services for the print disabled should offer more than a simple document delivery system. A number of other activities and services are integrated into or combined with these activities. Although not recognized at a first glance, these more comprehensive services allow integrated studying and enable the development of academic skills among print disabled students. This shows that one of the future challenges in a comprehensive service provision system is the networking between different aspects and players in the field.

3.3 Strategies for an Effective Service Provision

From Cataloguing to Document Management. Access to standard library catalogues has to be extended to cataloguing of all materials necessary for studying. The workflow of document delivery from authors/publishers to clients via service centers has to be managed in an efficient way. Work in this field has been done during and after the TESTLAB project, funded by the European Commission.

Meta-Data. The special needs of different groups of print disabled people in service provision ask for intensive meta-data enrichment of documents. Meta-data are a key issue for offering better access to documents. Document management and cataloguing ask for a lot of meta-data, too. Meta-data enrichment is the most time and resource consuming work in digitization and therefore also in service provision for print disabled people. The META DATA ENGINE project (meta-e) funded by the European Commission offers the possibility to do research and development work for support or automation of parts of this meta-data work. More efficient meta-data work should enable better access to documents and should free resources for other activities.

Virtual Libraries and Distance Learning Centers. Access to documents via digital libraries is a key issue in research and development today. Focusing on accessibility of these systems as well as offering training and support in using these systems to print disabled people can be seen as a key issue in future library services for print disabled people. The Austrian virtual library ALO (Austrian Literature Online) is an example, which was developed by *i³s³* in co-operation with the University Library of Graz and the Institute for German Literature Studies at the University of Innsbruck. Besides offering a standard virtual library system ALO focuses on accessibility and on the needs of service provision for print disabled people (e.g. Braille Print on Demand, secure documents delivery functionalities, e-book). The system is also open to be used for or to be integrated into distance learning environments. In addition the system will be developed further to an inter-library loan system based on digitization of documents.

Libraries – Meeting Place for Peer Groups. Libraries have been and will be a meeting place for students and researchers. People with disabilities more and more get integrated into education and work in the area they live. This positive process tends to separate the peer groups with similar interests and needs. Networking between library services for print disabled people should function as a platform for communication and exchange, should enable to come up from local minorities into a networked group of print disabled peers.

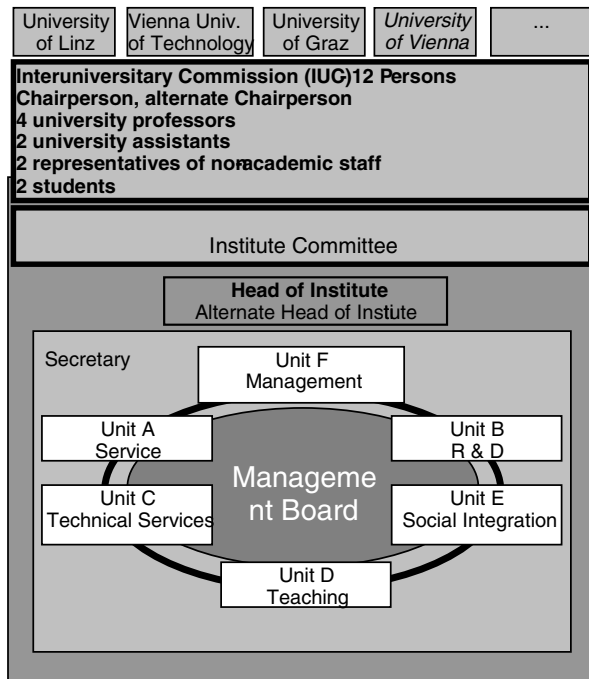


Fig. 1. Organisational Structure of *i³s³*

Adapted and Non-Visual Representation of Notations in Mathematics and Science. Increasing the skills in mathematics and science is one of the most important challenges in education and training for print disabled people and therefore also in the development of research skills. Future challenges in this field will go beyond a meta-data based representation of notations used in fields like mathematics, chemistry and electronics.

Services for print disabled people at least should provide access to a comprehensive network of competences, which is necessary to develop the skills for studying and research. Local centers can concentrate on their field of competence, networks provide what is often not affordable at a local level. Libraries are very well networked, much better than other organizations. The challenge for future library services will be related to more comprehensive service provision in a network of distributed competences.

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Access to Learning for All

Mirela Arion¹, Radu Ciupa², and Marius Iulian Tutuianu³

¹“Babes-Bolyai” University, Dept. of Special Education
M.Kogalniceanu 1, 3400 Cluj-Napoca, Romania
marion@hiphi.ubbcluj.ro

²Technical University of Cluj-Napoca, Dept. of Electrical Engineering, Daicoviciu 15
3400 Cluj-Napoca, Romania
Radu.Ciupa@et.utcluj.ro

³S.C. “SISTEC” S.A., Technical Dept., Deva 1-7, 3400 Cluj-Napoca, Romania
marius.tutuianu@sistec.ro

Abstract. This paper presents a real situation case study at “Babes-Bolyai” University, Cluj-Napoca, Romania, a pilot project for facilitating acces to communication and learning for visually impaired students, using open and distance learning techniques. There are at least two important implications when trying to facilitate the access of visually impaired students to communication and learning: implications for the design of web accessible interfaces and implications for didactics. Our paper is going to emphasize the first implication.

1 Introduction

The Internet and the World Wide Web can be the answer to many communication and learning issues for these students. They cannot only get access to available information, but can actually get access to learning. Studying is a critical issue for the visually impaired students in Romania, they have no access to any form of electronic information so far.

2 The Pilot Project

The pilot project is running within the frame of the Tempus Project S_JEP 12534 “Open and Distance Learning System for Permanent Education”, in the “Centre for Educational Technology Transfer”. The main objective of the project was to establish an Open and Distance Learning System for Permanent Education, while making full use of the Internet and World Wide Web standards. It was planned that several pilot centers would be established in several schools in order to ensure the success of the distance learning aspect of the project.

3 Personalized Web Interfaces

An accessible web site is one that can be accessed by anyone. Many people with sight problems have some useful vision, and read web pages in exactly the same way as fully sighted people: with their eyes. However, the needs of people with poor sight vary considerably, depending on how their eye condition affects their vision. To accommodate everyone, web sites should be flexible in design, enabling individual users to adjust the text size and colour settings to suit their own particular needs and circumstances. We provided buttons for increasing and decreasing the font size and for changing the foreground and background colours. Students were asked to participate in the development process of the sites. They had input about colours and font size.

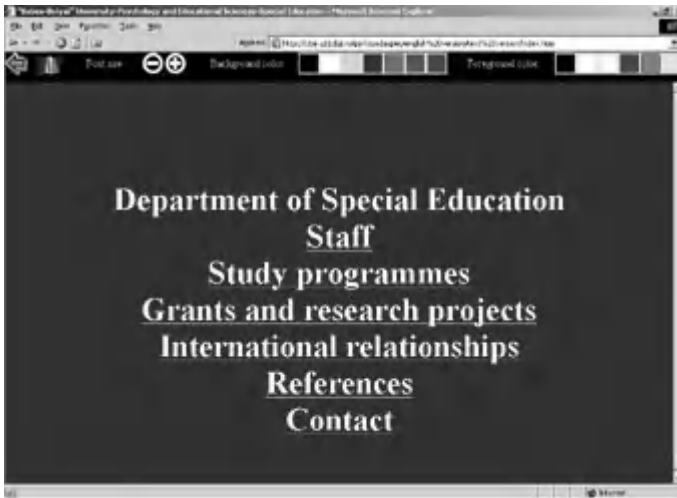


Fig. 1. Interface obtained using a personalized font size and foreground/background colours

4 Outcomes

There are a number of outcomes as a result of this pilot project, some of which we did not expect. The visually impaired students have changed their attitude towards computers; computers are seen now as useful tools, which can improve learning. They became not only proficient in using computers but also more involved in the social life of entire group. We, as teachers, realized that providing on line materials for our courses is vital for the visually impaired students.

The Evolving Door: Providing Technology Access for Post-secondary Students in a Constantly Changing Technology-Based Culture

Janice Hecht and Bogdan Zamfir

Center for Adaptive Technology, Southern Connecticut State University
501 Crescent St., Engleman 5, New Haven, CT 06515
cat@adaptivetechology.org
<http://www.adaptivetechology.org>

Abstract. The Center for Adaptive Technology at Southern Connecticut State University was established in 1988 to provide access to computers for students with disabilities. The challenge of keeping current with both standard and adaptive technology has caused our service to evolve from a focused, centralized model to an integrated model providing technology access to students regardless of their location on campus.

1 Introduction

With the development of new media and new technologies, computer use has greatly increased on college campuses. Students who once only needed to “type” their papers using word processors are now learning to design web pages, create PowerPoint presentations, conduct Internet research, correspond with faculty and students via e-mail, and download graphics and sound files. Many schools now offer online courses in which students never set foot in a traditional classroom. Some campuses are fostering the use of courseware by faculty to supplement traditional teaching methods, providing online course information, syllabi, additional resource materials, video clips, and even chat rooms through web-based software.

2 Center for Adaptive Technology

As this new technology has evolved, so have the technology access demands on our campus. When our Adaptive Technology Lab was established 14 years ago, we focused on introducing students to word processing using 5 computers running DOS. Adaptive applications were limited and often crude compared to today’s offerings. Our biggest concerns were providing physical and visual access to computers for the completion of writing assignments and helping learning disabled students with reading, organization and composition.

2.1 The Expanding Role of the Center for Adaptive Technology

Over the years, our facility has grown to meet the needs of an increasing population of students with disabilities attending college, and our services have evolved to reflect the development of new standard technologies now being used in education. Our lab, renamed the Center for Adaptive Technology, has moved physically to a larger facility with 15 computers and has moved organizationally into the department of Information Technology. A secondary lab under our management, the Educational Technology Resource Lab, now houses adaptive and educational technology for training SCSU students in education programs who will become teachers and speech and language pathologists. We continue to provide computer access evaluations for the statewide community on a limited basis at the Center for Adaptive Technology.

2.2 Technology Integration

Our services now include access to library databases and electronic card catalogs, access to technology in the classroom (for courses requiring computer use during class), access to general computer labs, access to web-based course materials, and access to academic and university materials in alternate formats, such as Braille, tactile images, electronic text, large print and video captioning.

