



# HTML5 and JavaScript Projects

Build on your Basic Knowledge of HTML5  
and JavaScript to Create Substantial HTML5  
Applications

—

*Second Edition*

—

Jeanine Meyer

Apress®

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Jeanine Meyer  
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Printed on acid-free paper

*To my family, including my parents, who still take care of me*

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# About the Author



**Jeanine Meyer** is a full professor at Purchase College/State University of New York. She teaches courses to students majoring in mathematics/computer science and also enjoys the frequent presence of others in her classes, including new media, music, dance, economics, and chemistry majors. She developed and teaches courses satisfying the mathematics general education requirement, including one on math in the news and one on origami. The website for her academic activities is <http://faculty.purchase.edu/jeanine.meyer>.

Before coming to academia, she was a research staff member and manager at IBM Research, focusing on robotics and manufacturing research, and she later worked on the corporate manufacturing staff and as a research consultant at IBM for educational grant programs.

She has enjoyed working with Apress, including updating the HTML5 books. She continues with the practice of building programming examples using media featuring her family and her activities and hopes that inspires readers to create work on topics that are important to them. Her hobbies and interests include studying Spanish and piano, playing computer games, doing origami, and volunteering for progressive candidates and causes. She enjoys her daughter Aviva's cooking while doing some baking herself and looks forward to travel this year.

# About the Technical Reviewer



**Takashi Mukoda** is an international student at Purchase College/State University of New York. He is currently taking a semester off and back home in Japan. At Purchase College, he majors in Mathematics/Computer Science and New Media and has worked as a teaching assistant for computing and mathematics courses.

Takashi likes playing the keyboard and going on hikes in the mountains to take pictures. His interest in programming and art motivates him to create multimedia art pieces. Some of them are built with Processing and interact with human motion and sounds.

(See his website at <http://www.takashimukoda.com>.)

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# Introduction

This book continues my exploration of HTML5. My approach in developing the projects was to combine features such as canvas and video, attempt more intricate drawing by using mathematics, and use standard programming techniques such as object-oriented programming and separation of content and logic. I was also interested in building applications combining HTML5 and JavaScript with other technologies, including Google Maps.

Each chapter in the book is focused on an application or set of related applications. This is because my experience as a teacher and a learner has shown that concepts and mechanics are best understood in the context of actual use. The applications start off with drawing the HTML5 official logo. As you will find out in Chapter 1, the way I developed this application prompted use of coordinate transformations.

The project in Chapter 2, involving a family collage, was inspired by my growing family and the desire to teach about object-oriented programming. It is a good application for you to use as a foundation to create your own, with your own photos and objects of your own invention. Chapter 3, which shows how to create a bouncing video, was built on other two-dimensional applications I have created, and features two different ways to combine canvas and video.

Chapters 4 and 5 demonstrate use of the Google Maps API (Application Programming Interface), a powerful facility that allows you to incorporate access to Google Maps as part of your own projects. Chapter 4 presents a user interface combining map and canvas and includes a custom-designed cursor and the use of alpha (transparency) in drawing paths. The map quiz in Chapter 5 demonstrates the use of mapping as a portal to media. The application shows you how to separate content and logic so you can scale up to various applications (e.g., a tour of a region or a geography quiz with many locations).

Chapter 6 features a game called Add to 15, which turned out to be an excellent example of arrays. It also demonstrated the necessity to prepare for bad behavior on the part of players.

In Chapter 7, I use the task of producing directions for origami to show how to combine line drawings, often using mathematical expressions, and video and photographs. You can use this as a model for your own set of directions for a task in which drawings, video, or images would be most appropriate. Or you can let the reading refresh your memory for topics in algebra and geometry. Chapter 8 features a jigsaw puzzle that is transformed into a video when it's completed. Chapter 9 is an educational game with questions on the states of the USA, and it includes the challenge of a jigsaw puzzle. The jigsaw puzzle includes the feature of saving the puzzle-in-progress using `localStorage`.

For Chapter 10, I decided to address challenges of responsive design and accessibility as being more appropriate for an HTML and JavaScript book than what I had before. My examples demonstrate ways to incorporate touch in addition to mouse actions, to respond to different screen dimensions, and to specify tab order to ease the use of screen readers.

## Who Is This Book For?

I do believe my explanations are complete, but I am not claiming, as I did for my previous book, *The Essential Guide to HTML5*, that this book is for the total beginner. This book is for the developer who has some knowledge of programming and who wants to build (more) substantial applications by combining features of JavaScript and going beyond the basics. It also can serve as an idea book for someone working with programmers to get an understanding of what is possible.

## How Is This Book Structured?

This book consists of 10 chapters, each organized around an application or type of application. You can skip around, though there are cross-references between chapters, indicated in the text. Each chapter starts with an introduction to the application, with screenshots of the applications in use. The chapters continue with a discussion of the critical requirements in which concepts are introduced before diving into the technical details. The next sections describe how the requirements are satisfied, with specific constructs in HTML5, JavaScript, and CSS. I then show the application coding line by line with comments. You can decide how to read these tables. You may decide

to use them as a reference when writing your own programs. Each chapter ends with instructions and tips for testing and uploading the application to a server, and a summary of what you learned.

The code is included as downloads available from the publisher. Go to <https://github.com/Apress/html-js-projs>. In addition, the figures are available as full-color TIFF files. Of course, you will want to use your own media for the projects. My media (video, audio, and images) is included with the code and this includes images for the 50 states for the states game in Chapter 9. You can use the project as a model for a different part of the world or a puzzle based on an image or diagram. There are extras: a program for an origami frog included with the code in Chapter 7 and a version of the jigsaw turning into a video from Chapter 8 adapted for use on devices requiring touch is included with the source code for Chapter 10.

Let's get started.



## CHAPTER 1

# Building the HTML5 Logo: Drawing on Canvas with Scaling and Semantic Tags

In this chapter, you will learn the following:

- Drawing paths on a canvas
- Placing text on a canvas
- Coordinate transformations
- Fonts for text drawn on canvas and fonts for text in other elements
- Semantic tags
- The range input element

## Introduction

The project for this chapter is a presentation of the official HTML5 logo, with accompanying text. The shield and letters of the logo are drawn on a canvas element and the accompanying text demonstrates the use of semantic tags. The viewer can change the size of the logo using a slider input device. It is an appropriate start to this book, a collection of projects making use of HTML5, JavaScript, and other technologies, because of the subject matter and because it serves as a good review of basic

event-driven programming and other important features in HTML5. The way I developed the project, building on the work of others, is typical of how most of us work. In particular, the circumstances provide motivation for the use of coordinate transformations.

The approach of this book is to explain HTML5, Cascading Style Sheets (CSS), and JavaScript chapters in the context of specific examples. The projects represent a variety of applications and, hopefully, you will find something in each one that you will learn and adapt for your own purposes.

---

**Note** If you need an introduction to programming using HTML5 and JavaScript, you can consult my book, *The Essential Guide to HTML5* or other books published by Apress or others. There also is considerable material available online, for example, at W3Schools.

---

Figure 1-1 shows the opening screen for the logo project on the Chrome browser. It is important to realize that browsers can be different. Look ahead to how this appeared using Firefox when I first wrote this example.



Scale percentage:  Note: slider treated as text field in some browsers.  
Built on [work by Daniel Davis, et al](#), but don't blame them for the fonts. Check out the use of *font-family* in the style element and the *fontfamily* variable in the script element for safe ways to do fonts. I did the scaling. Note also use of semantic elements.  
HTML5 Logo by [W3C](#).

---

**Figure 1-1.** Opening screen for HTML5 logo

Notice the slider feature, the accompanying text, which contains what appears to be a hyperlink, and the text in a footer below a yellow line. The footer also includes a hyperlink. As I will explain later, the function and the formatting of the footer and any other semantic element is totally up to me, but providing a reference to the owners of the logo, the World Wide Web Consortium would be deemed an appropriate use.

The viewer can use the slider to change the size of the logo. Figure 1-2 shows the application after the slider has been adjusted to show the logo reduced to about a third in width and in height.



Scale percentage:  Note: slider treated as text field in some browsers.

Built on [work by Daniel Davis, et al](#), but don't blame them for the fonts. Check out the use of *font-family* in the style element and the *fontfamily* variable in the script element for safe ways to do fonts. I did the scaling. Note also use of semantic elements.

---

HTML5 Logo by [W3C](#).

**Figure 1-2.** *Logo scaled down*

The implementation of HTML5 is complete, or pretty close, in all browsers. However, I want to show you something from the past to illustrate the term *graceful degradation*. Figure 1-3 shows the opening screen in the older Firefox. The range input is treated as text. Notice the initial value is displayed as 100.



Scale percentage:  Note: slider treated as text field in some browsers.

Built on [work by Daniel Davis, et al](#), but don't blame them for the fonts. Check out the use of *font-family* in the style element and the *fontfamily* variable in the script element for safe ways to do fonts. I did the scaling. Note also use of semantic elements.

---

HTML5 Logo by [W3C](#).

**Figure 1-3.** Application using Firefox

As will be the practice in each chapter, I now explain the critical requirements of the application, more or less independent of the fact that the implementation will be in HTML5, and then describe the features of HTML5, JavaScript, and other technologies as needed that will be used in the implementation. The “Building” section includes a table with comments for each line of code and guidance for building similar applications. The “Testing” section provides details for uploading and testing. This section is more critical in some projects than others. Lastly, there is a “Summary” section that reviews the programming concepts covered and previews what is next in the book.

## Project History and Critical Requirements

The critical requirements for this project are somewhat artificial and not easily stated as something separate from HTML. For example, I wanted to draw the logo as opposed to copying an image from the Web. My design objectives always include wanting to practice programming and prepare examples for my students. The shape of the shield part of the logo seemed amenable to drawing on canvas and the HTML letters could be done using the draw text feature. In addition, there are practical advantages to drawing images instead of using image files. Separate files need to be managed, stored, and downloaded. The image shown in Figure 1-4 is 90KB. The file holding the code for the program is only 4KB. Drawing a logo or other graphic means that the scale and other attributes can be changed dynamically using code.



**Figure 1-4.** *Image of a logo*

I looked online and found an example of just the shield done by Daniel Davis, @ourmaninjapan. This was great because it meant that I did not have to measure a copy of the logo image to get the coordinates. This begs the question of how he determined the coordinates. I don't know the answer, even though we had a pleasant exchange of emails. One possibility is to download the image and use the grid feature of image processing programs such as Adobe Photoshop or Corel Paint Shop Pro. Another possibility is to use (old-fashioned) transparent graph paper.

However, there was a problem with building on Daniel Davis's work. His application did not include the HTML letters. The solution to this was to position the letters on the screen and then move down, so to speak, to position the drawing of the shield using the coordinates provided in Daniel's example. The technical term for "moving down the screen" is performing a coordinate transformation. So the ability to perform coordinate transformations became a critical requirement for this project.

I chose to write something about the logo and, in particular, give credit and references in the form of hyperlinks. I made the decision to reference the official source of the logo as brief text at the bottom of the document below a line. The reference to Daniel Davis was part of the writing in the body. We exchanged notes on font choices and I will discuss that more in the next section.

In order to give the viewer something to do with the logo, I decided to present a means of changing the size. A good device for this is a slider with the minimum and maximum values and steps all specified. So the critical requirements for this application include drawing shapes and letters in a specific font, coordinate transformations, formatting a document with a main section and a footer section, and including hyperlinks.

## HTML5, CSS, and JavaScript features

I assume that you, the reader, have some experience with HTML and HTML5 documents. One of the most important new features in HTML5 is the canvas element for drawing. I describe briefly the drawing of filled-in paths of the appropriate color and filled-in text. Next, I describe coordinate transformations, used in this project for the two parts of the logo itself and for scaling, changing the size, of the whole logo. Lastly, I describe the range input element. This produces the slider.

### Drawing Paths on Canvas

Canvas is a type of element introduced in HTML5. All canvas elements have a property (aka an *attribute*) called the 2D context. The context has methods for drawing, which you will see in use. Typically, a variable is set to this property after the document is loaded:

```
ctx = document.getElementById('canvas').getContext('2d');
```

It is important to understand that canvas is a good name: code applies color to the pixels of the canvas, just like paint. Code written later can put a different color on the canvas. The old color does not show through. Even though our code causes rectangles and shapes and letters to appear, these distinct entities do not retain their identity as objects to be re-positioned.

The shield is produced by drawing six filled-in paths in succession with the accumulated results, as shown in Figure 1-5. You can refer to this picture when examining the code. Keep in mind that in the coordinates, the first number is the distance from the left edge of the canvas and the second number is the distance from the top edge of the canvas.



**Figure 1-5.** Sequence of paths for drawing the logo

By the way, I chose to show you the sequence with the accumulated results. If I displayed what is drawn, you would not see the white parts making up the left side of the five. You can see it because it is two white filled-in paths on top of the orange.

All drawing is done using methods and properties of the `ctx` variable holding the 2D context property of the canvas element. The color for any subsequent fill operation is set by assigning a color to the `fillStyle` property of the canvas context.

```
ctx.fillStyle = "#E34C26";
```

This particular color, given in the hexadecimal format—where the first two hexadecimal (base 16) digits represent red, the second two hexadecimal digits represent green, and the last two represent blue—is provided by the W3C website, along with the other colors, as the particular orange for the background of the shield. It may be counterintuitive, but in this system, white is specified by the value `#FFFFFF`. Think of this as all colors together make white. The absence of color is black and specified by `#000000`. The pearly gray used for the right side of the 5 in the logo has the value `#EBEBEB`. This is a high value, close to white. It is not necessary that you memorize any of these values, but it is useful to know black and white, and that a pure red is `#FF0000`, a pure green is `#00FF00`, and a pure blue is `#0000FF`. You can use the eyedropper/color picker tool in drawing programs such as Adobe Photoshop, Corel Paint Shop Pro, or the online tool <http://pixlr.com/> to find out values of colors in images *or* you can use the official designation, when available, for official images.

All drawing is done using the two-dimensional coordinate systems. Shapes are produced using the path methods. These assume a current location, which you can think of as the position of a pen or paint brush over the canvas. The critical methods are moving to a location and setting up a line from the current location to the indicated location. The following set of statements draws the five-sided orange shape starting at the lower, left corner. The `closePath` method closes up the path by drawing a line back to the starting point.

```
ctx.fillStyle = "#E34C26";
ctx.beginPath();
ctx.moveTo(39, 250);
ctx.lineTo(17, 0);
ctx.lineTo(262, 0);
ctx.lineTo(239, 250);
ctx.lineTo(139, 278);
ctx.closePath();
ctx.fill();
```

If you haven't done any drawing on canvas, here is the whole HTML script needed to produce the five-sided shape. The `onLoad` attribute in the `<body>` tag causes the `init` function to be invoked when the document is loaded. The `init` function sets the `ctx` variable, sets the `fillStyle` property, and then draws the path.

```
<!DOCTYPE html>
<html>
<head>
<title>HTML5 Logo</title>
<meta charset="UTF-8">
<script>
function init() {
  ctx = document.getElementById('canvas').getContext('2d');
  ctx.fillStyle = "#E34C26";
  ctx.beginPath();
  ctx.moveTo(39, 250);
  ctx.lineTo(17, 0);
  ctx.lineTo(262, 0);
  ctx.lineTo(239, 250);
  ctx.lineTo(139, 278);
  ctx.closePath();
  ctx.fill();
}
</script>
</head>
<body onLoad="init();">
<canvas id="canvas" width="600" height="400">
Your browser does not support the canvas element.
</canvas>
</body>
</html>
```

Do practice and experiment with drawing on the canvas if you haven't done so before, but I will go on. The other shapes are produced in a similar manner. By the way, if you see a line down the middle of the shield, this is an optical illusion.



## Placing Text on Canvas and in the Body of a Document

Text is drawn on the canvas using methods and attributes of the context. The text can be filled in, using the `fillText` method or drawn as an outline using the `strokeText` method. The color is whatever the current `fillStyle` property or `strokeStyle` property holds. Another property of the context is the `font`. This property can contain the size of the text and one or more fonts. The purpose of including more than one font is to provide options to the browser if the first font is unavailable on the computer running the browser. For this project, I use

```
var fontfamily = "65px 'Gill Sans Ultra Bold', sans-serif";

and in the init function

ctx.font = fontfamily;
```

This directs the browser to use the Gill Sans Ultra Bold font if it is available and if not, use whatever the default sans serif font on the computer.

I could have put this all in one statement, but chose to make it a variable. You can decide if my choice of font was close enough to the official W3C logo.

---

**Note** There are at least two other approaches to take for this example. One possibility is *not* to use text but to draw the letters as filled-in paths. The other is to locate and acquire a font and place it on the server holding the HTML5 document and reference it directly using `@font-face`.

---

With the font and color set, the methods for drawing text require a string and a position: x and y coordinates. The statement in this project to draw the letters is

```
ctx.fillText("HTML", 31,60);
```

Formatting text in the rest of the HTML document, that is, outside a canvas element, requires the same attention to fonts. In this project, I choose to make use of the semantic elements new to HTML5 and follow the practice of putting formatting in the style element. The body of my HTML script contains two article elements and one footer elements. One article holds the input element with a comment and the other article holds the rest of the explanation. The footer element contains the reference to W3C. Formatting and using these are up to the developer/programmer. This includes

making sure the footer is the last thing in the document. If I placed the footer before one or both articles, it would no longer be displayed at the foot, that is, the bottom of the document. The style directives for this project are the following:

```

footer {display:block; border-top: 1px solid orange; margin: 10px; ←
  font-family: "Trebuchet MS", Arial, Helvetica, sans-serif; font-weight:
bold;}
article {display:block; font-family: Georgia, "Times New Roman", Times,
serif; margin: 5px;}

```

The styles each set up all instances of these elements to be displayed as blocks. This puts a line break before and after. The footer has a border on the top, which produces the line above the text. Both styles specify a list of four fonts each. So the browser first sees if Trebuchet MS is available, then checks for Arial, then for Helvetica and then, if still unsuccessful, uses the system default sans serif font for the footer element. Similarly, the browser checks for Georgia, then Times New roman, then Times and then, if unsuccessful, uses the standard serif font. This probably is overkill, but it is the secure way to operate. The footer text is displayed in bold and the articles each have a margin around them of 5 pixels.

Formatting, including fonts, is important. HTML5 provides many features for formatting and for separating formatting from structure and content. You do need to treat the text on the canvas differently than the text in the other elements.

## Coordinate Transformations

I have given my motivation for using coordinate transformations, specifically to keep using a set of coordinates. To review, a coordinate system is the way to specify positions on the canvas. Positions are specified as distances from an origin point. For the two-dimensional canvas, two coordinates are necessary: the first coordinate governs the horizontal and is often called the x and the second coordinate governs the vertical and is called the y. A pesky fact is that when drawing to screens, the y axis is flipped so the vertical is measured from the top of the canvas. The horizontal is measured from the left. This means that the point (100,200) is further down the screen than the point (100,100).

In the logo project, I wrote code to display the letters HTML and then moved the origin to draw the rest of the logo. An analogy would be that I know the location of my house from the center of my town and so I can give directions to the center of town and then give directions to my house. The situation in which I draw the letters in the logo and

“move down the screen” requires the translate transformation. The translation is done just in the vertical. The amount of the translation is stored in a variable I named `offsety`:

```
var offsety = 80;
...
ctx.fillText("HTML", 31, 60);
ctx.translate(0, offsety);
```

Since I decided to provide a way for the viewer to change the size of the logo, I used the scale transformation. Continuing the analogy of directions, this is equivalent to changing the units. You may give some directions in miles (or kilometers) and other directions in yards or feet or meters or, maybe, blocks. The scaling can be done separately for each dimension. In this application, there is a variable called `factorvalue` that is set by the function invoked when the input is changed. The statement

```
ctx.scale(factorvalue, factorvalue);
```

changes the units for both the horizontal and vertical direction.

HTML5 provides a way to save the current state of the coordinate system and restore what you have saved. This is important if you need your code to get back to a previous state. The saving and restoring is done using what is termed a *stack*: last in first out. Restoring the coordinate state is termed *popping the stack* and saving the coordinate state is *pushing* something onto the stack. My logo project does not use this in its full power, but it is something to remember to investigate if you are doing more complex applications. In the logo project, my code saves the original state when the document is first loaded. Then before drawing the logo, it restores what was saved and then saves it again so it is available the next time. This is overkill for this situation, but it is a good practice just in case I add something in the future. Do your own experiments! The code at the start of the function `dologo`, which draws the logo, starts as follows:

```
function dologo() {
var offsety = 80 ;
ctx.restore();
ctx.save();
ctx.clearRect(0,0,600,400);
ctx.scale(factorvalue, factorvalue);
ctx.fillText("HTML", 31,60);
ctx.translate(0,offsety);
```

```

// 5 sided orange background
ctx.fillStyle = "#E34C26";
ctx.beginPath();
ctx.moveTo(39, 250);
ctx.lineTo(17, 0);
ctx.lineTo(262, 0);
ctx.lineTo(239, 250);
ctx.lineTo(139, 278);
ctx.closePath();
ctx.fill();

// right hand, lighter orange part of the background
ctx.fillStyle = "#F06529";
ctx.beginPath();
ctx.moveTo(139, 257);
ctx.lineTo(220, 234);
ctx.lineTo(239, 20);
ctx.lineTo(139, 20);
ctx.closePath();
ctx.fill();
...

```

Note that the canvas is cleared (erased) of anything that was previously drawn.

## Using the Range Input Element

The input device, which I call a *slider*, is the new HTML5 input type `range`, and is placed in the body of the HTML document. Mine is placed inside an article element. The attributes of this type and other input elements provide ways of specifying the initial value, the minimum and maximum values, the smallest increment adjustment, and the action to take if the viewer changes the slider. The code is

```

<input id="slide" type="range" min="0" max="100" value="100" ←
  onChange="changescale(this.value)" step="10"/>

```

The `min`, `max`, (initial) `value`, and `step` can be set to whatever you like. Since I was using percentage and since I did not want the logo to get bigger than the initial value or deal with negative values, I used 0 and 100.

In the proper implementation of the slider, the viewer does not see the initial value or the maximum or minimum. My code uses the input as a percentage. The expression `this.value` is interpreted as the value attribute of *this* element, emphasis given to convey the switch to English! The term `this` has special meaning in JavaScript and several other programming languages. The `changescale` function takes the value, specified by the parameter given in the assignment to the `onChange` attribute, and uses it to set a global variable (a variable declared outside of any function so it persists and is available to any function) named `factorvalue`.

```
function changescale(val) {
    factorvalue = val / 100;
    dologo();
}
```

It is part of the specification of HTML5 that the browsers will provide form validation, that is, browsers will check that the conditions specified by attributes in the input elements are obeyed. This can be a significant productivity boost in terms of reducing the work programmers need to do and a performance boost since the checking probably would be faster when done by the browser. In the HTML5 logo project, an advantage of the slider is that the viewer does not need to be concerned with values but merely moves the device. There is no way to input an illegal value. Figure 1-6 shows the results of entering a value of 200 in the input field.



**Figure 1-6.** Display in Firefox of scale of 200

The canvas is of fixed width and height and drawing outside the canvas, which is what is done when the scaling is done to accept numbers and stretch them out to twice the original value, is ignored.

## Building the Application and Making It Your Own

The project does one thing, it draws the logo. A function, `dologo`, is defined for this purpose. Informally, the outline of this program is

1. `init`: *Initialization*
2. `dologo`: *Draw the logo starting with the HTML letters and then the shield*
3. `changescale`: *Change the scale*

Table 1-1 shows the relationship of the functions. The `dologo` function is invoked when the document is first loaded and then whenever the scale is changed.

**Table 1-1.** *Functions in the HTML5 Logo Project*

Function	Invoked/Called By	Calls
<code>init</code>	Invoked by action of the <code>onLoad</code> attribute in the <code>&lt;body&gt;</code> tag	<code>dologo</code>
<code>dologo</code>	Invoked by <code>init</code> and <code>changescale</code>	
<code>changescale</code>	Invoked by action of the <code>onChange</code> attribute in the <code>&lt;input type="range" ...&gt;</code> tag	<code>dologo</code>

The coding for the `dologo` function puts together the techniques previously described. In particular, the code brings back the original coordinate system and clears off the canvas.

The global variables in this application are

```
var ctx;
var factorvalue = 1;
var fontfamily = "65px 'Gill Sans Ultra Bold', sans-serif";
```

As indicated earlier, it would be possible to not use the `fontfamily` but use the string directly in the code. It is convenient to make `ctx` and `factorvalue` global.

Table 1-2 shows the code for the basic application, with comments for each line.