2.3 Interdepartmental Collaboration

The integration of adaptive technology into many locations across campus has fostered interdepartmental collaborations. Our staff trains and interacts with staff from Information Technology, the library, academic departments, the Disability Resource Office, and Student Support Services.

2.4 Research and Testing

The increased complexity of the technology field and the integration of technology into daily educational activities have increased the need for research and testing, much of which is done over the World Wide Web. The Center also continues to be involved with producers of adaptive technology, contributing to beta testing and feature development.

3 Conclusion

The constantly changing field of adaptive technology has shaped the adaptive technology model on campus. From the initial, centralized model, we have evolved into a campus wide entity capable of providing technology access to all our students regardless of their location or needs.

Taking Assistive Technology to the Highest Degree

Todd Schmiedl and S.L. Dyser

Arizona Center for the Blind and Visually Impaired, Inc.

3100 E. Roosevelt Street Phoenix, Arizona 85008

<http://www.acbvi.org>

sdyser@acbvi.org

Abstract. This paper presents the case study of a 40 year old married man who sustained an incomplete C4-5 spinal cord injury with occipital lobe head trauma during an automobile accident in 1980. The event left him with a motor status of quadriplegia, significant speech aphasia, and severely impaired vision. It provides an overview of Dr. Schmiedl's background and his use of assistive technology during his doctoral program in neuropsychology.

Following the trauma Dr. Schmiedl spent eight months in an acute care setting followed by six months of intensive in-patient physical, occupational, speech, psychological, and recreational therapies at the Rehabilitation Institute of Chicago. After his discharge his vested interest in medicine motivated him to seek a better understanding of himself through neuropsychology.

While completing his undergraduate work at the University of Illinois Dr. Schmiedl used reading and writing assistants to aid him in accessing his textbooks, writing papers, taking notes, and completing exams. In his own words, "This was a real nightmare."

Dr. Schmiedl wanted to continue his education by earning a medical degree in psychiatry and scored high on the medical college admission test (MCAT). He applied to 152 medical schools and his academic record, above average scores, and the recommendations from his professors should have gained him admission to a top school. However, admissions officers informed him that while they had had students that were blind or quadriplegic, a blind speech impaired quadriplegic was just too much of a risk.

Dr. Schmiedl enacted his backup plan, a Masters degree in Rehabilitation Administration, finishing his first masters program in one year with honors and, still not content, he applied to the Arizona School of Professional Psychology where he was accepted into the clinical psychology program.

Dr. Schmiedl began his studies using the DOS version of Dragon Dictate (voice input to the computer) and Vocal-eyes, (a screen reader) in 1992. He had used these programs prior to his matriculation, and his software was upgraded to Dragon Dictate for Windows and JAWS for Windows in 1996.

Dr. Schmiedl used Dragon Dictate 3.0 for text input, with the text being read back to him using JAWS 3.0. The software was configured so that he would dictate one word at a time, wait for the screen reader to read back each word, and then make

corrections as required. He used this method even though it took 1-2 hours to complete a typed page. He continued to use this frustrating technique until 1999, when in an effort to explore alternatives, he was referred to the Arizona Center for the Blind and Visually Impaired (ACBVI) for an assistive technology assessment.

The transdisciplinary team addressing Dr. Schmiedl's strengths and needs included an Occupational Therapist, Speech and Language Pathologist, rehabilitation teacher for the blind and visually impaired, and an assistive technologist.

The team recommended software and hardware upgrades to allow Dr. Schmiedl to achieve an input/output speed consistent with his needs as a student and psychology intern, and to accommodate his projected needs as a professional. The goal was a rate to approximate 80WPM with 90% accuracy, and he has exceeded the team's expectations by achieving recognition rates nearing 100 wpm with 95% accuracy. His current assistive software consists of Dragon NaturallySpeaking Medical Suite 6.0, JAWS 4.0 and Jawbone 6.40. Jawbone serves the critical role of providing immediate read back of dictation and commands, and adds additional commands to Dragon NaturallySpeaking that permit the user to access the JAWS reading functions.

Another key objective was to give Dr. Schmiedl total autonomy in using the system. Large external power and reset switches accessible from his motorized wheelchair were installed, and, to avoid being tethered to the system, a desk mounted microphone that could provide the same recognition quality as a headset microphone was selected.

The team then focused on Dr. Schmiedl's speech intelligibility, and recommended he be evaluated for use of an Electronic Speech Enhancer (ESE). This technology not only amplifies; it also clarifies the communicator's speech. Dr. Schmiedl spoke to familiar and unfamiliar communication partners in quiet and noisy environments while wearing the Speech Enhancer, and his listeners were able to understand almost 100 percent of his speech. Dr. Schmiedl did not alter his speech patterns, and he commented that because he could now hear his own speech more clearly he was able to make corrections to improve the integrity of his conversation.

In the coming months the focus will be on integrating the ESE with a laptop to develop a mobile infrastructure that will allow Dr. Schmiedl to easily converse with others while utilizing the same microphone to control his computer. As always, this will keep him on the cutting edge of technology, thus taking it to "the highest degree."

Learning from Each Other: Comparing the Service Provision for Blind and Visually-Impaired Students in Post-secondary Education in Japan and Europe

Hiroshi Katoh¹, Martin Pauly¹, Shunsuke Hara¹, Hideji Nagaoka¹, and Klaus Miesenberger²

¹ Tsukuba College of Technology, 4-12-7 Kasuga, Tsukuba-shi, Ibaraki 305-0821, Japan

{katoh, pauly, hara, nagaoka}@k.tsukuba-tech.ac.jp

² *i³s³*, University of Linz, Altenberger Strasse 69, A-4040, Linz, Austria
klaus.miesenberger@jku.at

Abstract. The number of visually handicapped students who study at universities and other organizations for post secondary education is increasing gradually. The situation of higher education for the visually impaired is rapidly changing and different countries answer this situation in different ways. In this research, we started to compare the educational systems and the service provision systems for blind and visually handicapped students in post-secondary education in Japan and European countries, mainly Austria. The goal of these studies is to outline proposals for the improvement of the higher education for the target group.

1 Educational and Service Provision System

Due to social, political and economical reasons and also because of the Information Technology (IT) revolution, the situation of higher education for the visually impaired students is continually changing and varies among different countries. These rapid changes invite to compare the situation in different countries and to learn from each other.

In Japan, each year more than three hundred high school graduates with visual impairment leave secondary school level. Less than ten percent of them go to universities and colleges, including Tsukuba College of Technology (TCT), a special institution offering post-secondary education for sensory impaired students. These figures are considerably low, when compared to fifty percent of unimpaired high school graduates who go to universities or colleges and seventy percent of eighteen-year olds who enter into some kind of post-secondary educational institution in Japan. In European countries (e.g. Austria), the percentage of young people entering post secondary education is lower than in Japan. On the other hand the percentage of visually handicapped youngsters in post-secondary education is more similar as the one of the overall age group. [5] In most of the European countries a very restricted number of or no special institutions are

available. The orientation towards inclusive education tends to increase the ratio of blind and visually handicapped students attending post secondary education. There is of course a need to take the social and cultural background into account when comparing the systems. In Europe also education at elementary and secondary level most of the time, except for those with multiple impairments, is based on inclusion. In Japan however, many visually handicapped children attend special schools focusing mainly on vocational training. IT usage is an other important factor. In the present situation in Japan, less than thirty percent of the visually impaired are using the Internet[1]. In Europe almost any student in early ages learns to use the computer and modern communication technology as an assistive and general tool. Service provision systems in Europe are based on a high level of skills using IT and assistive technology. [3][4]

Tsukuba College of Technology (TCT) started to accept students from 1991. It is a three-year national college and is unique as it is only for those with visual or hearing disabilities. It is expected that TCT will be promoted to a full four-year university in the near future. It receives about forty blind or low vision students a year. The existence of such a college is in contrast to several European countries, where integration is commonly accepted, at least for higher education. Austria can be seen as one extreme; no special education is available after the age of 14 - 15 years. Vocational education as well as post secondary education are based on models of supported inclusion.

For visually impaired students, in Japan, who study at universities other than TCT, they must acquire essential PC skills for learning from computer or software-sales companies and/or from volunteers. Unfortunately, there are almost no support centers. For the visually impaired, to master IT skills is very important but no systematic study has been carried out on ways of developing methods of; teaching, teaching manual preparation, and staff training. The number of students who can use PCs before the university entrance is rather small[2]. Although students in these schools often have more training (albeit still insufficient for university-level study) in IT than students at regular Japanese schools, the environment for other academic subjects is often inadequate. For example, the mathematics textbooks used at schools for the blind are usually more basic than those used at regular schools. This is perhaps another reason for the low number of students entering universities.

In many European countries, on the other hand, many students practice IT skills at elementary or secondary school and/or in special courses such as International Computer Camps (ICC)[6]. Several higher-education institutions offer disability support centers.[3] In Austria a nation wide network for the support of integration at universities was established recently. [4]

2 Research and Development

The Research Center on Educational Media in TCT, in cooperation with related departments and staff in TCT, is developing new teaching methods and devices (e.g., Braille translation systems, high speed Braille printer) and support sys-

tems for the visually handicapped. Both TCT and the Research Center are also offering support to students of other educational institutions, e.g., Braille textbooks (especially science-oriented and graduate-level) translation and delivery of originally-created software.

Service provision in Europe very often is organised as a special library service. Only in some exceptional cases libraries do run research units. *i³s³* is also a research and development institute. The main areas of research are electronic document management, electronic libraries, access to mathematics and science and IT supported education. Both situations give evidence that the speciality of inclusive teaching asks for accompanying research and development.

3 Developing Proposals for the Future

Through discussion of similarities and differences, it is recommended that a method will be outlined showing how comparative studies in educational, socio-cultural, as well as technical fields, could support the evaluation and orientation of service provision and integration. Examples are; 1) upgrading of English literacy for accessing internet resources for studying, 2) co-development of educational curriculum, 3) co-development of staff training programs, 4) co-development of strategic papers on the development of higher education in different cultural, economical and social contexts. The comparative study would enable us to better learn and benefit from each other and to consider and drive changes and adaptations in the style of service provision and also research and development. The first preliminary studies done already show the fruitfulness of such a co-operation.

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How Accessible Are Web Information Resources for Students with Disabilities?

Sri H. Kurniawan

Department of Computation, UMIST
P.O. Box 88, Manchester M60 1QD, U.K.
s.kurniawan@co.umist.ac.uk

Abstract. This study investigated the accessibility of web information resources for students with disabilities of 120 academic sites from the U.K., U.S., Australia and Canada using Bobby automatic accessibility tool. The analysis revealed that web sites in this study have higher percentage of accessible sites than most findings from other studies, but 48% of the sites were still inaccessible. The U.K. and U.S. web sites were more superior to the Canadian and Australian sites for major accessibility issues. The difference was less clear in minor issues. There was no significant difference in browser compatibility across originating countries.

1 Introduction

Students with disabilities represent a significant portion of students worldwide. In a survey of 21,000 representative samples of U.S. undergraduates, 6% stated to have disabilities and 72% of 5,040 U.S. institutions enrolled students with disabilities in 1995-1996 [4]. Up to 15% of Canadian students arrived at school with severe disability [2].

Some countries had developed some regulations to facilitate students with disabilities (e.g. US's Individuals with Disabilities Education Act [5] and UK's Special Education Needs and Disability Rights in its Education Bill [3]). Although it seems that the legal and mandates of web accessibility of information resources for students with disabilities have been well set up in those countries, the practice is somewhat different. In Canada, a study of 27 colleges and universities web homepages revealed that 25 of them failed the "audit" for Web accessibility as reported by Bobby (www.cast.org/bobby), an automatic web accessibility evaluation tool [1]. The present study extends the previous study [1] by analyzing more web sites (120 sites) and focusing only on sites that contain resources for students with disabilities.

This study aims to answer two research questions:

1. How accessible are academic information resources for students with disabilities in Canada, U.S., Australia and U.K. as rated by Bobby?
2. Are there significant accessibility differences from those groups of web sites?

Thirty academic/education web sites from each of those four countries containing online information resources/services for students with disabilities were analysed in the study using Bobby's accessibility measures (Priorities 1-3, which are in accordance to WCAG's priorities, browser compatibility and Approval status). The

web sites were collected using keyword search of “services for students with disabilities” from <http://www.google.com> search engine. The web site’s domain name extension (.edu, .ca, .ac.uk, and .edu.au) was used as a filter. Since Canadian university sites are not differentiable from other Canadian sites (e.g. commercial, governmental or organizational), visual observations were used to choose the academic sites.

2 Results and Discussions

The descriptive statistics of the 120 analyzed web sites show that:

1. Web sites from the U.K. and US have the highest Bobby’s approval (67% & 63%). Australian and Canadian sites have significantly lower scores (40% and 37%).
2. Across all tested countries, 52% sites are accessible, higher than average accessible web sites (7-28%).
3. Across all tested countries, the ANOVA showed significant differences ($p < 0.05$) for all of Bobby’s measures except for the browser compatibility errors.

3 Conclusions

From the analysis, the answer to the first research question is that higher percentage of academic sites is more accessible compared to general sites as other studies showed, although almost half were still inaccessible. To answer the second question, the web sites from U.S. and U.K. were similar in major accessibility ratings and were more highly rated than the sites from Canada and Australia (which were also similar in major ratings). In minor accessibility issues, the separation was less clear between countries.

Developers of web sites for people with disabilities and research community need to be aware that there were still a large percentage of inaccessible web sites, and it is a serious problem when the sites are for people with disabilities. It is important to test the accessibility of the sites during the development process or before they are published, and Bobby can be a very useful automatic tool to perform this check.

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Providing Assistive Technology and Alternate Media in Community Colleges: A Case Study

Calais Roussel

Cabrillo College
6500 Soquel Drive Aptos, California, 95003, USA
carousse@cabrillo.cc.ca.us

Abstract. While required by federal and state law, full access at the community college level for students with assistive technology (AT) and alternate media needs presents multiple challenges. Programs must be carefully planned to not only instruct students in assistive technologies which will enable them to access instructional materials, but entire campuses and college systems must work as cohesive units in order to create access for all students. One example of a community college AT and alternate media plan will be presented, with discussion regarding technological limitations and future directions. California community colleges provide a useful case study, as recent changes in the law and campus practices have led to widespread adoption of assistive technologies and principles of universal access.

1 Introduction

The California community college system, with 108 campuses, is the largest public college system in the world. The system serves over 2.5 million students annually; of these, 10% on average are students with disabilities. While legislation has existed on the national level for over a decade which requires equal access to programs and materials for people with disabilities [2], most colleges did not provide timely, comprehensive access to all instructional materials in alternate formats [5]. The colleges have a new mandate to make materials available to students with print disabilities in the alternate format students prefer (Braille, electronic text, large print, etc.) With the recent implementation of a law requiring textbook publishers to provide textbooks in electronic text to a student with a print disability [1], followed by publication of the Chancellor's Office of the California community college guidelines for production of materials in alternate formats [4], an additional legal imperative was established. Finally, with specific funding for alternate media and assistive technology provided to each college, campuses were able to act upon these mandates.

A grant was made available to each college in 2000-2001 for the purchase of equipment to produce Braille and closed captioning videotapes. A mandate to provide alternate media for all instructional material of the college has led to greater need for staff to obtain or produce these materials. One staff position per college for the production of materials in alternate formats has been funded by the Chancellor's Office. Training for Assistive Technology Instructors and Alternate Media Specialists is provided by a system-wide High Tech Center Training Unit [6]. In addition, the

process to create a system-wide alternate text production center has begun. Finally, colleges have developed teams to ensure equal access for students with disabilities by providing assistive technology, alternate media, and examining the delivery of distance education and other web-based content for accessibility.

2 Summary of Research

The Office For Civil Rights investigated the issue in 1997 after a complaint was filed against a community college regarding timely access to alternate format materials [7]. In research conducted system-wide [8], results confirmed those of the Office For Civil Rights investigation: that campuses were not meeting the needs of students with disabilities that required the most expensive and time-intensive accommodations, most notably Braille, electronic text, and distance education accessibility. While the majority of campuses provided large print and audio taped materials, and most provided access to scanners and screen reading software for student use, just over half of campuses reported that their campus websites were accessible to screen reading software, and fewer provided distance education courses which were accessible to screen reading software. Additionally, less than one quarter of colleges provided access to electronic Braille equipment (Table 1).

However, with the impetus of new mandates and the requisite funding, over 90% of campuses are now providing these technologies for universal access [8]. A lending program for electronic Braille devices is now available through the system-wide AT and alternate media training unit. Planning is underway for a distributed scanning network, by which colleges will assist each other with the large volume of instructional materials to be converted into Braille or electronic text. While the impetus for these changes was certainly a function of funding and legal mandates, and while cooperation at a system-wide level is a key component for cost-effective technology and media delivery, the extent to which each college's program will remain successful involves the development of dedicated campus teams with the ability to create change within the campus environment.

Table 1. Provision of Assistive Technology and Alternate Media (2000)

Technology or Alternate Media	CA Community Colleges (%)
Large Print and Audio Tape	92%
Scanners and Screen Readers	89%
Electronic Text	65%
Electronic Braille	49%
Refreshable Braille Displays	24%
Accessible College Website	54%
Accessible Distance Education	26%

3 Implications

At Cabrillo College, for example, the campus team is comprised of the AT instructor, the alternate media specialist, the library director, the director of the program for students with disabilities, the director of the computing resources (IT) department, and other key faculty. Recommendations come from the team, which avoids the perception that meeting the needs of students with disabilities is anything less than a mission of the entire college. Recent recommendations include a 10% college standard for accessible computer workstations in all computer-equipped classrooms and laboratories, and the provision of mobile technology (e.g. a mobile closed circuit television system, a notebook computer, etc.) for use in classrooms when networked technology is unavailable.

Teaching the use of AT is the final key component for ensuring the success of students with AT needs on campus. Students who need screen reading software, voice recognition software, screen enlargement software, or other assistive technologies are trained in their use in an occupational-level course. An AT lab, integrated within a large computer lab, allows students to complete courses and to work independently. Other campus access points for AT include the library [3], the student writing center and tutorials laboratory, and the Access Lab, a small computer lab dedicated to AT. In this way, students with AT needs are integrated into the campus community. The focus of this session will be program replication, technological limitations, and future directions. Current implementation issues include the storage and sharing of electronic text files, methods of delivering accessible distance education, and delivery of user settings across networks.

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International Collaboration to Improve Assistive Technology Outcomes

Introduction to the Special Thematic Session

Marcia J. Scherer

Institute for Matching Person & Technology
486 Lake Road
Webster, NY 14580 USA Craddock, B.Eng

Abstract. The outcomes of assistive technology has relied on anecdotal evidence since the inception of the field. With the current healthcare and AT funding situations that exist in North America and Europe, such evidence is no longer sufficient. With the support of RESNA and AAATE, developers of AT outcomes measures have formed the Assistive Technology International Outcomes Consortium (ATIOC) to collaboratively work on the development and dissemination of high quality measures of AT use.

Differences among individual users of assistive technology (AT) can now be accommodated, often making the process of matching a person with a technology complex. Needs for and preferences regarding AT are highly personal and individual. They emerge from varying needs, abilities, preferences, and past experiences with and exposures to technologies. Predispositions to and outcomes of technology use also depend on the outlook and goals a person has for future functioning, expectations help by others, and financial and environmental support for technology use.

Developers of outcomes measures in North America and Europe are working collaboratively to develop and disseminate instruments to guide consumers and providers of AT in the selection of the most appropriate AT and to minimize the rate of AT non-use and abandonment. In June, 2001, representatives met during the annual conference of the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) to form an agreement jointly supported by RESNA and the Association for the Advancement of Assistive Technology in Europe (AAATE). Key sections of the agreement are as follows:

1 Assistive Technology International Outcomes Consortium (ATIOC)

1.1 Preamble

The consortium is essential to serve as a vehicle to positively impact the lives of individuals who use assistive technology through the international development and implementation of outcomes measurement tools.