**Table 1-2. Complete Code for the HTML5 Logo Project**

Code Line	Description
<code>&lt;!DOCTYPE html&gt;</code>	Header
<code>&lt;html&gt;</code>	Opening html tag
<code>&lt;head&gt;</code>	Opening head tag
<code>&lt;title&gt;HTML5 Logo &lt;/title&gt;</code>	Complete title element
<code>&lt;meta charset="UTF-8"&gt;</code>	Meta tag
<code>&lt;style&gt;</code>	Opening style tag
<code>footer {display:block; border-top: 1px solid orange; margin: 10px; font-family: "Trebuchet MS", Arial, Helvetica, sans-serif; font-weight: bold;}</code>	Style for the footer, including the top border and font family
<code>article {display:block; font-family: Georgia, "Times New Roman", Times, serif; margin: 5px;}</code>	Style for the two articles
<code>&lt;/style&gt;</code>	Close the style element
<code>&lt;!-- Start of script element --&gt;</code>	HTML comment
<code>&lt;script language="JavaScript"&gt;</code>	Opening script tag. Note: Case doesn't matter in JavaScript
<code>var ctx;</code>	Variable to hold the context; used in all drawings
<code>var factorvalue = 1;</code>	Set initial value for scaling
<code>var fontfamily = "65px 'Gill Sans Ultra Bold', sans-serif";</code>	Set the fonts for the text drawn on the canvas
<code>function init() {</code>	Start of init function
<code>    ctx = document.     getElementById('canvas').     getContext('2d');</code>	Set ctx

(continued)

**Table 1-2.** *(continued)*

<b>Code Line</b>	<b>Description</b>
<code>ctx.font = fontfamily;</code>	Set font for text drawn on canvas
<code>ctx.save();</code>	Save the original coordinate state
<code>dologo();</code>	Invoke function to draw the logo
<code>}</code>	Close function
<code>/* dologo function definition. This is the main function. It uses factorvalue to change the scale.</code>	Multi-line comment in JavaScript
<code>*/</code>	
<code>function dologo() {</code>	Start of dologo function
<code>var offsety = 80 ;</code>	Specify amount to adjust the coordinates to draw the shield part of the logo
<code>ctx.restore();</code>	Restore original state of coordinates
<code>ctx.save();</code>	Save it (push onto stack) so it can be restored again
<code>ctx.clearRect(0,0,600,400);</code>	Erase the whole canvas
<code>ctx.scale(factorvalue,factorvalue);</code>	Scale horizontally and vertically using value set by slider
<code>ctx.fillText("HTML", 31,60);</code>	Draw the letters: HTML
<code>ctx.translate(0,offsety);</code>	Move down the screen (canvas)
<code>// 5 sided orange background</code>	Single-line comment
<code>ctx.fillStyle = "#E34C26";</code>	Set to official bright orange
<code>ctx.beginPath();</code>	Start a path
<code>ctx.moveTo(39, 250);</code>	Move to indicated position at lower left
<code>ctx.lineTo(17, 0);</code>	Draw line up and more to the left
<code>ctx.lineTo(262, 0);</code>	Draw line straight over to the right
<code>ctx.lineTo(239, 250);</code>	Draw line down and slightly to the left

*(continued)*



**Table 1-2.** *(continued)*

<b>Code Line</b>	<b>Description</b>
<code>ctx.lineTo(139, 278);</code>	Draw line to the middle, low point of the shield
<code>ctx.closePath();</code>	Close the path
<code>ctx.fill();</code>	Fill in with the indicated color
<code>// right hand, lighter orange part of the background</code>	
<code>ctx.fillStyle = "#F06529";</code>	Set color to the official darker orange
<code>ctx.beginPath();</code>	Start the path
<code>ctx.moveTo(139, 257);</code>	Move to middle point, close to the top
<code>ctx.lineTo(220, 234);</code>	Draw line to the right and slightly up
<code>ctx.lineTo(239, 20);</code>	Draw line to the right and up
<code>ctx.lineTo(139, 20);</code>	Draw line to the left (point at the middle)
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in with the indicated color
<code>//light gray, left hand side part of the five</code>	
<code>ctx.fillStyle = "#EBEBEB";</code>	Set color to gray
<code>ctx.beginPath();</code>	Start path
<code>ctx.moveTo(139, 113);</code>	Move to middle horizontally, midway vertically
<code>ctx.lineTo(98, 113);</code>	Draw line to the left
<code>ctx.lineTo(96, 82);</code>	Draw line up and slightly further left
<code>ctx.lineTo(139, 82);</code>	Draw line to right
<code>ctx.lineTo(139, 51);</code>	Draw line up
<code>ctx.lineTo(62, 51);</code>	Draw line to the left
<code>ctx.lineTo(70, 144);</code>	Draw line to the left and down

*(continued)*

**Table 1-2.** *(continued)*

<b>Code Line</b>	<b>Description</b>
<code>ctx.lineTo(139, 144);</code>	Draw line to the right
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in with indicated color
<code>ctx.beginPath();</code>	Start a new path
<code>ctx.moveTo(139, 193);</code>	Move to middle point
<code>ctx.lineTo(105, 184);</code>	Draw line to the left and up
<code>ctx.lineTo(103, 159);</code>	Draw line slightly to the left and up
<code>ctx.lineTo(72, 159);</code>	Draw line more to the left
<code>ctx.lineTo(76, 207);</code>	Draw line slightly to the right and down
<code>ctx.lineTo(139, 225);</code>	Draw line to the left and down
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in the shape in the indicated color
<code>// white, right hand side of the 5</code>	
<code>ctx.fillStyle = "#FFFFFF";</code>	Set color to white
<code>ctx.beginPath();</code>	Start path
<code>ctx.moveTo(139, 113);</code>	Start at middle pint
<code>ctx.lineTo(139, 144);</code>	Draw line down
<code>ctx.lineTo(177, 144);</code>	Draw line to the right
<code>ctx.lineTo(173, 184);</code>	Draw line slightly left and down
<code>ctx.lineTo(139, 193);</code>	Draw line more left and down
<code>ctx.lineTo(139, 225);</code>	Draw line down
<code>ctx.lineTo(202, 207);</code>	Draw line to the right and up
<code>ctx.lineTo(210, 113);</code>	Draw line slightly right and up
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in white

*(continued)*

**Table 1-2.** (continued)

Code Line	Description
<code>ctx.beginPath();</code>	Start a new path
<code>ctx.moveTo(139, 51);</code>	Move to middle point
<code>ctx.lineTo(139, 82);</code>	Move down
<code>ctx.lineTo(213, 82);</code>	Move to the right
<code>ctx.lineTo(216, 51);</code>	Move slightly to the right and up
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in white
<code>}</code>	Close <code>dologo</code> function
<code>// The changescale function, response to user input.</code>	
<code>function changescale(val) {</code>	Open function <code>changevalue</code> with parameter
<code>factorvalue = val / 100;</code>	Set <code>factorvalue</code> to the input divided by 100
<code>dologo();</code>	Invoke function to draw logo
<code>}</code>	Close <code>changevalue</code> function
<code>&lt;/script&gt;</code>	Close the script element
<code>&lt;/head&gt;</code>	Close the head element
	The rest of the document is the body element
<code>&lt;body onLoad="init();"&gt;</code>	Body tag with attribute set to invoke <code>init</code>
<code>&lt;canvas id="canvas" width="600" height="400"&gt;</code>	Canvas tag setting dimensions and with ID to be used in code
Your browser does not support the canvas element.	Message to appear if canvas not supported
<code>&lt;/canvas&gt;</code>	Close canvas tag

(continued)

**Table 1-2.** (continued)

Code Line	Description
<code>&lt;article&gt;</code>	Article tag
Scale percentage: <code>&lt;input id="slide" type="range" min="0" max="100" value="100" onChange="changescale(this.value)" step="10"/&gt;</code>	The slider (range) input with settings
Note: slider treated as text field in some browsers.	Comment to note that slider may be text field; it is still usable
<code>&lt;/article&gt;</code>	Article close tag
<code>&lt;article&gt;Built on &lt;a href="http://daniemon.com/tech/html5/html5logo/"&gt;work by Daniel Davis, et al&lt;/a&gt;, but don't blame them for the fonts. Check out the use of <code>&lt;em&gt;font-family&lt;/em&gt;</code> in the style element and the <code>&lt;em&gt;fontfamily&lt;/em&gt;</code> variable in the script element for safe ways to do fonts. I did the scaling. Note also use of semantic elements.&lt;/article&gt;</code>	Article tag with some text, including hyperlink
<code>&lt;footer&gt;HTML5 Logo by &lt;a href="http://www.w3.org/"&gt;&lt;abbr title="World Wide Web Consortium"&gt;W3C&lt;/abbr&gt;&lt;/a&gt;.</code>	Footer tag and footer content, including abbr element
<code>&lt;/footer&gt;</code>	Footer close tag
<code>&lt;/body&gt;</code>	Body close
<code>&lt;/html&gt;</code>	HTML close

You can make this application your own by using all or parts of it with your own work. You probably want to omit the comments about fonts.

## Testing and Uploading the Application

This is a simple application to test and upload (and test) because it is a single file. The variable `factorvalue`, changed when the range input element is modified and the `changescale` function is invoked, can be used to adapt to different screens. This program appears to work well on different devices. The challenge of what is termed *responsive design* will be discussed in Chapter 10.

## Summary

In this chapter, you learned how make a specific drawing and learned the steps to take in producing other, similar, applications. The features used in this chapter include

- Paths
- Text on the canvas and text in semantic elements in the body
- The range input element and its associated change event
- Coordinate transformations, namely translate and scale
- Specification of sets of fonts
- Styles for semantic elements, including the border top to make a line to go before the footer

The next chapter describes how to build a utility application for making compositions or collages of photographs and shapes. It combines techniques for drawing on canvas and creating HTML elements with a standard technique in computing, objects. It also uses coordinate transformations.

## CHAPTER 2

# Family Collage: Manipulating Programmer-Defined Objects on a Canvas

In this chapter, you will learn the following:

- Creating and manipulating object oriented programming for drawing on canvas
- Handling mouse events, including double-clicks
- Saving the canvas to an image
- Using try and catch to trap errors
- Browser differences involving the location of the code
- Using algebra and geometry to construct shapes and determine when the cursor is over a specific object
- Controlling the icon used for the cursor

## Introduction

The project for this chapter is a utility for manipulating objects on a canvas to produce a picture. I call it a utility because one person does the programming and gathers photographs and designs and then can offer the program to friends, family members,

colleagues, and others to produce the compositions/collages. The result can be anything from an abstract design to a collage of photographs. The objects in my example include one rectangle, two ovals, a heart, two family photographs, and one video (Annika on the monkey bars). It is possible for you, or, perhaps, your end-user/customer/client/player, to make duplicate copies of any of the objects and remove items. The end-user positions the object using drag and drop with the mouse. When the picture is judged to be complete, it is possible to create an image that can be downloaded into a file.

Figure 2-1 shows the opening screen for my program. Notice that you start off with seven objects to arrange.

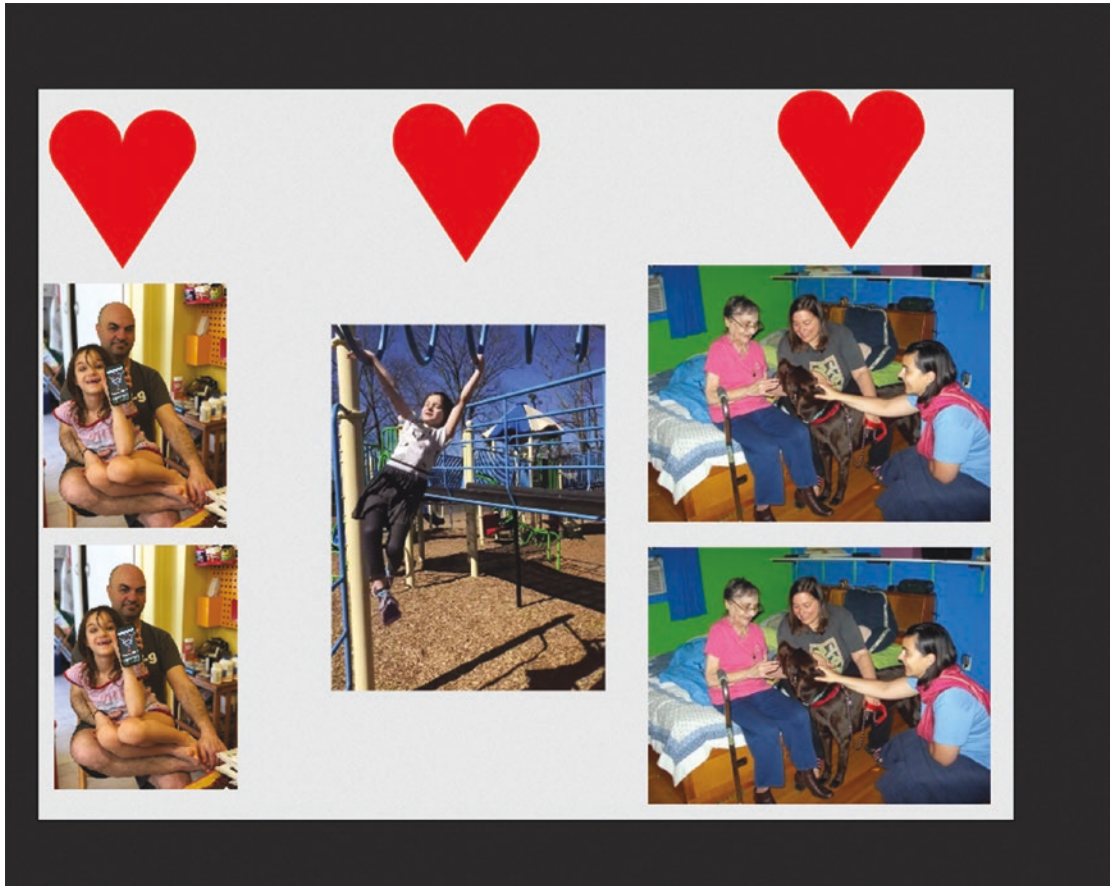
Mouse down, move and mouse up to move objects. Double click for make a copy of any object.