1.2 Mission

The ATIOC is an international consortium designed to promote universally accessible, effective and efficient outcomes measurement in technology and disability through collaborative research and development activities. Through the use of information technology, the consortium partner members of the ATIOC collaborate seamlessly across international boundaries.

1.3 Goals

The goals of the consortium include but are not limited to:

- development of research protocols to examine the feasibility as well as reliability and validity of measurement tools and systems
- information and database management
- dissemination
- international consensus on measurement terminology and standards
- training and education
- systems/service delivery models

The members of ATIOC look beyond environmental accommodations and individual functional capabilities and consider capability enhancement within a comprehensive assessment of individual interests, needs, and background experiences, and participation in desired activities. There is a dynamic, interactive relationship among these elements that changes over time and that leads ultimately to user-perceived quality of life. Therefore, this full constellation of factors needs to be regularly addressed.

Furthermore, the members of ATIOC view consumer preferences as driving the AT selection process and see the role of the professional as an expert resource to the consumer in the selection and use of the technologies. Such expertise can help a person access more opportunities and exercise more options and identify support services and training. Key to the expertise of many AT providers is that they themselves may have disabilities and be users of AT, thereby also serving as role models for individuals with newer disabilities.

To express this perspective on AT provision and outcomes assessment, the table below considers the example of a person being matched with a mobility device such as a wheelchair or a walker. Some guiding questions when conducting an assessment and evaluating the outcomes of the AT service delivery process are organized around considerations regarding the milieu or environments of use, the preferences and needs of the user, and features of the AT itself.

Milieu	Person	Technology
Where does the person want to go?	With what does the person need/want assistance?	Is the AT affordable for this person?
What barriers exist to getting there?	Does this person want the proposed AT?	Is the AT safe, reliable and comfortable?
What forms of assistance are available?	Does the person have realistic expectations for the AT?	Will the AT truly benefit the person using it?
What in the environment <u>needs</u> to be changed?	Will use of the AT require Changes in the persons' Basic way of doing things?	Is the AT aesthetically pleasing?
What in the environment <u>can</u> be changed?	Is the AT easy to use, repair,	Will AT fill an unmet need enhance quality of life?

Adapted from: Scherer, M.J. (2000). Living in the state of stuck: How technology impacts the lives of people with disabilities, Third Edition. Cambridge, MA: Brookline Books.

A great many persons with disabilities can now lead more independent lives in their communities, attend regular schools, and seek professional careers. A great many more want to, and can, providing they have the individually appropriate blend of AT, personal assistance, and environmental accommodations they require. We are moving away from a *medical model* of rehabilitation, which focused on the disability and the limitation of its effects, to a *social model*, which emphasizes the person and his or her full participation in society; we are going beyond the provision of a wheelchair or walker to the consideration of how they enable people to choose the activities they engage in and how they affect the places that person can be and the goals that can be achieved once there. In keeping with the spirit of the World Health Organization's recently adopted International Classification of Functioning, Disability, and Health (ICF), persons with disabilities have the right to be self-determining and to make their own choices about their lives and to achieve the quality of life each believes is personally best. To provide evidence that AT has an important role in this achievement is the purpose of ATIOC.

The Study of Assistive Technology Outcomes in the United States

Marcia J. Scherer

Institute for Matching Person & Technology
486 Lake Road
Webster, NY 14580 USA

Abstract. The importance of assistive technology (AT) in helping individuals with disabilities lead more independent and participatory lives is not in debate. What is in debate is the reasons for AT non-use and abandonment and how this field has lagged behind others in assessing the outcomes of AT service delivery. Rather than focus on the alleviation of AT abandonment, this paper argues for an emphasis on optimizing the appropriate match of AT and user. Ways to achieve this focus on characteristics of the milieu of use, user/person and the particular AT being considered.

1 Introduction

Assistive technology (AT) devices improve individuals' functioning, independence and participation in education, employment and community activities. Yet the rate of abandonment, non-use, and less-than-optimal use of AT is high – in general, about 33 percent [1]. This does vary according to the type of AT, with the most needed devices being the least abandoned and the most optional being the most abandoned [2]. Most abandonment occurs within the first year (especially the first three months), or after five years of use [1]. These statistics suggest that users learn relatively quickly whether a device works for them. If it doesn't, it is quickly discarded. If it does, the user may keep it until it needs to be replaced [2].

1.1 Efforts to Study AT Outcomes in the U.S.

Factors contributing to diverse outcomes of efforts to provide individuals with disabilities with appropriate AT arise from the immense individual differences among the target population. These include, but are not limited to, age and disability, expectations of and preferences for AT, social and cultural factors, life experiences, outlook, and customary routines. Equally diverse is the plethora of AT technologies and strategies currently available: In April, 2002, ABLEDATA (www.abledata.com) lists 29,000 assistive technology products, over 19,000 of which are available presently. Along with the increasing availability and capability of these technologies has been an expansion of their flexibility. Technologies have become more affordable, portable, and easier to use and maintain. Thus, the process of matching user and AT is complex.

In order to address the complexity of AT outcomes in the U.S., two Disability and Rehabilitation Research Projects on Assistive Technology Outcomes and Impacts has been funded by the National Institute on Disability and Rehabilitation Research (NIDRR), U.S. Department of Education, Office of Special Education and Rehabilitative Services Research. These projects have been funded for five years and began Fall, 2001.

The Consortium for Assistive Technology Outcomes Research (CATOR)

[<http://www.atoutcomes.com>]. The CATOR is a multicenter consortium consisting of programs and individuals active in the research, development, and dissemination of assistive technology outcomes. The CATOR is comprised of:

- Frank DeRuyter, PhD, Duke University,
- Jeffrey Jutai, PhD, University of Western Ontario, and
- Marcia Scherer, PhD, Institute for Matching Person & Technology.

Working with this team is a cadre of other AT experts in the U.S., Canada, and many EU countries. CATOR brings an international perspective through its alliance with the Assistive Technology International Outcomes Consortium (ATIOC) comprised of AT measure developers in the U.S., Canada, and European Union. ATIOC was formed under the joint auspices of the Association for the Advancement of Assistive Technology in Europe (AAATE) and the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA).

The ATOMS Project: Assessing Needs to Develop Next Generation Assistive Technology Outcomes Measures

[<http://www.uwm.edu/CHS/atoms>]. The Assistive Technology Outcomes Measurement System (ATOMS Project) is also a multicenter consortium consisting of programs and individuals active in the research, development, and dissemination of assistive technology outcomes. The leadership of ATOMS is comprised of:

- Roger Smith, Ph.D., OT, University of Wisconsin-Milwaukee, and
- Dave Edyburn, Ph.D.

The ATOMS Project has an interdisciplinary team to bring together eight agencies representing assistive technology related services in special education, vocational rehabilitation, consultation to commercial industry, law, and medical rehabilitation.

As these projects have only recently begun their study of AT outcomes, their respective web sites should be consulted regularly for updates on project activities and results.

1.2 AT Abandonment versus AT Use

People stop using AT for a variety of reasons, many of which can be for positive reasons such as the need for the AT no longer exists. Rather than focus on AT abandonment and non-use, it may be more useful to address the factors that are

strongly associated with optimal use. Optimal use of an AT fundamentally depends on matching an individual with the most appropriate AT for the need that exists at the time and which suits the user's goals, preferences and lifestyle. .

2 Considerations for Improved AT Use

2.1 Determine the Milieu/Environment Factors Influencing Use

AT that individuals feel comfortable using both physically and psychologically have a high likelihood of being used. While people with disabilities tend to dislike products that make stand out in a crowd, increasingly many people with disabilities view assistive technologies as desirable markers of a need for accommodation. For the most part and for a variety of reasons, persons with disabilities have been socialized to minimize their disabilities. In the context of such legislative backing as the Americans with Disabilities Act, when the existence of a disability is addressed up front, the disability is minimized and the person can get on with being just that – a person.

Aesthetic aspects aside, another important milieu and social factor associated with the optimal use of assistive technologies is how much the use of the technology adds convenience to both the user and others in the environments of use. In this fast-paced world, it may often be easier for family members to just jump in and do a task for a child than to patiently step aside and watch the individual struggle to accomplish a task independently. Therefore, other people in the environment are important influences on the use of an assistive technology.

Devices that are affordable, easy to maintain and repair, and are adjustable, are features that lead to use.

2.2 Assessing Milieu Influences

Trials of equipment in natural environments that involve everyone affected by the assistive technology have proven to be cost effective in the long term because obstacles to optimal technology use are identified while there is time to make adjustments, order additional accessories, etc. When trials are videotaped, the entire team can then participate in identifying solutions to potential obstacles to optimal technology use.

Know the Person. When a person in the process of being matched with an assistive technology is involved in selecting the equipment and encouraged to exercise choice regarding the equipment's features, the likelihood of the most appropriate assistive technology being identified is enhanced, as is the probability of it being optimally used. However, many consumers may see only limited alternatives for themselves because they have not been exposed to sufficient options to make informed choices and express appropriate preferences. Individuals who have not yet come to terms with their disabilities and who may be depressed may not be ready to see the value and virtues in the use of a particular device. Additionally, depression may mask

capabilities and capacities that would obviate the need for a technology. Alternately, premature introduction of assistive technologies before the person has a “psychological readiness” for use may assume capacities and coping skills that in fact need to develop over time, and this may result in the person feeling confused and frustrated. Many individuals who have a recent and severe disability due to trauma need to first be helped to understand the benefits of AT and how it will assist them to achieve an active lifestyle of participation in desired activities. As one person with a C4 spinal cord injury said to me:

"In rehab they handle your broken neck, but the broken neck isn't the problem. The paralysis is the problem. They don't confront the paralysis."

Before a technology will be optimally used, a person must both want it and see benefit in it. If an assistive technology enhances the individual's self-esteem, self-efficacy, and overall quality of life, it will be used.

Assessing Characteristics and Preferences of the Person. Proper timing is of the essence. So is privacy. Individuals with disabilities appreciate being asked about their preferences, needs, and capabilities when their significant others are not present. Significant others want to be helpful and should be involved, but let them know that they will have opportunities to express their preferences separately and at another time.

2.3 Find the Best Technology

Assistive technology is abandoned when it is perceived as not being worth the effort required to set it up and operate it, is never there when needed, and is costly or inconvenient to maintain. Selecting the most appropriate technology with all the right features is a complex process. A technology must have enough features to be useful and expandable, but not so many that the user becomes overwhelmed. Overload is a concern when an individual already uses or is being matched with more than one technology. Multiple technology use can bring overload of many types -- power, cognitive, and willingness to tolerate technical assistance.

2.4 Assessing Features of and Comparing Technologies

It has become increasingly difficult to keep up to date with new assistive technologies and improvements in existing ones. For this reason, the Technology Related Assistance for Individuals with Disabilities Act was passed in 1988 (and reauthorized in 1998 as the Assistive Technology Act) to help establish assistive technology centers in each U.S. state and territory. A major responsibility of these centers is to provide information about technologies and help individuals to obtain them. Equipment loan and trial programs, user/peer networks, and equipment funding assistance exist in many states. To find out the lead agency in any particular state or territory, contact RESNA Technical Assistance Project, 1700 N. Moore St., Suite 1540, Arlington, VA 22209-1903; phone is 703/524-6686 (703/524-6639 TT/TDD).

The RESNA web site is: [www.resna.org]. For information about the many available assistive technologies, the best resource is ABLEDATA at [www.abledata.com].

3 Assessing Individual Preferences and Perspectives of Assistive Technology

The Matching Person and Technology (MPT) Model [3] is a tool designed to assess potential barriers to individuals' optimal use of technologies. The MPT Model is useful in documenting consumer goals and preferences, views of the benefits to be gained from a technology, and changes in self-perceived functioning and outcome achievement over time.

The MPT Model consists of paper-and-pencil questionnaires, which can also be used as interview guides. They assess the quality of match of a person with a specific type of technology (assistive, educational, workplace and a general survey of technology use). The Assistive Technology Device Predisposition Assessment (ATD PA) addresses the milieu, person and technology influences on a person's technology use. It has both a consumer form and professional form as well as summary sheet to list challenges to optimal use and recommendations for making a quality match of person and technology. The two forms of the ATD PA were designed to be used as a set in order to ensure:

1. Consumer input drives the Matching Person and Technology (MPT) process,
2. Professionals consider a variety of relevant influences on technology use,
3. Different perspectives of professional and consumer become evident so they can be addressed [4].

Each form is on a single two-sided sheet and requires about 15 minutes to complete. The items emerged from the actual experiences of technology users and non-users, so they have "content validity." Evidence regarding reliability and validity exists that they are quality assessments [5]. Another version exists that was developed in Ireland [5] which combines elements of the ATD PA and the educational and general technology predisposition assessment forms.

On one side of the consumer form are questions given *per consumer*. They address characteristics of the person's self-reported capabilities, quality of life, temperament, psychosocial arena, self-determination and self-esteem, and program/therapist trust. The following are sample portions of the assessment in each of these areas:

Table 1. Sample Items from the ATD PA – Consumer Form

How are your current capabilities in the following areas? Circle the best response for each:

		Poor	Average			Good
b.	Hearing	1	2	3	4	5
c.	Speech	1	2	3	4	5
f.	Mobility	1	2	3	4	5
g.	Dexterity	1	2	3	4	5

How satisfied are you with what you have achieved in the following areas? Please circle the best response for each:

		Not Satisfied	Satisfied			Very Satisfied
b.	Physical comfort & well-being	1	2	3	4	5
c.	Overall health	1	2	3	4	5
d.	Ability to go where desired	1	2	3	4	5
e.	Emotional well-being	1	2	3	4	5

Put a [+] beside the one(s) you most want to improve over time.

Check all statements below that apply to you a majority of the time:

- * curious & excited about new things
- * cooperative
- * have many things I want to accomplish
- * discouraged
- * often depressed

The other side of the **ATD PA** consumer form address characteristics of a technology being proposed for that person's use. These questions need to be completed *on each technology* being matched with the consumer. Sample items are:

Table 2. ATD PA items regarding characteristics of the particular technology

5. How much do you believe you will benefit from using this device?
9. How much will this device require changes in how you usually go about doing things?
10. How much do you believe this AT will enhance your quality of life?

4 Concluding Thoughts

Some strategies for enhancing optimal AT use according to known influences on use are provided in the following table.

Key Factor	Influences on AT Use:	To Enhance Optimal AT Use:
User/provider interactions	Milieu characteristics	<ul style="list-style-type: none"> * Have AT-using peers as * Improve the information regarding the AT and its use * Have more tailored & convenient training for user & significant others in environments of use * Ensure environments of use are reinforcing of use * Assist AT providers to work in partnership with the user
User	Person characteristics	<ul style="list-style-type: none"> * Ensure the user participates in device selection, evaluation * Assess the person's knowledge of and comfort with AT
AT	Technology characteristics	<ul style="list-style-type: none"> * Select according to what is already used and familiar * Tailor to the person references, lifestyle, accustomed routines

Source: Adapted from Scherer [6,7]

To fail to involve consumers in the process of matching person and assistive technology perpetuates a system of service delivery that has not been as effective as it could be from both an outcome achievement and marketplace perspective. Too much AT continues to be abandoned and too little interdisciplinary and consumer collaboration take place today throughout the U.S. The situation can be improved by asking, listening, and responding; by following a systematic approach to matching a person with a technology; and by involving the consumer in the process at the outset. Only in this way can it be said the individual has been matched with the most *appropriate assistive technology*.

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Future Challenges in AT Outcome Measurement

Luc P. de Witte, G.J. Gelderblom, and R.D. Wessels

iRv, Institute for Rehabilitation Research, P.O. Box 192, 6430 AD Hoensbroek, Netherlands
lp.dewitte@irv.nl, www.irv.nl

Abstract. This paper goes into some of the advantages and problems of international collaboration in developing measurement instruments for Assistive Technology outcome assessment. It results in a strong plea for developing an international network of researchers and institutes, together developing a common research agenda for this field. By joining the efforts in different countries, the quality of outcome measurement in Assistive Technology is likely to improve and the use of good instruments to increase. As a result, the (quality of) knowledge about the effectiveness of Assistive Technology will increase, which will contribute to the quality of Assistive Technology provision and service delivery.

1 Introduction

In recent years several new instruments that aim to measure the effects of Assistive Technology (AT) have been developed. Developments in Europe and the United States have been relatively independent but show considerable similarities. Also within the US and within Europe these developments have been relatively independent, although some examples of international collaboration exist. Most new initiatives to develop instruments in this field seem to come from individual researchers and institutes who feel the need for specific AT oriented instruments, without very strongly taking other developments into account. This is not because they would deliberately not look at other developments, but mainly because these developments are not known. The result of this is a number of promising instruments and methods, examples of which are presented by others during this conference. The independent and somewhat fragmented developments, however, also imply that the speed of the development is low and that the continuity of the development, dissemination and implementation of instrument is uncertain. The quality of outcome measures for AT might benefit from a more coordinated international approach regarding development, dissemination and implementation. In this paper an example of international collaboration in this field is given and some initiatives are presented. The possibilities of such collaboration are discussed, as are the difficulties of it. Some of the future challenges for this field are given and it is argued that an international network of researchers and institutes active in this field should be developed.

2 AT Outcome Assessment: A New and Challenging Field

Due to the pressure to economize, increased consumerism and concerns about quality in relation to costs, the assessment of the outcome of AT has been given increasing attention in recent years. The political and economical call for rationalising the amount of recourses spent on assistive technology, but also the intention to enhance the outcome of AT, make insight into the outcome of provided assistive technology necessary.

In contrast to most fields of health care, where decisions on the application of medical interventions are evidence based, the provision of AT has been an exception. One of the reasons for this exception is the complexity of AT outcomes. This complexity originates from a) the diversity in contributing variables, b) outcome being a multidimensional concept, c) the embedding of an AT device, and d) the goals to be reached with an assistive device.

- a) The impact of AT does not only depend on the characteristics of the end user, but also on the context of application and the type of AT. Living conditions and/or type of care can influence the outcome. The diversity within assistive technology introduces a large spectrum of potential outcomes to be assessed by an instrument, e.g. the functional effect of a wheelchair is completely different from that of a computer.
- b) The outcome of AT is at closer inspection a composition of various effects at different levels and of different nature. Effects on user satisfaction, functional independence, societal and individual gains, increased social participation, enhanced normative social roles, the promotion and sustaining of employment and facilitation of activities of daily living may all add to the outcome of AT.
- c) Provision of AT is seldom an isolated action. Users commonly make use of one or more AT devices in combination with care and the outcome of a specific device should be assessed with reference to the context it is embedded in.
- d) The goals for providing a device can be divers and highly individual. Between persons an assistive device can be provided to reach different goals and reaching an identical goal may require different devices for different persons.

Instruments (or a set of instruments) assessing the outcome of assistive technology should therefore be generic and flexible, consider the range of possible outcome elements with reference to the context the device is embedded in and express the effect in terms of the extent to which individual goals were reached.

Dealing with this complexity in the processes of planning and developing an measuring instrument for the assessment of AT outcomes is a difficult task for a single researcher or research institute. Potentially, this complexity may be better dealt with through an international collaboration.

3 Possibilities and Difficulties of International Collaboration: The Example of QUEST

International collaboration in the development of instruments may lead to a number of effects, both positive and negative. The positive effects include that, preceding individual instrument development, international collaboration may induce coherence in choice of concepts to be assessed and during instrument development such collaboration will facilitate the gathering of required expertise and collection of data. A potential disadvantage of establishing international collaboration is that it may require additional funding which may be difficult to obtain. To illustrate some of the effects of international collaboration in the development of an outcome assessment instrument the development of the QUEST instrument is described.