Open window with image (which you can save into image file)  
Remove last object moved



Figure 2-1. Opening screen for Family Pictures

Figure 2-2 shows what I, as an end-user, produced as a final product and saved as an image in a new window. I have duplicated (clones) the two photographs and the video, added two more hearts, and removed the rectangle and ovals.



**Figure 2-2.** *Sample final product: rearranged objects*

I decided on including a heart, not just for sentimental reasons, but because it required me to use algebra and geometry. Don't be afraid of mathematics. It is very useful. I invented, so to speak, a canonical heart. For other shapes, you may be able to find a standard definition in terms of mathematical expressions.

In this situation, I created the set of objects and then I used the program to make a composition. You can plan your application include pictures and videos with some graphics, rectangles, and hearts. When you are finished, you can offer this program to others for them to use. This is analogous to building a game program for players. The



end-users for this application may be family members, friends, or colleagues. The list of items is stored in a separate file from the main program so it is easy to change what is included. The technique of separating specification of content from program is a good trick to master.

Of course, it certainly is possible to use a drawing program such as Adobe Photoshop or Corel Paint Shop Pro to create compositions such as these, but this application provides considerable ease-of-use for its specific purpose. The project also serves as a vehicle to learn important programming techniques as well as features of HTML5 and JavaScript. And, as will be a continual refrain, there are differences among the browsers to discuss.

## Critical Requirements

The critical requirements for this project include constructing a framework for manipulating objects on the screen, including detecting mouse events on the objects, deleting objects and creating copies of objects, and specifying content in an external file. The current framework provides a way to specify rectangles, ovals, hearts, and images, but the approach can accommodate other shapes, which is an important lesson of the chapter.

The objective is for the drag-and-drop operations to be reasonably precise: not merely moving something from one region of the window to another. I will re-visit this topic in Chapters 8 and 9 on making jigsaw puzzles.

I also made the decision to control the look of the cursor. The cursor when the mouse is not on the canvas is the standard arrow. When on the canvas element, the cursor will be the crosshairs. When the user presses down on the mouse button and drags an object, the cursor changes to a hand with pointer finger.

When the work is complete, it is a natural desire to save it, perhaps as an image file, so this also is a requirement for the project.

When working on this project for the second edition of the book, I discovered a feature of the Chrome browser that I need to discuss: the autoplay policy.

## Autoplay Policy

Autoplay refers to a situation in which a video clip is played automatically, without action by the user. In the collage project, the bouncing video to be described in Chapter 3, and in the jigsaw turning into a video program to be described in Chapter 8, my intentions are for the videos to play under program control. I acknowledge that there

are arguments against this. Autoplay of video may subject users to data fees and may overload networks. Video ads can be annoying.

As of April 2018, the Chrome browser adopted a policy for autoplay of video (see <https://developers.google.com/web/updates/2017/09/autoplay-policy-changes> for details) in which autoplay in most cases is not allowed. However, there are exceptions, including muting the audio. For the collage program, I decided to enable videos to play by muting the video. My original program provides a way to have a different volume level for each video. Since this works in Firefox, and perhaps other browsers, at least right now, I have kept the mechanism for specifying volume of video in the program. However, the code does include a muted attribute in the video tag, so you will need to remove it for the audio to be heard. Apple for some time has required the user on iPhones and iPads to start any video and I will describe the implications of this in Chapter 8.

This is a lesson for us that 1) things change and 2) HTML/JavaScript/CSS programs are dependent on browsers.

## HTML5, CSS, and JavaScript Features

We now explore the features of HTML5 and JavaScript that are used for the Family Collage project. The idea is to maintain a list of the material on the canvas. This list will be a JavaScript array. The information will include the position of each item, how it is to be drawn on the canvas, and how to determine if the mouse cursor is on the item.

### JavaScript Objects

Object oriented programming is a standard of computer science and a critical part of most programming languages. Objects have *attributes*, also called *properties*, and *methods*. A method is a function. Put another way, an object has data and code that may make use of the data. HTML and JavaScript have many built-in objects, such as document and window, and also arrays and strings. For the Family Collage project, I use a basic facility in JavaScript (established before HTML5) for defining my own objects. These sometimes are called user-defined objects, but the term I and others prefer is programmer-defined objects. This is an important distinction for the Family Collage project in which you, the programmer, may create an application, with pictures and other shapes you identify and design, and then offer it to a family member to use.

The objective of this project is to set up a framework for creating and manipulating different shapes on the canvas, keeping in mind that once something is drawn to the canvas, its identity as a rectangle or image is lost. The first step for each shape is to define what is called a *constructor* function that stores the information that specifies the shape. The next step is to define the methods, code for using the information to do what needs to be done.

My approach gives the appearance of moving things on the canvas. In fact, information kept in internal variables is changed and the canvas is cleared and new drawings made each time something happens to change the look of the canvas.

My strategy is to define new types of objects, each of which will have two methods defined:

- draw for drawing the object on the canvas
- `overcheck` for determining if a given position, specifically the mouse position, is on the object

These methods reference the attributes of the object and use these values in mathematical expressions to produce the results. Once the constructor functions are defined, values can be created as new instances of these objects. An array called `stuff` holds all the object instances.

---

**Note** Object oriented programming in all its glory has a rich and often daunting vocabulary. Classes are what define objects. I have hinted here at what is called an interface. Classes can be subclasses of other classes and this may have been useful for pictures and rectangles. I'm aiming for a more casual tone here. For example, I will speak of objects and object instances.

---

Let's move away from generalities and see how this works. There is an expression: what comes first, the chicken or the egg? I have a "chicken and egg" problem on order. I first describe the specification of the content in an external file. Then I will describe the functions I created and named `Rect`, `Oval`, `Picture`, `Videoblock`, and `Heart`. These will be what are called the constructor functions for the `Rect`, `Oval`, `Picture`, `Videoblock`, and `Heart` object instances. It is a convention to start such functions with capital letters. Then I will describe the `createelements` function that invokes the constructor function. There is a similar "chicken and the egg" problem regarding drawing the objects.

## External File of Specifications

The specification for objects is kept in a separate file. I show the long comment because I need it to remember what the parameters for each object are.

```

/*
Information on videos, other objects used in collagebase.html
You need to produce 3 video files for each video, type mp4,ogg,webm, with
names as indicated in the videoinfo array.
The first element of each subarray indicates the type of object, that is,
'video', 'heart', 'picture', 'oval','rectangle'.
The elements for video objects are
"video", basename of video files, angle in radians, source x, source y,
destination on canvas x, destination y, width, height, scale factor
(x and y), volume level (0 to 1)
The angle can be used to change the orientation for clips shot on iPhone or
iPads.
The source x and y, with the width and height, allows you to use only some
of the source video.

The elements for 'picture' are
'picture',x,y,w,h,imagename.

The elements for heart are
'heart',x,y,h,drx,color

The elements for oval are
'oval',x,y,r,horizontal scaling, vertical scaling, color

The elements for rectangle are
'rect',x,y, w,h,color

The element for video are
'video',videoname, angle, sourcex, sourcey, x, y, width, height, scale,
volume, alpha
Note: the width and height are the final (destination) width and height.
*/

```

```

var mediainfo=
[
['heart', 300,40,100,30,'red'],
['rect',620,400,100,150,"purple"],
['oval',600,50,30,2,1,'green'],
['oval',80, 500, 30, 2, 1, 'blue'],
['video','monkeyMar18',0,0,0,1000,800,896,1198,.25,1],
['picture',5,150, 150, 200,'danielAndAnnika.jpg'],
['picture',500,150,280,210,'threePlusDog.jpg']
];

```

## Rect

The definition of the Rect constructor function is

```

function Rect(x,y,w,h,c) {
    this.x = x;
    this.y = y;
    this.w = w;
    this.h = h;
    this.draw = drawrect;
    this.color = c;
    this.overcheck = overrect;
}

```

The function could be called in the following way:

```
var r1 = new Rect(2,10,50,50,"red");
```

The variable r1 is declared and set to a new object constructed using the function Rect. The built-in term new does the task of creating a new object. The newly constructed object holds the values 2 and 10 for the initial x and y positions, accessed using the attribute names x and y and the values 50 and 50 for width and height accessed using the

attribute names `w` and `h`. The term `this` refers to the object being constructed. The English meaning and the computer jargon meaning of *new* and *this* match. The `Rect` function also stores away values for the attributes `draw` and `overcheck`. It is not obvious from what you have seen so far, but these values will be used to invoke functions named `drawrect` and `overrect`. This is the way to specify methods for the programmer-defined objects. Lastly, the `color` attribute is set to "red". Other possibilities exist for specifying color.

## Oval

Moving on, the constructor function for `Oval` is similar.

```
function Oval(x,y,r,hor,ver,c) {
    this.x = x;
    this.y = y;
    this.r = r;
    this.radsq = r*r;
    this.hor = hor;
    this.ver = ver;
    this.draw = drawoval;
    this.color = c;
    this.overcheck = overoval;
}
```

The `x` and `y` values refer to the center of the oval. The `hor` and `ver` attributes will be used to scale the horizontal and vertical axis respectively and, depending on the values, produce an oval that is not a circle. The `radsq` attribute is calculated and stored to save time in the `overoval` function.

---

**Note** Computers are very fast and I am showing my age by storing away and then using the square of the radius. Still, making this trade-off of extra storage for savings in computation time may be justified.

---

A way to set a teal-colored oval would be

```
var oval1 = new Oval(200,30,20,2.0,1.0, "teal");
```

The purple circle has the `hor` and `ver` values the same and so is a circle. You have every right to ask how or where this information is used to produce an oval or circle. The answer is in the `drawoval` function that will be shown later. Similarly, the `overoval` function checks if a given `x,y` position is on the oval.

## Picture

The constructor for `Picture` objects stores away position, width, and height, as well as the name of an image object.

```
function Picture(x,y,w,h,imagenamename) {
    this.x = x;
    this.y = y;
    this.w = w;
    this.h = h;
    this.imagenamename = imagenamename;
    this.draw = drawpic;
    this.overcheck = overrect;
}
```

Setting up a picture would require the following coding, setting an `Image` variable and then the `Picture` object:

```
var dad = new Image();
dad.src = "daniel1.jpg";
var pic1 = new Picture(10,100,100,100,dad);
```

## Videoblock

The constructor for `Videoblock` provides considerable flexibility. The video can be tilted at an angle (though I choose not to do it for the monkey bar video clip). The volume of the audio can be controlled. If you decided to include more than one video and all the videos have audio, you may want to control the volumes. The video can be scaled. The `sx` and `sy` (`s` for source) allows me to specify where in the video to start extracting the video to be displayed. The `x` and `y` specify where in the canvas and the `w` and `h` specify the final width and height. The `alpha` parameter can be used to set different transparencies

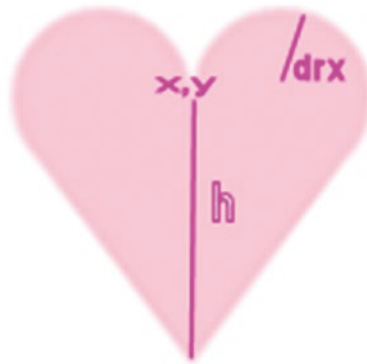
for the video. I stick with a setting of 1, no transparency, for videos, but my code does provide a way for videos to appear lighter over other elements. This should serve as a notice to investigate combining images and properties such as `globalAlpha`.

```
function Videoblock(sx,sy,x,y,w,h,scale,videoel,volume,angle,alpha) {
    this.sx = sx;
    this.sy = sy;
    this.x = x;
    this.y = y;
    this.w = w;
    this.h = h;
    this.videoelement = videoel;
    this.volume = volume;
    this.draw = drawvideo;
    this.overcheck = overvideo; //need more complex checking because of
    angle and scale
    this.angle = angle;
    this.cosine = Math.cos(angle);
    this.sine = Math.sin(angle);
    this.scale = scale;
    this.alpha = alpha;
    videoel.volume = 0;
}
```

## Heart

We have one more of the programmer defined objects to cover. The challenge I set myself was to define values that specify a heart shape. I came up with the following: a heart shape is defined by the position—an x,y pair of values that will be the location of the cleft of the heart; the distance from the cleft to the bottom point; and the radius for the two partial circles representing the curved parts of the heart. You can think of this as a canonical heart. The critical pieces of information are shown in Figure 2-3. If and when you add new types of shapes to your application, you will need to invent or discover the data that defines the shape.





**Figure 2-3.** *Data defining a heart*

The constructor function saves the indicated values, along with the color, into any newly constructed object. You might be suspecting that the drawing and the overcheck will be somewhat more complicated than the functions for rectangles and you would be correct. The constructor function resembles the other constructor function.

```
function Heart(x,y,h,drx,color) {
    this.x = x;
    this.y = y;
    this.h = h;
    this.drx = drx;
    this.radsq = drx*drx;
    this.color = color;
    this.draw = drawheart;
    this.overcheck = overheart;
    this.ang = .25*Math.PI;
}
```

The `ang` attribute is a case of my hedging my bets. You notice that it is a constant and I could avoid making it an attribute. You will see later when I explain `drawheart` how my coding uses it to make the heart rounded. I made it an attribute just in case I want to change to allow hearts to have more variability.

## Creating the Elements

At this point, I have shown you the specification of the objects and how to create objects, but I have not shown you the code for going from specification to creation. This is done in my `createelements` function. Notice the `switch` statement that uses the type of element to determine the action. The most complicated case is `video`, with `picture` following. My code needs to create a HTML video element and that is done by inserting the name of the video files in the string my code creates called `videomarkup`. The `videomarkup`, in turn, is created by combining three variables: `videotext1`, `videotext2`, and `videotext3`. I could have used just one, but then the statements initializing them would have been very long. The insertion of the name is done using a `String` method that JavaScript supplies named `replace`. This is part of a full implementation of what are called *regular expressions*. The `video` case also has two calls to `addEventListener`. One call, for the event `loadeddata`, is used to wait for all the videos to be fully loaded. The other call, for the event `ended`, invokes a `restart` function. This was necessary for browsers that do not support looping. All the cases include a statement that adds the element to an array called `stuff`.

```
function createelements() {
    var name;
    var i;
    var type;
    var divelement;
    var videomarkup;
    var velref;
    var vb;
    var imgdummy;

    for (i=0;i<mediainfo.length;i++) {
        type = mediainfo[i].shift(); //removes 1st element from array
        info = mediainfo[i];

        switch(type) {
            case 'video':
                videocount++;
                name = info[0];
                divelement= document.createElement("div");
```

```

        videomarkup = videotext1+videotext2+videotext3;
        videomarkup = videomarkup.replace(/XXXX/g,name);
        divelement.innerHTML = videomarkup;
        document.body.appendChild(divelement);
        velref = document.getElementById(name);
        velref.addEventListener("ended",restart,false);
        velref.addEventListener("loadeddata",videoloading,false);
vb = new Videoblock(info[2],info[3],info[4],info[5],info[6],info[7],
info[8],velref,info[9],info[1],info[10]);
        stuff.push(vb);
        break;
    case 'picture':
        imgdummy = new Image();
        imgdummy.src = info[4];
        images.push(imgdummy);
        stuff.push( new Picture(info[0],info[1],info[2],info[3],
            images[images.length-1]));

        break;
    case 'heart':
        stuff.push(new Heart(info[0],info[1],info[2],info[3],
            info[4]));
        break;
    case 'oval':
        stuff.push(new Oval(info[0],info[1],info[2],info[3],
            info[4],info[5]));
        break;
    case 'rect':
        stuff.push(new Rect(info[0],info[1],info[2],info[3],
            info[4]));
        break;
    }
}
}
}

```

## Drawing

I still need to explain the functions that serve to accomplish the draw method for each different type of element, but let's go to where the drawing is done in order to demonstrate how all of this works together. I define an array, initially empty

```
var stuff = [];
```

The `createelements` function invokes the array `push` method to add each element to the array.

At appropriate times, namely after any changes, the function `drawstuff` is invoked. It works by erasing the canvas, drawing a rectangle to make a frame, and then iterating over each element in the `stuff` array and invoking the draw methods. The function is

```
function drawstuff() {
    ctx.clearRect(0,0,800,600);
    ctx.strokeStyle = "black";
    ctx.lineWidth = 2;
    ctx.strokeRect(0,0,800,600);
    for (var i=0;i<stuff.length;i++) {
        stuff[i].draw();
    }
}
```

Notice that there is no coding that asks, is this an oval, if so do this, or is it a picture, if so do that.... Instead, the draw method that has been established for each member of the array does its work! The same magic happens when checking if a position (the mouse) is on an object. The benefit of this approach increases as more object types are added.

I did realize that since my code never changes the `strokeStyle` or the `lineWidth`, I could move those statements to the `init` function and just do them one time. However, it occurred to me that I might have a shape that does change these values and so to prepare for that possible change in the application at a later time, I set `strokeStyle` and `lineWidth` in `drawstuff`.

Now I will explain the methods for drawing and the methods for checking if a position is on the object. The `drawrect` function is pretty straight-forward:

```
function drawrect() {
    ctx.fillStyle = this.color;
    ctx.fillRect(this.x, this.y, this.w, this.h);
}
```

Remember the term `this` refers to the object for which `drawrect` serves as a method. The `drawrect` function is the method for rectangles.

The `drawoval` function is slightly, but only slightly, more complex. You need to recall how coordinate transformations work. HTML5 JavaScript only allows circular arcs but does allow scaling the coordinates to produce ovals (ellipses) that are not circles. What the coding in the `drawoval` function does is save the current state of the coordinate system and then perform a translation to the center of the object. Then a scaling transformation is applied, using the `hor` and `ver` properties. Now, after setting the `fillStyle` to be the color specified in the `color` attribute, I use the coding for drawing a path made up of a circular arc and filling the path. Arcs can be portions of circles, with the starting and the ending angle specified, with `true` indicating counter-clockwise. The default is `false`, for clockwise. For a complete circle, which is what is indicated here, I could have omitted the `true`, since it has the same result as `false`. See the coding for the heart in which the direction is critical. The last step is to restore the original state of the coordinate system.

```
function drawoval() {
    ctx.save();
    ctx.translate(this.x, this.y);
    ctx.scale(this.hor, this.ver);
    ctx.fillStyle = this.color;
    ctx.beginPath();
    ctx.arc(0, 0, this.r, 0, 2*Math.PI, true);
    ctx.closePath();
    ctx.fill();
    ctx.restore();
}
```

This is the way ovals that may or may not be circles are drawn on the canvas. Since my code restored the original state of the coordinate system, this has the effect of undoing the scaling and translation transformations.

Again, the terms starting with `this` followed by a dot and then the attribute names reference the stored attributes.

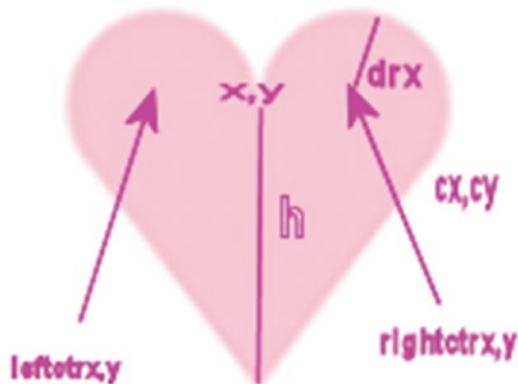
---

**Note** Please keep in mind that I didn't plan and program this whole application all at once. I did the rectangles and ovals and later added the pictures and much later the heart. I also added the duplication operation and the deletion operation much later. Working in stages is the way to go. Planning is important and useful, but you do not have to have all the details complete at the start.

---

The `drawheart` function starts by defining variables to be used later. The `leftctrx` is the x coordinate of the center of the left arc and the `rightctrx` is the x coordinate of the center of the right arc. The arcs are each more than a half circle. How much more? I decided to make this be `.25 * Math.PI` and to store this value in the `ang` attribute.

The tricky thing was to determine where the arc stops on the right side. My code uses trig expressions to set the `cx` and `cy` values. The `cx`, `cy` position is where the arc meets the straight line. Figure 2-4 indicates the meaning of the variables.



**Figure 2-4.** Added pieces of data used in functions

The path will start at what we are calling the cleft or the cleavage (giggle) and draw the arc on the left. Then it will draw a line to the bottom point, then up to the *cx*, *cy* point, and then finish with the arc on the right. The function is the following:

```
function drawheart() {
    var leftctrx = this.x-this.drx;
    var rightctrx = this.x+this.drx;
    var cx = rightctrx+this.drx*Math.cos(this.ang);
    var cy = this.y + this.drx*Math.sin(this.ang);
    ctx.fillStyle = this.color;
    ctx.beginPath();
    ctx.moveTo(this.x,this.y);
    ctx.arc(leftctrx,this.y,this.drx,0,Math.PI-this.ang,true);
    ctx.lineTo(this.x,this.y+this.h);
    ctx.lineTo(cx,cy);
    ctx.arc(rightctrx,this.y,this.drx,this.ang,Math.PI,true);
    ctx.closePath();
    ctx.fill();
}
```

The drawing of pictures is straight-forward. For both pictures and videos, I provide a way to produce a composite drawing if one object is on top of another.

```
function drawpic() {
    ctx.globalAlpha = 1.0;
    ctx.drawImage(this.imagename,this.x,this.y,this.w,this.h);
}
```

The drawing of the Videoblock is more complex because of the facility to put the video at an angle and scale it. It also is important to understand that what is being drawn is the current frame of the video clip. This is done using the *drawimage* method of canvas elements.

```
function drawvideo() {
    var savedalpha = ctx.globalAlpha;
    ctx.globalCompositeOperation = "lighter";
    ctx.globalAlpha = this.alpha;
```

```

if (this.angle!=0) {
    ctx.save();
    ctx.translate(this.x,this.y);
    ctx.rotate(this.angle);
    ctx.translate(-this.x,-this.y)
    if (this.scale!=1) {
        ctx.scale(this.scale,this.scale); }
    ctx.drawImage(this.videoelement,this.sx,this.sy,
    this.w,this.h,this.x,this.y, this.w, this.h);

    ctx.restore();

}
else {
    if (this.scale!=1) {
        ctx.save();
        ctx.scale(this.scale,this.scale);

    ctx.drawImage(this.videoelement,this.sx,this.sy,
    this.w,this.h,this.x,this.y, this.w, this.h);

        ctx.restore();

    }
    else {
    ctx.drawImage(this.videoelement,this.sx,this.sy,
    this.w,this.h,this.x,this.y, this.w, this.h);
    }
}
ctx.globalAlpha = savedalpha;
ctx.globalCompositeOperation = savedgco;
}

```



## Checking for a Mouse Over Object

Before describing the functions for the `overcheck` method, I will preview why it is needed. HTML5 and JavaScript provide ways to handle (listen for and respond to) mouse events on the canvas and supply the coordinates of where the event took place. However, our code must do the work of determining what object was involved. Remember: there are no objects actually on the canvas, just the remains, think of it as paint, of whatever drawing was done. My code accomplishes this task by looping through the `stuff` array and invoking the `overcheck` method for each object. As soon as there is a hit (and I will explain the order in which this is done later), my code proceeds with that object as the one selected. The functions in which this checking occurs are `startdragging` and `makenewitem` and are explained in the next section.

There are four functions to explain for the `overcheck` method since `Picture` and `Rect` refer to the same function. Each function takes two parameters. Think of the `mx,my` as the location of the mouse. The `overrect` function checks for four conditions each being true. In English, the question is: Is `mx` greater than or equal to `this.x` *and* is `mx` less than or equal to `this.x + this.w` *and* is `my` greater than or equal to `this.y` *and* is `my` less than or equal to `this.y + this.h`? The function says this more compactly:

```
function overrect (mx,my) {
    return (
        (mx>=this.x)&&(mx<=(this.x+this.w))&&(my>=this.y)&&(my<=(this.
            y+this.h)));
}
```

The function defining the `overcheck` method for ovals is `overoval`. The `overoval` function performs the operation of checking if something is within a circle, but in a translated and scaled coordinate system. The check for a point being within a circle could be done by setting the center of the circle to `x1,y1` and the point to `x2,y2` and see if the distance between the two is less than the radius. I use a variation of this to save time and compare the square of the distance to the radius squared. I define a function called `distsq` that returns the square of the distance. But now I need to figure out how to do this in a translated and scaled coordinate system. The answer is to set `x1,y1` to `0,0`. This is the location of the center of the oval in the translated coordinate system. Then my code sets `x2` and `y2` as indicated in the code to what would be the scaled values.

```
function overoval(mx,my) {
    var x1 = 0;
    var y1 = 0;
    var x2 = (mx-this.x)/this.hor;
    var y2 = (my-this.y)/this.ver;
    if (distsq(x1,y1,x2,y2)<=(this.radsq) ){
        return true
    }
    else {return false}
}
```

This did not come to me instantly. I worked it out trying values for `mx` and `my` located in different positions relative to the oval center. The code does represent what the transformations do in terms of the translation and then the scaling.