QUEST (Quebec User Evaluation of Satisfaction with assistive Technology) was initially developed in Canada as an instrument for the assessment of user satisfaction with Assistive Technology [1]. Based on literature and clinical experience a list of aspects was formulated relevant for the satisfaction of a user with the provided AT device. This list of aspects was converted into a questionnaire subsequently discussed and evaluated by a panel of experts. After some initial trailing and minor modifications the questionnaire was re-evaluated by the same panel of experts. The resulting questionnaire was tested in a substantial multinational study on reliability and validity. This first version of QUEST (24 aspects) was later shortened into a 12 aspect questionnaire. A more complete description of the instrument can be found elsewhere [2]

The development of QUEST involved extensive international collaboration in formulating the relevance of aspects and collecting the required data. The use of content experts was particularly relevant in the development of QUEST to seize the opportunity created by the international interest for this assessment tool and to build on the shared experiences and opinions of assistive technology experts of several countries. Participants in this international network were able to work in close collaboration with the QUEST authors. Through electronic mail, difficulties related to geographical distances between testing sites were considerably reduced and communication was easy, quick and accessible to all. In addition, international conferences such as those held by the World Federation of Occupational Therapists (WFOT) in Montreal (1998), the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) in Pittsburgh (1997) and Minneapolis (1998), as well as the Telematics application for the Integration of the Disabled and the Elderly (TIDE) conference in Helsinki (1998) allowed several of the experts to meet with the QUEST authors as well as with other content experts.

The international collaboration brought a number of advantages to the development of the QUEST instrument. It obviously facilitated the collection of data to evaluate the first version of QUEST on the basis of a relative large sample size ($n=578$).

The development of the QUEST further gained by the international collaboration in that the expert evaluation of items and collection of data on reliability and validity are automatically multi-cultural and established in a shorter period. Finally, the multi-lingual and multi-cultural basis of Quest created an advantage in the ongoing implementing of the instrument.

The involvement of several cultural backgrounds also introduced some difficulties. Differences in the meaning of language can lead away from the intended purpose of

the items and rating instructions and therefore, when an instrument is standardized for use with different cultural groups, word-by-word translation is not sufficient. In translating QUEST from English to Dutch (D-QUEST), several Dutch assistive technology provision counselors were involved. In order to compare results, it was of critical importance that the translated QUEST versions measured the exact same scope of the concept of satisfaction in French, English, and Dutch.

In retrospect, in the case of QUEST the benefits of the international collaboration certainly outweighed the disadvantages connected to the collaboration.

4 Challenges for Future Research

The present state of the art in the field of AT outcome assessment is that there is a number of promising instruments available, non of which has really reached a 'mature' state. A number of these instruments has been presented during this conference. What is lacking is a common conceptual framework in which these instruments can be clearly positioned and that could serve as a guide for further developments. Also lacking is sufficient data collection. Serious testing and validation of instruments requires series of studies, which are seldom done, simply because most instrument do not 'survive' their developers; researchers leave institutes, change to others fields or don't succeed in finding sufficient funding. There are only few examples of rigorous development trajectories in other fields, like the FIM (Functional Independence Measure) [3] and the EuroQol [4]. For these instruments more or less structural collaboration between groups have been established, resulting in large data sets and convincing evidence about their feasibility, reliability and validity in different countries and settings. In the field of assistive technology outcome measures there are some positive experiences as described above and also presented by Scherer and Gelderblom during this conference. These experiences are, however, still very fragile and they lack a strong basis in running and well-financed projects.

What needs to be done in the near future can be summarised in six points:

- a) An international conceptual framework for AT outcome assessment needs to be developed, as well as international consensus on measurement terminology and standards;
- b) On the basis of international consensus a limited set of promising or established instruments and methods needs to be selected for further development and testing;
- c) Common international research protocols for examining the feasibility, reliability and validity of measurement tools, procedures and systems, have to be developed and carried out;
- d) Existing instruments, procedures and systems with proven psychometric or clinometric quality need to be translated according to international standards and need to be disseminated;
- e) Training modules on the use of these instruments and methods need to be developed and disseminated;
- f) Experiences with the application of instruments and methods in different countries and settings need to be shared and accumulated.

In this way a common research agenda can be formulated that can guide the activities of researchers in this field. Such a common agenda should not become too 'closed'; new initiatives and promising developments must get a proper chance to mature, but on the other hand a completely uncontrolled development, as for example has been witnessed in the field of quality of life measures, could better be prevented.

5 Conclusion

Although it is obvious that international collaboration in instrument development is complex and goes together with serious challenges, the advantages of such collaboration for the field are great. International collaboration allows for cross-cultural validation throughout the development process, experiences of experts with different background can be combined without direct competition on the respective national research 'markets', and data can be collected at a much higher speed. It is our conviction that these advantages outweigh the difficulties. The successful development of QUEST may serve as proof of this statement. Therefore it is recommended to invest in building an international network of researchers in the field of instrument development for AT outcome assessment, who work along a common research agenda, share experiences and data, exchange instruments, etcetera. Such an investment will in the long run improve the quality of outcome measurement in AT, increase the use of good instruments and increase the knowledge about the effectiveness of assistive technology. In the end this will contribute to the quality of AT provision and service delivery.

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European Instruments for Assistive Technology Outcome Assessment

G.J. Gelderblom, L.P. de Witte, and R.D. Wessels

iRv, Institute for Rehabilitation Research, P.O. Box 192, 6430 AD Hoensbroek,
The Netherlands
g.j.gelderblom@irv.nl, www.irv.nl

Abstract. The need for insight in cost effectiveness of Assistive Technology at both policy and individual level has led to the development of a number of generic instruments measuring the outcomes of Assistive Technology. Three important instruments, all emerged from the context of European funded projects, are described. First, a method combining an adaptation of EuroQol to Assistive Technology application, then IPPA, an highly individualised instrument assessing effectiveness and finally SCAI, a method for the economic evaluation of additional social costs resulting from the provision of an assistive device. The need for a strategy for further development of instruments is discussed resulting in a call for European collaboration.

1 Introduction

In recent years an increasing interest was witnessed in outcomes of the use of Assistive Technology (AT) across Europe. Parties financing AT are becoming more and more concerned about the lack of insight into the relation between outcomes of assistive devices and the costs involved. Simultaneously, there is a growing awareness that, due to lack of information on the outcomes to be expected, the selection from the available range of AT devices made by an end-user and his or her advisors may be sub-optimal, resulting in a low effectiveness.

Effectiveness on societal level is often considered in relation to costs; i.e. cost-effectiveness. Then effectiveness is regarded as the whole of benefits potentially resulting from the introduction of any intervention. Benefits can be expressed in financial units, utility measures or functional outcomes. Costs, on the other hand, are expressed in both financial and other terms, all following from the availability of the intervention. The cost-effectiveness of the intervention is then established by weighing the benefits against the costs.

When the benefits of the intervention can be expressed in financial units, obtaining a cost-benefit ratio is easy. When the benefits are expressed in a uniform utility measure, for example Quality Adjusted Life Years (QUALY), direct comparisons between benefit and costs are also possible by adding a financial value per unit of the utility measure. The value of such comparisons is however debated upon. When the benefits are expressed in functional outcomes, i.e. changes produced by the Assistive Technology in the lives of users and their environments [1], then comparisons between benefit and costs can no longer be made directly. In most fields of health

care, decisions on the application of medical interventions are evidence based by a direct comparison between benefit and cost, but the provision of AT has been an exception. One of the reasons for this exception is the complexity of AT outcomes.

The assessment of outcomes should address a variety of aspects covering both the effects and costs of AT use. The effects of AT use can be established on various aspects of the users' life but also on aspects not strictly related to the individual. Individual related aspects range from *functional performance* to *perceived quality of life*, while aspects that are not individual related include *the availability of personal care* and *the societal view on AT use and provision*.

The assessment of costs involved in the provision and use of AT can be approached in more or less complex ways. To be able to properly judge the costs-effect relation of an AT device, more types of costs should be considered than just the costs of purchase.

To assess this variety of aspects contributing to the effects and costs, measurement instruments have been developed. A relatively small number of these instruments developed into reliable and valid instruments. These can in principle be applied for all types of AT and can be used both at individual and at policy level.

This paper focuses on three European instruments developed in the past decade; EuroQol & PIRS, IPPA and SCAI. These three instruments answer to the requirements outlined above and are considered to be among the most promising instruments available.

2 European Instruments

In support of the aims of the Special Thematic Session *International Collaboration To Improve Assistive Technology Outcomes* a brief outline of the history of some European outcome assessment instruments is provided. It should be noted though, that these events did not take place without reference to what happened elsewhere. Simultaneous with the developments in Europe instruments were developed in North America, in a number of cases in collaboration.

In Europe, till date, most work in the development of AT outcome assessment instruments has been achieved through international collaboration in projects funded by the European Community. In a series of projects partly overlapping interdisciplinary teams have been able to develop conceptual notions into usable instruments. The results of the HEART study [2] into the economic factors impacting the availability of Assistive Technology led the CERTAIN study [3] to an explicit exploration of the possibilities of Cost Utility Analysis of AT [4]. Subsequently, in the EATS study [5] the obtained results from earlier projects were converted into an adaptation of the EuroQol instrument to the application with Assistive Technology and the foundation for the PIRS instrument was laid. The method combining these two instruments is described in Section 3, below. Also resulting from the EATS study is the development of the IPPA instrument aimed at individualizing the effect of AT application. This instrument is described in Section 4.

Finally, the results of the CERTAIN study led in Italy to the development of a method of comparing costs resulting from the provision of AT alternatives. This method is described in Section 5.

3 EuroQol and PIRS

For the assessment of outcomes of the use of Assistive Technology, Persson and colleagues [6] propose a method combining an extension of EuroQol, in its original form a well known, standardised Utility instrument and a problem oriented scale PIRS (Problems Impact Rating Scale) .

The need for such a method became clear from the efforts to perform Cost Utility Analysis (CUA) on Assistive Technology in the EC funded CERTAIN project [3]. An extension of the original EuroQol instrument, adapting it to the application for Assistive Technology, was developed in the EC funded EATS project [5]. The adaptation involved the topics social relationships, mobility (instead of locomotion) and problem impact. The first two topics were addressed by adding two items to the EuroQol instrument and the need for a problem impact assessment is addressed with PIRS.

The resulting method, consisting of the adapted EuroQol and the new PIRS instrument constitutes an outcome measure for respondents with long term disabilities, functioning as an estimator for utilities, corresponding to the outcomes as perceived by the users.

Individual scores obtained with the adapted EuroQol instrument are translated into utility scores based on social weights attached to each score (only for the original EuroQol instrument). The impact of the two new items added to EuroQol requires further investigation. With the PIRS instruments the individually perceived effect of problems related to disability on daily life is assessed. The relation between a PIRS score and (EuroQol) utility score is to be studied further.