The `overheart` function consists of several distinct `if` statements. This is a case of not trying for a simple expression but thinking about various situations. The function starts off by setting variables to be used later. The first check made by the function is to determine if the `mx, my` point is outside the rectangle that is the bounding rectangle for the heart. I wrote the `outside` function to return true if the position specified by the last two parameters was outside the rectangle indicated by the first four parameters. The `qx, qy` point is the upper-left corner. `qwidth` is the width at the widest point and `qheight` is the total height. I thought of this as a quick check that would return false most of the time. The next two `if` statements determine if the `mx, my` point is contained in either circle. That is, I again use the comparison of the square of the distance from `mx, my` to the center of each arc to the stored `radsq` attribute. At this point in the function, that is, if the `mx, my` position was not close enough to the center of either circle and if `my` is above (less than) `this.y`, then the code returns false. Lastly, the code puts the `mx` value in the equation for each of the sloping lines and compares the result to `my`. The equation for a line can be written using the slope `m` and a point on the line `x2, y2` (note: this is mathematics, not programming):

$$y = m * (x - x2) + y2$$

The code sets `m` and `x2, y2` for the line on the left and then modifies it to work for the line on the right by changing the sign of `m`. The check is for `x` set to `mx`, is `my` less than the expression shown. One possible concern here is whether or not the fact that the screen coordinate system has upside down vertical values (vertical values increase going down the screen) causes a problem. I checked out cases and the code works.

```

function overheart(mx,my) {
    var leftctrx = this.x-this.drx;
    var rightctrx = this.x+this.drx;
    var qx = this.x-2*this.drx;
    var qy = this.y-this.drx;
    var qwidth = 4*this.drx;
    var qheight = this.drx+this.h;

    //quick test if it is in bounding rectangle
    if (outside(qx,qy,qwidth,qheight,mx,my)) {
        return false;}

    //compare to two centers

    if (distsq(mx,my,leftctrx,this.y)<this.radsq) return true;
    if (distsq(mx,my,rightctrx,this.y)<this.radsq) return true;
    // if outside of circles AND below (higher in the screen) than this.y,
    return false
    if (my<this.y) return false;

    // compare to each slope
    var x2 = this.x;
    var y2 = this.y + this.h;
    var m = (this.h)/(2*this.drx);
    // left side
    if (mx<=this.x) {
        if (my < (m*(mx-x2)+y2)) {return true;}
        else { return false;}
    }
    else {
    //right side
    m = -m;

    if (my < (m*(mx-x2)+y2)) { return true}
    else return false;
    }
}

```

The reasoning underlying the `outside` function is similar to the `overrect` function. You need to write code comparing the `mx,my` value to the sides of the rectangle. However, for `outside` I chose to use the OR operator, `||`, and to return its value. This will be true if any of the factors are true and false otherwise.

```
function outside(x,y,w,h,mx,my) {
    return ((mx<x) || (mx > (x+w)) || (my < y) || (my > (y+h)));
}
```

Actually, what I said was true, but misses what could be an important consideration if performance is an issue. The `||` evaluates each of the conditions starting from the first (leftmost) one. As soon as one of them is true, it stops evaluating and returns true. The `&&` operator does a similar thing. As soon as one of the conditions is false, it returns false.

The `overvideo` function must allow for the angle and scaling.

```
function overvideo (mx,my) {
    //need to add code to check in rotation case and scaling
    omx = mx;
    omy = my;

    if (this.angle!=0) {
        omx = omx-this.x;
        omy = omy - this.y;
        mx = omx*this.cosine + omy*this.sine;
        my = -omx*this.sine + omy*this.cosine;
        mx = this.x +mx;
        my = this.y + my;
    }
    if (this.scale!=1) {
        //alert("prescaling mx is "+mx+" prescaling my is "+my);
        mx = mx/this.scale;
        my = my/this.scale;
        //alert("post scaling mx is "+mx+" post scaling my is "+my);
    }
    return (
        (mx>=this.x)&&(mx<=(this.x+this.w))&&(my>=this.y)&&(my<=(this.
        y+this.h)));
}
```

This is the basis for the five types of objects I designed for manipulation on the canvas. You can look ahead to examine all the code or continue to see how these objects are put in use in the responses to mouse events.

---

**Note** This example does not demonstrate the full power of object oriented programming. In a language such as Java (or the variant Processing designed for artists), I could have programmed this in such a way to check that each additional object was defined properly, that is with the x and y attributes for location and methods for drawing and checking.

---

## User Interface

The application requirements for the user interface include dragging, that is, mouse down, mouse move, and mouse up, for re-positioning items and double-clicking for producing a duplicate copy of an item. I decided to use buttons for the other end-user actions: removing an item from the canvas and creating an image to be saved. The button action is straight-forward. I write two instances of the HTML5 button element with the `onClick` attributes set to the appropriate function.

```
<button onClick="saveasimage();">Open window with image (which you can save
into image file)↵
</button></br>
<button onClick="removeobj();">Remove last object moved </button>
```

The `saveasimage` function will be explained in the next section. The `removeobj` function deletes the last moved object from the `stuff` array because the last moved object has been positioned as the last element in the array. This makes the coding extremely simple:

```
function removeobj() {
    stuff.pop();
    drawstuff();
}
```

A pop for any array deletes the last element. The function then invokes the `drawstuff` function to display all but the last element. By the way, if the button is clicked at the start of the application, the last element pushed on the `stuff` array will be deleted. If this is unacceptable, you can add a check to prevent this from happening. The cost is that it needs to be done every time the user clicks on the button.

Fortunately, HTML5 provides the mouse events that we need for this application. In the `init` function, I include the following lines:

```
canvas1 = document.getElementById('canvas');
canvas1.onmousedown = function () { return false; };
canvas1.addEventListener('dblclick', makenewitem, false);
canvas1.addEventListener('mousedown', startdragging, false);
```

The first statement sets the `canvas1` variable to reference the canvas element. The second statement is necessary to turn off the default action for the cursor. I also included a style directive for the canvas, which made the positioning absolute and then positioned the canvas 80 pixels from the top. This is ample space for the directions and the buttons.

```
canvas {position:absolute; top:80px;
  cursor:crosshair;
}
```

The third and fourth statements set up event handling for double-click and mouse button down events. We should appreciate the fact that we as programmers do not have to write code to distinguish mouse down, click, and double-click. However, unfortunately, a double-click will invoke both the `makenewitem` function and the `startdragging` function. That is okay in this situation, but do be aware of it for future work.

The `makenewitem` and the `startdragging` functions start off the same. The code first determines the mouse cursor coordinates and then loops through the `stuff` array to determine which, if any, object was clicked on. You probably have seen the mouse cursor coordinate code before, in the *Essential Guide to HTML5*, for example. The looping through the array is done in reverse order. Calls are made to the `overcheck` method, defined appropriately for the different types of objects. If there is a hit, then the `makenewitem` function calls the `clone` function to make a copy of that item. The code modifies the `x` and `y` slightly so the new item is not directly on top of the original. The new item is added to the array and there is a `break` to leave the `for` loop.

```

function makenewitem(ev) {
    var mx;
    var my;
    if (ev.layerX || ev.layerX == 0) {
        mx= ev.layerX;
        my = ev.layerY;
    } else if (ev.offsetX || ev.offsetX == 0) {
        mx = ev.offsetX;
        my = ev.offsetY;
    }
    var endpt = stuff.length-1;
    var item;
    for (var i=endpt;i>=0;i--) { //reverse order
        if (stuff[i].overcheck(mx,my)) {
            item = clone(stuff[i]);
            item.x +=20;
            item.y += 20;
            stuff.push(item);
            break;
        }
    }
}

```

As I indicated earlier, the `clone` function makes a copy of an element in the `stuff` array. You may ask, why not just write

```
item = stuff[i];
```

The answer is that this assignment does not create a new, distinct value. JavaScript merely sets the `item` variable to point to the same thing as the `i`th member of `stuff`. This is called “copy by reference”. We don’t want that. We want a brand new, separate thing that we can change. The way to copy is demonstrated in the `clone` function. A new object is created and then a `for` loop is invoked. The `for(var info in obj)` says: for every attribute of `obj`, set an equivalently named attribute in `item` to the value of the attribute.

```

function clone(obj) {
    var item = new Object();
    for (var info in obj) {

```

```

        item[info] = obj[info];
    }
    return item;
}

```

So the effect of the two functions is to duplicate whatever element is under the mouse cursor. You or your end-user can then mouse down on the original or the cloned object and move it around.

The `startdragged` function proceeds as indicated to determine which object was under the mouse. The code then determines what I (and others) call the offsets in `x` and `y` of the mouse coordinates versus the `x,y` position of the object. This is because we want the object to move around, maintaining the same relationship between object and mouse. Some folks call this the flypaper effect. It is as if the mouse cursor came down on the object and stuck like flypaper. The `offsetx` and `offsety` are global variables. Note that the coding works for objects for which the `x,y` values refer to the upper-left corner (pictures and rectangles), to the center (ovals), and to a specific internal point (hearts).

The coding then performs a series of operations that has the effect of moving this object to the end of the array. The first statement is a copy by reference operation to set the variable `item`. The next step saves the index for the last element of the `stuff` array to the global variable `thingInMotion`. This variable will be used by the `moveit` function. The `splice` statement removes the original element and the `push` statement adds it to the array at the end. The statement referencing `cursor` is the way to specify a cursor. The “pointer” refers to one of the built-in options. The last two statements in the function set up the event handling for moving the mouse and releasing the button on the mouse. This event handling will be removed in the `dropit` function.

```

function startdragging(ev) {
    var mx;
    var my;
    if (ev.layerX || ev.layerX == 0) {
        mx= ev.layerX;
        my = ev.layerY;
    } else if (ev.offsetX || ev.offsetX == 0) {
        mx = ev.offsetX;
        my = ev.offsetY;
    }
}

```



```

var endpt = stuff.length-1;
for (var i=endpt;i>=0;i--) { //reverse order
    if (stuff[i].overcheck(mx,my)) {
        offsetx = mx-stuff[i].x;
        offsety = my-stuff[i].y;
        var item = stuff[i];
        thingInMotion = stuff.length-1;
        stuff.splice(i,1);
        stuff.push(item);
        canvas1.style.cursor = "pointer"; // change to finger
        canvas1.addEventListener('mousemove',moveit,false);
        canvas1.addEventListener('mouseup',dropit,false);
        break;
    }
}
}

```

The `moveit` function moves the object referenced by `thingInMotion` and uses the `offsetx` and `offsety` variables to move the object. The `drawstuff` function is invoked to show the modified canvas.

```

function moveit(ev) {
    var mx;
    var my;
    if ( ev.layerX || ev.layerX == 0) {
        mx= ev.layerX;
        my = ev.layerY;
    } else if (ev.offsetX || ev.offsetX == 0) {
        mx = ev.offsetX;
        my = ev.offsetY;
    }
    stuff[thingInMotion].x = mx-offsetx; //adjust for flypaper dragging
    stuff[thingInMotion].y = my-offsety;
}

```

A mousemove event is triggered if the mouse moves a single pixel in any direction. If this seems too much, remember that the computer does it, not you or I. The user gets a smooth response to moving the mouse.

The dropit function is invoked at a mouseup event. The response is to remove, stop the listening for moving and releasing the mouse, and then changing the cursor back to the crosshairs.

```
function dropit(ev) {
    canvas1.removeEventListener('mousemove',moveit,false);
    canvas1.removeEventListener('mouseup',dropit,false);
    canvas1.style.cursor = "crosshair"; //change back to crosshair
}
```

To summarize, the user interface for this application involves two buttons and several mouse actions. The drag-and-drop operation is implemented using mouse down, mouse move, and mouse up and cloning an object is done using double-click.

## Saving the Canvas to an Image

After creating a composition, I provide a way for the user to save it to an image file. The Firefox browser makes this easy. You can right-click on the canvas when using a PC or do the equivalent operation on a Mac and a pop-up menu will appear with the option to Save Image As... However, Chrome, Safari, and Opera do not provide that facility. If you right-click, the options concern the HTML document. There is, however, an alternative provided in HTML5 that works for Firefox and, perhaps, other browsers. Support for Chrome changed with the most recent update.

A canvas element has a method called toDataURL that will produce an image from the canvas. The method provides a choice of image file types, including PNG and JPG. What I choose to do with the result of this operation is write code to open a new window with the image as the content. The user then can save this image as a file either by the Save File option or the right-click for the image. However, there is one more consideration. Firefox require that this code run from a server, not on the client computer. The client computer is the one running the browser program. The server computer would be the website to which you will upload your finished work. You may or may not have one. Opera and Safari allow the code to run from the client computer. This has an impact on testing, since, generally speaking, we test programs locally and then upload to a server. Because of this situation, this is an appropriate place to use the try/catch facility of

JavaScript for catching errors (so to speak) for the programmer to take action. Here is the code for the `saveasimage` function. The variable `canvas1` has been set to the canvas element in the `init` function invoked when the document is loaded.

```
function saveasimage() {
  try {
    window.open(canvas1.toDataURL("image/png"));
  } catch(err) {
    alert("You need to change browsers AND/OR upload the file to a
    server.");
  }
}
```

## Building the Application and Making It Your Own

You can make this application your own by identifying your own media files, specifying what rectangles, ovals, and hearts you want to include in the collection of objects to be manipulated and, after you have something working, adding new object types. The application has many functions but they each are small and many share attributes with others. An informal summary/outline of the application is

1. `init` for initialization, including the `createelement` function, setting up event handling for double-click, mouse down, mouse move, and mouse up.
2. object definition methods: constructor functions, draw functions, and `overcheck` functions.
3. event handling functions: mouse events and button `onClick`.

More formally, Table 2-1 lists all the functions and indicates how they are invoked and what functions they invoke. Notice that several functions are invoked as a result of the function being specified as a method of an object type.

**Table 2-1.** *Functions in the HTML5 Family Collage Project*

<b>Function</b>	<b>Invoked/Called By</b>	<b>Calls</b>
init	Invoked by action of the onLoad attribute in the <body> tag	Picture, Rect, Oval, Heart, drawstuff
saveasimage	Invoked by action of the onClick attribute in a button tag	
removeobj	Invoked by action of the onClick attribute in a button tag	drawstuff
createelements	Invoked by init	Videoblock, Picture, Rect, Oval, Heart
restart	Invoked by action of addEventListener in createelements	
videoloaded	Invoked by action of addEventListener in createelements	
loading	Invoked by action of setInterval in init	
Picture	Invoked in createelements function	
Rect	Invoked in createelements function	
Oval	Invoked in createelements function	
Heart	Invoked in createelements function	
Videoblock	INVOKED in createelements function	
drawheart	Invoked in drawstuff	
drawrect	Invoked in drawstuff	
drawoval	Invoked in drawstuff	
drawpic	Invoked in drawstuff	
drawvideo	Invoked in drawstuff	
overheart	Invoked in startdragging and makenewitem	distsq, outside
overrect	Invoked in startdragging and makenewitem	
overoval	Invoked in startdragging and makenewitem	distsq
overvideo	Invoked in startdragging and makenewitem	

*(continued)*

**Table 2-1.** (continued)

Function	Invoked/Called By	Calls
distsq	Invoked by <code>overheart</code> and <code>overoval</code>	
drawstuff	Invoked by <code>makenewitem</code> , <code>removeobj</code> , <code>init</code> and the action of <code>setInterval</code> in <code>loading</code>	Draw method of each item in the <code>stuff</code> array
moveit	Invoked by action set by <code>addEventListener</code> for <code>mousemove</code> set in <code>startdragging</code>	
dropit	Invoked by action set by <code>addEventListener</code> for <code>mouseup</code> set in <code>startdragging</code>	
outside	Invoked by <code>overheart</code>	
makenewitem	Invoked by action set by <code>addEventListener</code> for <code>dblclick</code> set in <code>init</code>	<code>clone</code>
clone	Invoked by <code>makenewitem</code>	
startdragging	Invoked by action set by <code>addEventListener</code> for <code>mousedown</code> set in <code>init</code>	

Table 2-2 shows the code for the basic application, with comments for each line.

**Table 2-2.** Complete Code for the Family Collage Project

---

<code>&lt;!DOCTYPE html &gt;</code>	Standard heading for HTML5 documents
<code>&lt;html&gt;</code>	html tag
<code>&lt;head&gt;</code>	head tag
<code>&lt;title&gt;Collage, with video&lt;/title&gt;</code>	Complete title
<code>&lt;meta charset="UTF-8"&gt;</code>	meta tag
<code>&lt;style&gt;</code>	Start of style
<code>canvas {position:absolute; top:80px;</code>	Directive for canvas, setting its position as absolute and its location 80 pixels from the top of the document
<code>    cursor:crosshair;</code>	Specifying the cursor icon for when the mouse is over the canvas
<code>}</code>	Close directive
<code>video {display:none;}</code>	Initial setting
<code>&lt;/style&gt;</code>	Close style
<code>&lt;script type="text/javascript"</code> <code>src="collagedataV2.js"&gt; &lt;/script&gt;</code>	External script element link
<code>&lt;script language="Javascript"&gt;</code>	Local script tag
<code>var ctx;</code>	Variable to hold the canvas context
<code>var canvas1;</code>	Variable to hold reference to canvas
<code>var stuff = [];</code>	Array for all the objects on the canvas
<code>var thingInMotion;</code>	Reference to object being dragged
<code>var offsetx;</code>	Horizontal offset for object being dragged
<code>var offsety;</code>	Vertical offset for object being dragged
<code>var tid;</code>	Hold timing identifier for periodically re-drawing canvas.
<code>var savedgco;</code>	Stores prior composition value
<code>var images = [];</code>	Holds images

---

*(continued)*

**Table 2-2.** (continued)

---

<pre>var videotext1 = "&lt;video id=\"XXXX\" preload=\"auto\" loop=\"loop\" muted&gt; &lt;source src=\"XXXX.webm\" type='video/webm; codec=\"vp8, vorbis\"'\&gt; ";</pre>	<p>Template for start of video element html; note muted attribute</p>
<pre>var videotext2="&lt;source src=\"XXXX. mp4\" type='video/mp4; codecs=\"avc1.42E01E, mp4a.40.2\"'\&gt; &lt;source src=\"XXXX.ogv\" type='video/ogg; codecs=\"theora, vorbis\"'\&gt;";</pre>	<p>Template for middle of video element html</p>
<pre>var videotext3="Your browser does not accept the video tag.&lt;/video&gt;";</pre>	<p>Template for last part of video element html</p>
<pre>function restart(ev) { var v = ev.target; v.currentTime=0; v.play(); }</pre>	<p>Restarting video clip The video that just ended Set current time back to 0 Play the video Close restart</p>
<pre>var videocount =0;</pre>	<p>Global variable keeping track of videos to be loaded</p>
<pre>var okaytogo = false;</pre>	<p>Will be changed to true when all videos loaded</p>
<pre>function videoloaded(ev) {     ctx.fillText(ev.target.id+"     loaded.",400,100*videocount);     ev.target.play();     videocount--;     if (videocount==0) {         okaytogo = true;</pre>	<p>Header for videoloaded function; handler for event of data being loaded for a video Put message onscreen (will not remain on canvas for long) Start playing the video Decrement the count of videos still to be loaded When no more ... Set okaytogo to true</p>

---

*(continued)*

**Table 2-2.** *(continued)*


---

}	Close true clause
}	Close videoloaded function
var textmsg = "Loading videos";	Message while videos still being loaded
function init() {	Header for init
canvas1 = document.	Set variable to reference to canvas element
getElementById('canvas');	
canvas1.onmousedown = function	Prevents change of cursor to default
( ) { return false; };	
canvas1.addEventListener	Set handling for double-click
('dblclick', makenewitem, false);	
canvas1.addEventListener	Set handling for start of dragging
('mousedown', startdragging, false);	
ctx = canvas1.	Set variable to hold the context
getContext("2d");	
savedgco = ctx.	Save initial gco
globalCompositeOperation;	
createelements();	Call createelements, which uses the external
	file contents
drawstuff();	Draw all the elements in stuff
ctx.fillText(textmsg, 100, 100);	Write the textmsg indicating waiting for videos
loadid = setInterval	Set up handling for timing
(loading, 2000);	
ctx.strokeStyle = "blue";	Set border color
}	Close init
function loading() {	Header for loading
if (okaytogo) {	If all video(s) loaded
clearInterval(loadid);	Stop the timing

---

*(continued)*



**Table 2-2.** *(continued)*

---

<pre>                 tid = setInterval                 (drawstuff,40);             }         else {             textmsg+=".";             ctx.fillText             (textmsg,100,100);         }     } </pre>	<p>Start new timing event, to draw every 40 millisec</p> <p>Close if okaytogo</p> <p>Else</p> <p>Add a dot to the message</p> <p>Write out the message</p> <p>Close the else</p> <p>Close the loading function</p>
<pre> function createelements() {     var name;     var i;     var type;     var divelement;     var videomarkup;     var velref;      var vb;     var imgdummy;     for (i=0;i&lt;mediainfo. length;i++) {         type = mediainfo[i].             shift();         info = mediainfo[i];          switch(type) {             case 'video': </pre>	<p>Header for createelements</p> <p>Will hold name of media</p> <p>Used to manipulate array</p> <p>Will hold the type</p> <p>Will hold the divelement</p> <p>Will hold the combined videomarkup template</p> <p>Will hold the ref. to any newly created video element</p> <p>Will hold any newly created videoblock</p> <p>Will hold any newly created image variable</p> <p>Loop through all the content</p> <p>Removes first element from array</p> <p>Holds the first subarray (minus the original 0<sup>th</sup> element)</p> <p>Switch on the type</p> <p>Video case</p>

---

*(continued)*

**Table 2-2.** *(continued)*


---

videocount++;	Increment this count, to be used for determining if all videos loaded
name = info[0];	Base name of the three video files
divelement= document.createElement("div");	Create a div
videomarkup = videotext1+videotext2+videotext3;	Make the template
videomarkup = videomarkup.replace(/XXXX/g,name);	Swap in the base name
divelement. innerHTML = videomarkup;	Put the result in the div
document.body. appendChild(divelement);	Add to the body so it is now part of document; Note: it isn't visible yet
velref = document.getElementById(name);	Get the reference
velref.addEvent Listener("ended",restart,false);	Start the ended event
velref.addEvent Listener("loadeddata",videoloading, false);	Start the loadeddata event
vb = new Videoblock(info[2], info[3],info[4],info[5], info[6],info[7],info[8],velref, info[9],info[1], info[10]);	Create the videoblock element
stuff.push(vb);	Add to the stuff array
break;	Exit the switch
case 'picture':	Picture case
imgdummy = new Image();	Create an image variable
imgdummy.src = info[4];	Set its src

---

*(continued)*

**Table 2-2.** (continued)

---

images.push(imgdummy);	Add to the array of images
stuff.push( new Picture	Add to the stuff array
(info[0],info[1],info[2],info[3],	
images[images.length-1]));	
break;	Exit the switch
case 'heart':	The heart case
stuff.push(new Heart	Create heart object and add to stuff
(info[0],info[1],info[	
2],info[3],info[4]));	
break;	Exit the switch
case 'oval':	The oval case
stuff.push(new Oval	Create the oval object and add to stuff
(info[0],info[1],info[2],info[3],	
info[4],info[5]));	
break;	Exit the switch
case 'rect':	The rect case
stuff.push(new Rect	Create the rect object and add to stuff
(info[0],info[1],info[	
2],info[3],info[4]));	
break;	Exit the switch
}	Close the switch
}	Close the for loop
}	Close the createelements function
function distsq (x1,y1,x2,y2) {	Function header for distsq. Takes two points
	(2x2 values) as parameters
//done to avoid taking square	
roots	

---

*(continued)*

**Table 2-2.** *(continued)*


---

<code>var xd = x1 - x2;</code>	Set difference in x
<code>var yd = y1 - y2;</code>	Set difference in y
<code>return ((xd*xd) + (yd*yd) );</code>	Returns sum of squares; this is the square of the distance between the two points
<code>}</code>	End distsq function
<code>function Videoblock(sx,sy,x,y,w,h, scale,videoel,volume,angle,alpha) {</code>	Header for videoblock
<code>this.sx = sx;</code>	Save source x
<code>this.sy = sy;</code>	Save source y
<code>this.x = x;</code>	Save x on canvas
<code>this.y = y;</code>	Save y on canvas
<code>this.w = w;</code>	Save the width
<code>this.h = h;</code>	Save the height
<code>this.videoelement = videoel;</code>	Save the ref to the video element
<code>this.volume = volume;</code>	Save the volume
<code>this.draw = drawvideo;</code>	Set the draw method
<code>this.overcheck = overvideo;</code>	Need more complex checking because of angle and scale
<code>this.angle = angle;</code>	Save the angle
<code>this.cosine = Math.cos(angle);</code>	Calculate in advance the cosine
<code>this.sine = Math.sin(angle);</code>	Calculate in advance the sine
<code>this.scale = scale;</code>	Save the scale
<code>this.alpha = alpha;</code>	Save alpha
<code>videoel.volume = 0;</code>	Save the volume
<code>}</code>	