Throughout the development of the method the feasibility, reliability and validity of the instruments have been monitored. This has lead to a number of adjustments and refinements. Further research will be required to establish the validity of the extension to the EuroQol instrument. The instruments have been applied to mobility-, hearing- and speech impaired subjects. Besides the English version, the instruments are available in Italian, Dutch, Norwegian and Swedish. The importance of this method is its ability to translate outcomes of AT use into utility scores, making Cost Utility Analysis possible.

4 IPPA

The IPPA (Individually Prioritised Problem Assessment) instrument has been designed to individually assess effectiveness of Assistive Technology provision. It assesses the extent to which problems in daily life, identified by individual users of AT, have been diminished as a result of the AT provision. Wessels and colleagues provide a comprehensive description of the instrument [7]. IPPA also was developed as part of the EATS project and has its roots in the CERTAIN project.

By the use of the instrument only the change in activities relevant for the assessment of individual effectiveness is monitored, after the activity related goals have been defined by the individual prior to the AT provision. Through this procedure the importance of the individual circumstances that determine the effectiveness of an AT device is valued. Moreover, it makes the instrument sensitive to inter-individual

differences, sensitive to changes, small according to general standard but essential in individual perspective and, finally, sensitive to the type of effects specific for the type of AT under consideration.

The instrument has been used in a number of studies through which the feasibility, responsiveness and validity was evaluated. Changes in IPPA score appear to be larger than on comparable instruments, supposedly due to its individualised quality. Application so far concerned (outdoor) mobility, communication aids, hearing aids and the use of MANUS, a robot manipulator. Besides the English version, IPPA is available in Italian, Dutch, Norwegian and Swedish.

The individually oriented nature and its sensibility to individual circumstances resulting from this makes IPPA an important instrument in assessing AT outcomes.

5 SCAI

Only few instruments are available to assess the cost side of cost effectiveness of AT provision. One of these is the SCAI instrument developed by Andrich [8]. The SCAI instrument has been designed to help AT professionals and users to estimate the economic aspects of an individual AT provision. It can provide a comparison of costs involved, for AT alternatives. The conceptual basis for SCAI also originates from the CERTAIN study.

The type of costs addressed in SCAI go beyond just financial costs and include the use of resources such as manpower and transport. It focuses on additional social costs of individual AT programmes, including the costs of all actors involved but excluding the costs of the assessment leading to the choice of an AT device. Such costs obviously exceed the purchase price, which is the basis for selection in many Service Delivery Systems. The comparison of just purchase prices easily leads to a completely different insight than the comparison of all social additional costs (investment, maintenance, services and assistance) and may, as a consequence, result in a different selection of AT.

For usability reasons the level of financial complexity of the calculations in SCAI is limited. Although this leads to less accurate figures, the comparison between AT alternatives is said to result in ranking identical to comparison based on more sophisticated financial calculations. This suggests good responsiveness and validity.

The SCAI instrument is important for its structured method in estimating costs and the adopted comprehensive attitude towards costs involved with AT provision, for example reflected in the valuation of assistance provided by a non professional carer. Such costs are usually considered free of charge.

6 Discussion

The instruments described in this paper are among the leading European instruments developed for the assessment of AT outcomes. The common background of the instruments and the overlap in researchers contributing to the development is striking. The combination of three instruments however, does not form a sufficient set of tools for the assessment of AT outcomes. Even with the available North American

instruments taken into account, there is a need for further development of instruments. Unfortunately, although evidence for cost-effectiveness is increasingly required across Europe at both policy and individual level, an increasing development of generic instruments tailored to the assessment of outcomes of Assistive Technology is not witnessed yet. A number of barriers can be mentioned as an explanation; 1) the specific nature of AT outcomes is not generally acknowledged, related to this is the absence of a conceptual framework on the nature of AT outcomes, 2) instruments from adjacent domains (e.g. HTA) are considered applicable and are being applied and, finally 3) the development of a generic instrument involves considerable effort requiring the investment of both time and resources.

Overcoming these barriers will require European collaboration. Collaboration in raising awareness of the specific problems related to the assessment of AT outcomes and a coherent strategy in the development of instruments, including the development of a conceptual framework of AT outcomes is necessary. Such a framework can steer instruments under development and initiate new instruments. Furthermore, the international exchange of data obtained with standardised instruments can speed up the development of instruments.

Unfortunately, recent initiatives in restarting European collaboration in the development of instruments for outcome assessment have not been successful in obtaining financial support from the European Commission.

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Implementing Outcomes Measurement in an Assistive Technology Service Delivery System

Gerald Craddock

Client Technical Services Department,
Central Remedial Clinic, Dublin, Ireland
gcraddock@crc.ie

Abstract. The purpose of this paper is to outline the Assistive Technology (AT) national service delivery system in Ireland. Assessing both the structural supports and barriers that are present within the Irish system. National governments throughout Europe are looking to streamline their services and to monitor and measure the quality of those services. In Ireland these initiatives have come at a time where the health service is in urgent need of reorganisation and restructuring. Massive cuts and lack of government funding over the past three decades has dangerously depleted the whole health care system. At the same time the health services are looking at how to measure the quality of service. The outcomes of two national projects carried out by the Central Remedial Clinic's (CRC) Client technical Services Dept. (CTS) are outlined to show one possible way that the future may be constructed through positive action within a partnership philosophy.

1 The Macro Level – How the System Works in Ireland

At present the legislators are under increasing pressure by the citizens of Ireland who are demanding to be provided with improved state services and in particular with a better quality and a more efficient health care system. Although less people are going out to vote there are more people demanding their rights through advocacy groups, lobbyists and consumer rights. Today consumers are more educated and they have more access to information than ever before. In this unprecedented "Celtic tiger" economic boom consumers are angry that so many state services are ineffectual and fail to provide the services that people need. A person can wait up to a year or more for a consultants appointment and up to two years to receive assistive devices.

One of the most powerful examples of the power of the people was the defeat of the government's Disability bill earlier this year. It was defeated and withdrawn by the government as a result of intense public outcry. There had been no consultation with disability groups and many of the issues that people with disabilities have been fighting for, were ignored. Criticisms of the Bill centred on the long delays before many of the provisions were made, for example it would be fifteen years before transport would be fully accessible and twenty years before the platforms would be accessible. " You wait thirteen years for an accessible train to come and then discover that you can't get into the station for a further five years [1]. The bill also sought to

actually take away the right of people with disabilities to fight for their rights through legal challenge if the government failed to provide the services

It is almost a decade since the Department of health produced a health strategy, *Shaping a Healthier Future* [2]. The document laid out a strategy for developing health services that was guided by three main principles of equity, quality of service and accountability. The Health Strategy stated that access to health care should be determined by actual need rather than by ability to pay or geographical location. Ten years later the rhetoric is the same. The government has just introduced a new Health Strategy to try and reform a now seriously ailing health care system. Four key principals also guided the development of this strategy

1. Equity, people are treated fairly according to need
2. People-centeredness, health system will identify and respond to the needs of individuals and take part in the decision making to improve their health
3. Quality, evidence based standards are set in partnership with consumers and are externally validated and continuous improvement is valued
4. Accountability, financial, professional and organisational accountability is strengthened for better quality, efficiency and effectiveness

"Partnership with the consumers", the new health strategy contends that increasingly it will be the clients who will have the say and service providers must move towards giving their clients a more active role. For many years it was the professionals who drove the system, however now, it is the client who will hold the system accountable.[3] At the present moment people with disabilities have no legislative rights, if government departments fail to provide services their only recourse is to go to court and force them to provide the services through a judicial order. This is a long arduous and costly procedure and for the majority, not a possibility. Further to the lack of legislative rights, an anomaly exists in that the state health boards not only fund the services but they are also the service providers. There is no independent body. Disability groups have been lobbying the government for some time for three autonomous authorities, one for independent assessment, a second to deliver the service and a third a grievances/complaints authority.

In parallel with the new strategy, the Irish health services are also considering how to measure the quality of service. The five key elements that they are endeavouring to measure in this complex area are, Effectiveness, Efficiency, Health improvement, Equity/access, Patient satisfaction/experience of the health services.

However noble and worthwhile the performance measures may be, the information available at the moment does not look promising, if one looks at precisely how they propose to define and measure these indicators. Taking for example "effectiveness", this performance indicator will be measured by the median waiting time between referral and assessment as well as the median waiting time between assessment and commencement of treatment. The rationale for this is to provide baseline data, which will enable a review of the efficiency of the services. The definition of effectiveness put forward in the European HEART [4] initiative reads "Effectiveness means the capacity to find the best solutions for the greatest number of people, using available resources at the lowest cost, in the shortest possible time".

It is obvious that the performance indicator of effectiveness falls a long way short of the European HEART definition regarding the provision and measurement of quality services to people with disabilities. Quality service outcomes, as voiced by people with disabilities should produce an improved quality of life for the participant

and a greater capacity to participate in their own communities, be it for leisure, work, living at home, education or training. This relationship between the delivery of goods and/or services and the consequential outcomes has long been recognised [2]

2 The Meso Level – Organisations

In Ireland services for people with disabilities lies within the remit of the health services. This has led to the understanding of disability within a medical interpretation of needs over a more holistic view of disability grounded in the everyday experiences of people with disabilities themselves. The development of disability services within a medical framework is one of the reasons why the primary responsibility for the assessment and administration of grant aided technical equipment for people with disabilities lies with the health authorities. Eight health boards act on behalf of the Department of Health. Funding is secured, usually through a local occupational therapist or speech therapist employed by the health board. The health and needs of people with disabilities are predominantly looked after by voluntary agencies. Out of these voluntary organisations has grown many of the specialist services, such as assistive technology, that are provided for people with disabilities. Historically these agencies were set up as charitable institution in response to the lack of care provided by the state. These agencies are now part-funded by the department of Health and fund raising activities. They provide health care, therapy, day care centres, sheltered employment, Assistive technology and special schooling. The agencies work independently of each other, due to their historic roots and tend to split according to the disability, hence we the National Association for the Deaf People, Muscular Dystrophy Ireland, National Council for the Blind, Spina Bifida Association etc.

The Department of Education also provides funding for Assistive Technology through its provision for children with special needs. The Education Act 1998 [7] sets out the responsibility of the Minister of Education to ensure that an education is made available to every person, including those with disabilities, support services and a level and quality of education appropriate to their needs and abilities. However each provision for children with disabilities within the bill is followed by the proviso by "as far as practicable and having regard to the resources available". So if there is money available, students with special needs will be catered for. In reality, an increasing numbers of parents have no other option but to sue the Department of Education to force them to provide an education for their children with special needs.

Schools have been given resource teachers and special needs assistants (in some cases) however the reality is that one resource teacher has to cater for the whole school and this includes children with learning difficulties, reading difficulties, etc. On average there could be up to 5 children per class who needs the attention of a resource teacher. The Irish education system was developed on the basis of a narrowly defined concept of normality. What is of concern to many is that the environment, the academic processes and social relations in schools do not provide adequate supports for the full spectrum of students needs [8]. Mason [9] contends that the school system can never meet the needs of students because it was developed by practitioners of our past, faulty eugenics-based education system: Standardised Testing, Setting, Selective specialist schools are no measure of a child's worth.

In Ireland there is no legislation governing the right of people with disabilities to Assistive Technology. Students with special needs can apply for grants, but unlike other countries, for example in America where legislation guarantees the rights of people to AT, if their application is turned down, they have no legal recourse. AT is funded through Department of Education and the Department of Health. Applications can take a long time, one school documented that by the time the school was given the money to buy a student with special needs a computer, she was about to leave the school. While once the computer is purchased there is one special advisor in the whole country to advise teachers on suitable software. There are 3,303 primary school and 759 secondary schools under this one advisor's remit.

At present The National Centre for Technology (NCTE) acts as a think tank on technology for the Department of Education (in their latest report they made no mention of assistive technology for students with disabilities [10]), however funding comes directly from the department itself. The number of students with disabilities in education is estimated to be least 4% of the school-going population. There is an AT scheme in place since 1995 known as M11/95 which allows for provision of technology at second-level. However it does not contain any element of either training or support which are essential to the successful use of technology. Neither is there an equivalent funding system for other educational sectors, i.e. primary or third level.

The need for structure and funding policies has long been recognised. Ten years ago the National Council for Curriculum and Assessment described the need for computers for special needs as critical. A Strategy for Equality argued that if "one is to measure the status of people with disabilities by their rate of participation and success in education, equality is still a long way off. Participation by people with disabilities in education at all levels is significantly below that of the population in general" [6]

3 Micro Level – The Service Providers

In Ireland AT is still seen as a rehabilitative tool which will help in the eventual rehabilitation of the "patient" rather than as an enabling tool to support people with disabilities to achieve a better quality of life. It is assumed that AT can be administered by therapists, although it is still not part of their training and in a recent study it was found that in one area of the country some therapists reported that they had heard of the term AT, while others had heard of AT but wanted training. [11] In Fact The Strategy for Equality [6] argued that AT is inappropriately placed within the context of health services which are dominated by medical concerns and recommended that responsibility should be transferred to the Department of Social Welfare and the Department of Transport, Energy and Communications. The Strategy argued that these two departments should introduce legislation to ensure access to AT and telecommunications in line with UN Standard Rules. Six years later none of these recommendations have been implemented.

The Client technical Services (CTS) in the Central Remedial Clinic (CRC) has been working for the past five years on implementing an outcomes based AT service for people with physical disabilities throughout Ireland. The Matching Person and Technology (MPT) research model developed by Dr Marcia Scherer in America was adapted for use in the Irish context. This model emphasises the active participation of

the client in the selection of appropriate equipment and in the ongoing evaluation and decision making processes through two European funded projects (STATEMENT and APHRODITE), CTS have taken a bottom up approach to the complex issues involved in service delivery. The Client is central to the whole process and collaborates with an evaluation team of therapists, technical and engineering staff..

In the outcomes approach to quality, the personal outcome is what the individual expects as a result of this activity. It is the outcomes that dominate the discussion of quality in service and supports for people with disabilities. With the financial support of the European project, CTS formed a partnership with one of the main disability groups in Ireland; The Centre for Independent Living (CIL), the motto of its members is "Nothing about us, without us". In collaboration a user centred approach was perceived as the only way forward.

CTS is modelled on the client focused Social & Participatory Service Delivery Model in AT [12]. This is based on studies of people with disabilities and their own experiences, There is an emphasises on bringing AT to people in their own environment which lead to the development of two important strategies within the service; the employment of Technical Liaison Officers (six working in various parts around the country) to support people with disabilities in the local area and secondly to provide an outreach service comprising of the CTS evaluation team who assess people for AT in their own environment and act as support in training and updating information to the TLOs. Briefly CTS has provided the following

1. A Certificate in Assistive Technology (CATA) which has provided training to people with disabilities, carers and professionals in AT, (Accredited through the University College Dublin, a diploma will be provided this year and there are plans for a masters course)
2. Training and employing TLOs (Technology Liaison Officers) who are people with disabilities to become the local support for other people with disabilities in their geographic area. This has the double effect of both providing employment and a vital local support network
3. TLOs provide ongoing support for those in use of their technology (studies have shown lack of support and training is the main reason for people not using the technology)
4. TLOs also provide information to those who have yet to hear of the technology and the CTS service
5. CTS provide a local assessment for users, co-ordinated by the TLOs, they provide a link between CTS and the user - this allows the assessment team to evaluate the user in their own environment.
6. Public information sessions have been held nationwide with the express purpose of raising public awareness of, and promoting public access to AT;

TLOs point out that there are various advantages in having a disability while working with people with disabilities, there is an increased knowledge of disability, they have the ability to empathise, they recognise the need to make contact with people who are often isolated and lonely, there is the breaking down of professional barriers and they provide positive role models for other people with disabilities.

A further important aspect of the Aphrodite project was to work with the local professionals both to give them up-to-date information on technology but also importantly that they might also work with the TLOs as local supporters for people

with disabilities. While working with local professionals a number of issues became apparent

1. The need for regionalised, AT services was strongly identified by professionals.
2. The lack of regular contact between the Aphrodite project and local services was viewed as an obstacle to integration and credibility. The outcome is that the project does not have a local profile and the perception is that it is centralised in Dublin. Therefore, professionals are reluctant to initiate contact with the project or to contact the TLO locally.
3. The low level of knowledge and expertise in AT amongst professionals means that the assimilation of AT into professional practice is at a very early stage of development in many regions.
4. The current grant system has been shown to be unsatisfactory in that the ultimate decision making to apply for grant aided technology lies with the occupational therapist rather than with the individual. This perpetuates dependency relationships between service users and providers rather than independence.
5. Occupational therapists reported their frustration at having to work within budgetary confinements for technical equipment. They particularly noted the lack of costing for follow up training and maintenance once equipment was issued. There was consensus that this contributed to abandonment and wastage.
6. Potential demand for grant aided technology remains invisible in the official statistics sent to the Department of Health by the Community Occupational Therapy Services, as many reportedly do not apply for funding in the belief that applications will be rejected. This discretionary power of professionals is viewed as an obstacle to promoting the rights of individuals with disabilities.
7. The self-belief of the Occupational Therapy profession in the uniqueness of its holistic approach is viewed as a potential obstacle to the acceptance and integration of other personnel who are holistically trained on the CATA course such as TLOs attached to the project.
8. A major obstacle for the TLOs is the lack of common language between themselves and professionals. This has led to difficulties in establishing two-way communication channels.

4 Case Study

The interview was with a resource teacher and class teacher in a rural primary school that was attempting to cater for a pupil with disabilities. The pupil had been in Junior Infants in the last school year but her teachers were concerned about her future development as she had difficulties with fine motor skills. The resource teacher explained their predicament:

"Last year when she was in Junior Infants I was wondering about a computer but I wasn't sure if we bought it what to do with it." "Its only in recent years resource teachers have been allocated to schools to teach children with special needs rather than sending them to special schools. Everything would have been in place there. We don't have any guidelines as resource teachers yet. There are no procedures in place yet. We have no information." They made contact with the TLO when he was in training. "Without the TLO we wouldn't have known what to do. We'd have been

ringing the Department and whoever. It's new for us too. Other things, situations you know 'this is what you do'. This is new."

5 Outcomes

The TLO was able to arrange an assessment by CRC's Client Technical Services as part of their outreach programme. The fact that the assessment could happen in her own school had clear advantages as far as her teachers are concerned:

"In a new situation Joanne can be nervous. So the fact that she was here, that we were here as well, all that - X (HB Occupational Therapist) was here as well I had been doing a bit of thinking about skills so we could see exactly what she wanted to do. In fact I was there to say Joanne type such and such a thing, to spell it out for her. If she was above in Dublin nobody would know exactly what she could do. They could see exactly what she could do because she felt at home."

It also was beneficial for her mother who is a lone parent and meant she did not have the financial expense of travelling to Dublin.

Because they had availed of the services of the TLO before the assessment they were able to see how the pupil managed with a keyboard he made available. The assessment process was very much a collaborative effort.

"An educational psychologist, OT as well as teachers were involved in the process. Probably for the first time there was a meeting of all the people who were involved with the child. Everybody was there and there was a chance for an exchange of views that couldn't have happened on a one to one basis They could see Joanne's school. They could see the environment she's living in". They were also able to get the equipment before the start of the next academic year, if we had gone through the Department of Education it could have been next year."

They know that they can contact the TLO if they have concerns in the future.

6 Conclusion

CTS has been providing an AT service for people with disabilities for the past twenty years. There have been many important changes in that time but none as important as the founding of the Independent Living movement in Ireland, people with disabilities have found a voice and they are gradually shifting from 'patient status to consumer status". There have been important developments in AT also. The emphasis has shifted from medical equipment to tools for independent living from professional driven choice to user-driven choices, It is no longer sufficient to look to AT to enhance individual functioning. It is more important to address whether or not that AT assists the user in achieving valued life roles and goals. The Aphrodite project succeed in bringing AT services to users. The TLOs are employed now by CTS and are part of mainstream services. We will continue to work in partnership and already future projects are planned. The wealth of experience of working in partnership brings an important dimension to AT service delivery.

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