---

*(continued)*

**Table 2-2.** *(continued)*

---

<pre>function overvideo (mx,my) {   //need to add code to check in   rotation case and scaling     omx = mx;     omy = my;   if (this.angle!=0) {     omx = omx-this.x;     omy = omy - this.y;     mx = omx*this.cosine +       omy*this.sine;     my = -omx*this.sine +       omy*this.cosine;     mx = this.x +mx;     my = this.y + my;   }   if (this.scale!=1) {     alert("prescaling mx is "+mx+"     prescaling my is "+my);     mx = mx/this.scale;     my = my/this.scale;   }   return( (mx&gt;=this.x)&amp;&amp;(mx&lt;=   (this.x+this.w))&amp;&amp;(my&gt;=this.y)   &amp;&amp;(my&lt;=(this.y+this.h))) ; }</pre>	<p>Header for overvideo</p> <p>Store the mouse x</p> <p>Store the mouse y</p> <p>Is angle not 0...need to do more complex checking</p> <p>Calculate horizontal distance</p> <p>Calculate vertical difference</p> <p>Multi-steps for adjustment for angle</p> <p>Now do adjustment for scaling</p> <p>Can now do standard rectangle checking</p> <p>Close overvideo</p>
---	--

*(continued)*

**Table 2-2.** *(continued)*


---

<code>function drawvideo() {</code>	Header for drawvideo
<code>var savedalpha = ctx.     globalAlpha;</code>	Save current <code>globalAlpha</code>
<code>ctx.globalCompositeOperation =     "lighter";</code>	Set how to combine
<code>ctx.globalAlpha = this.alpha;</code>	Set new alpha
<code>if (this.angle!=0) {</code>	If angle not = zero...
<code>ctx.save();</code>	Save current coordinate state
<code>ctx.translate(this.x,this.y);</code>	Translate to position of video
<code>ctx.rotate(this.angle);</code>	Rotate angle
<code>ctx.translate(-this.x,-this.y)</code>	Translate back
<code>if (this.scale!=1) {</code>	If scaling..
<code>    ctx.scale(this.         scale,this.scale); }</code>	Do the scaling
<code>ctx.drawImage(this.     videoelement,this.sx,this.     sy,this.w,this.h,this.x,     this.y, this.w, this.h);</code>	Draw from the video
<code>ctx.restore();</code>	Restore previous coordinate state
<code>}</code>	Close if angle
<code>else {</code>	Else
<code>if (this.scale!=1) {</code>	If scaling
<code>ctx.save();</code>	Save coordinate state

---

*(continued)*

**Table 2-2.** *(continued)*

---

<code>ctx.scale(this.scale,this.scale);</code>	Do the scaling
<code>ctx.drawImage(this. videoelement,this.sx,this. sy,this.w,this.h,this.x,this.y, this.w, this.h);</code>	Draw from the video
<code>ctx.restore();</code>	Restore coordinate state
<code>}</code>	Close if scaling
<code>else {</code>	Else
<code>ctx.drawImage(this. videoelement,this.sx,this. sy,this.w,this.h,this.x,this.y, this.w, this.h);</code>	Draw from the video
<code>}</code>	Close else
<code>}</code>	Close the else
<code>ctx.globalAlpha = savedalpha;</code>	Restore the globalAlpha
<code>ctx.globalCompositeOperation = savedgco;</code>	Set the savedgco
<code>}</code>	Close drawvideo
<code>function Picture(x,y,w,h,imagename) {</code>	Function header for Picture constructor, positioned at x,y, with width w and height h, and the imagename Image object
<code>this.x = x;</code>	Set attribute
<code>this.y = y;</code>	Set attribute
<code>this.w = w;</code>	Set attribute

---

*(continued)*

**Table 2-2.** *(continued)*


---

<code>this.h = h;</code>	Set attribute
<code>this.imagename = imagename;</code>	Set attribute
<code>this.draw = drawpic;</code>	Set drawpic function to be the draw method
<code>this.overcheck = overrect;</code>	Set overrect function to be the overcheck method
<code>}</code>	Close function
<code>function Heart(x,y,h,drx,color) {</code>	Function header for Heart constructor, located with the cleavage at x, y, distance from x, y to lower tip h, radius drx, and color
<code>    this.x = x;</code>	Set attribute
<code>    this.y = y;</code>	Set attribute
<code>    this.h = h;</code>	Set attribute
<code>    this.drx = drx;</code>	Set attribute
<code>    this.radsq = drx*drx;</code>	Set attribute to avoid doing this operation repeated times later
<code>    this.color = color;</code>	Set attribute
<code>    this.draw = drawheart;</code>	Set drawheart function to be the draw method
<code>    this.overcheck = overheart;</code>	Set overheart function to be the overcheck method
<code>    this.ang = .25*Math.PI;</code>	Set attribute to be this constant value; may make more general at a later time
<code>}</code>	Close function
<code>function drawheart() {</code>	Function header for drawheart
<code>    var leftctrx = this.x-this.drx;</code>	Calculate and set variable to be x coordinate of center of left curve
<code>    var rightctrx = this.x+this.drx;</code>	Calculate and set variable to be x coordinate of center of right curve

---

*(continued)*



**Table 2-2.** *(continued)*

---

<code>var cx = rightctrx+this.drx*Math.cos(this.ang);</code>	Calculate and set variable to be x coordinate of point where curve on the right changes to straight line
<code>var cy = this.y + this.drx*Math.sin(this.ang);</code>	Calculate and set variable to be y coordinate of point where curve on the right changes to straight line
<code>ctx.fillStyle = this.color;</code>	Set fillStyle
<code>ctx.beginPath();</code>	Begin path
<code>ctx.moveTo(this.x,this.y);</code>	Move to cleft of heart
<code>ctx.arc(leftctrx,this.y,this.drx,0,Math.PI-this.ang,true);</code>	Draw left curve
<code>ctx.lineTo(this.x,this.y+this.h);</code>	Move to bottom point
<code>ctx.lineTo(cx,cy);</code>	Move to point where straight line meets curve
<code>ctx.arc(rightctrx,this.y,this.drx,this.ang,Math.PI,true);</code>	Draw right curve
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in path
<code>}</code>	Close function
<code>function overheart(mx,my) {</code>	header for overheart function
<code>var leftctrx = this.x-this.drx;</code>	Set variable to be x coordinate of center of left curve
<code>var rightctrx = this.x+this.drx;</code>	Set variable to be x coordinate of center of right curve
<code>var qx = this.x-2*this.drx;</code>	Calculate and set variable to be x coordinate of left of bounding rectangle
<code>var qy = this.y-this.drx;</code>	Calculate and set variable to be y coordinate of top of bounding rectangle
<code>var qwidth = 4*this.drx;</code>	Calculate and set variable to be width of bounding rectangle

---

*(continued)*

**Table 2-2.** (continued)

---

<pre>var qheight = this.drx+this.h;</pre>	Calculate and set variable to be height of bounding rectangle
<pre>if (outside(qx,qy,qwidth, qheight,mx,my)) {     return false;} if (distsq(mx,my,leftctrx,this.y) &lt;this.radsq) return true; if (distsq(mx,my,rightctrx,this.y) &lt;this.radsq) return true; if (my&lt;=this.y) return false;</pre>	Quick test if it is in bounding rectangle  Check if inside left curve or right curve Return false if above y on screen (and not previously determined to be within curves)
<pre>var x2 = this.x</pre>	Start calculations to compare my to slopes. Set x2 and
<pre>var y2 = this.y + this.h; var m = (this.h)/(2*this.drx); if (mx&lt;=this.x) {     if (my &lt; (m*(mx-x2)+y2)) {         return true;}     else {         return false;} }</pre>	set y2 to have x2, y2 point on each sloping line calculate slope of left line If mx is on the left side... compare my to the y value corresponding to mx. If my is above (on the screen), then return true Else Otherwise return false
<pre>else { m = -m; if (my &lt; (m*(mx-x2)+y2)) {return true} else return false;</pre>	Close if if (mx<=this.x) clause Else Change sign of slope to be slope of the right line Compare my to the value corresponding to mx on the right line and if less than (farther up on the screen) return true Else return false

---

(continued)

**Table 2-2.** (continued)

---

}	Close clause
}	Close function
function outside(x,y,w,h,mx,my) {	Header for outside
return ((mx<x)    (mx > (x+w))	Return based on calculation with x,y and width
(my < y)    (my > (y+h)));	and height
}	Close outside
function drawpic() {	Header drawpic
ctx.globalAlpha = 1.0;	Set alpha
ctx.drawImage(this.imagename,	Draw the image
this.x,this.y,this.w,this.h);	
}	Close drawpic
function Oval(x,y,r,hor,ver,c) {	Function header for Oval constructor, position
	x, y, horizontal scaling hor, vertical scaling ver,
	color c
this.x = x;	Set attribute
this.y = y;	Set attribute
this.r = r;	Set attribute
this.radsq = r*r;	Store as attribute to avoid repeated calculations
	later
this.hor = hor;	Set attribute
this.ver = ver;	Set attribute
this.draw = drawoval;	Set drawoval as the draw method
this.color = c;	Set attribute
this.overcheck = overoval;	Set overoval as the overcheck method
}	Close function

---

*(continued)*

**Table 2-2.** (continued)

---

<code>function drawoval() {</code>	Function header for <code>drawoval</code>
<code>ctx.save();</code>	Save current coordinate state
<code>ctx.translate(this.x,this.y);</code>	Move to center
<code>ctx.scale(this.hor,this.ver);</code>	Scale as indicated by attributes
<code>ctx.fillStyle = this.color;</code>	Set color
<code>ctx.beginPath();</code>	Start path
<code>ctx.arc(0,0,this.r,0,2*Math.PI,true);</code>	Draw arc (complete circle)
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in
<code>ctx.restore();</code>	Restore original coordinate state
<code>}</code>	Close function
<code>function Rect(x,y,w,h,c) {</code>	Function header <code>Rect</code> constructor: position <code>x,y</code> , width <code>w</code> and height <code>h</code> , color <code>c</code>
<code>this.x = x;</code>	Set attribute
<code>this.y = y;</code>	Set attribute
<code>this.w = w;</code>	Set attribute
<code>this.h = h;</code>	Set attribute
<code>this.draw = drawrect;</code>	Set <code>drawrect</code> as the draw method
<code>this.color = c;</code>	Set attribute
<code>this.overcheck = overrect;</code>	Set <code>overrect</code> as the overcheck method
<code>}</code>	Close function
<code>function overoval(mx,my) {</code>	Function header for <code>overoval</code>
	Compute positions in the translated and scaled coordinate system
<code>var x1 = 0;</code>	Set variable to be used in call to <code>distsq</code> ; this represents <code>x</code> coordinate of point at center of oval

---

(continued)

**Table 2-2.** (continued)

---

<pre>var y1 = 0;</pre>	Set variable to be used in call to <code>distsq</code> ; this represents y coordinate of point at center of oval
<pre>var x2 = (mx-this.x)/this.hor;</pre>	Calculate the x2 using input and scaling factor
<pre>var y2 = (my-this.y)/this.ver;</pre>	Calculate the y2 using input and scaling factor
<pre>if (distsq(x1,y1,x2,y2)&lt;= (this.radsq) ){</pre>	If distance squares is less than stored radius squared....
<pre>    return true</pre>	Return true
<pre>}</pre>	End clause
<pre>else {return false}</pre>	Else return false
<pre>}</pre>	Close function
<pre>function overrect (mx,my) {</pre>	Header for overrect
<pre>    return ( (mx&gt;=this.x)&amp;&amp;(mx&lt;= (this.x+this.w))&amp;&amp;(my&gt;=this.y) &amp;&amp;(my&lt;=(this.y+this.h))) ;</pre>	Standard calculation for rectangles
<pre>}</pre>	Close overrect
<pre>function makenewitem(ev) {</pre>	Function header for makenewitem; has as a parameter and event <code>ev</code> set by JavaScript
<pre>    var mx;</pre>	Variable will hold x coordinate of mouse
<pre>    var my;</pre>	Variable will hold y coordinate of mouse
<pre>    if ( ev.layerX    ev.layerX == 0) { // Firefox, ???</pre>	Does this browser use layer...
<pre>        mx= ev.layerX;</pre>	... set mx
<pre>        my = ev.layerY;</pre>	... set my
<pre>    } else if (ev.offsetX    ev.offsetX == 0) { // Opera, ???</pre>	Does browser use offset...
<pre>        mx = ev.offsetX;</pre>	... set mx
<pre>        my = ev.offsetY;</pre>	... set my

---

*(continued)*

**Table 2-2.** *(continued)*


---

}	End clause
var endpt = stuff.length-1;	Store index of last item in stuff array
var item;	Will hold the new item
for (var i=endpt;i>=0;i--) {	Start search from the end
//reverse order	
if (stuff[i].	Is the mouse over this member of stuff
overcheck(mx,my)) {	
item = clone(stuff[i]);	Clone (make copy of)
item.x +=20;	Move over slightly horizontally
item.y += 20;	and vertically
stuff.push(item);	Add newly created item to stuff array
break;	Leave for loop
}	End if clause
}	End for loop
}	Close function
function clone(obj) {	Function header for clone
var item = new Object();	Create an Object
for (var info in obj) {	Loop over all attributes of the obj passed as parameter
item[info] = obj[info];	Set an attribute by that name to the attribute value
}	Close for loop
return item;	Return the newly created object
}	Close function
function startdragging(ev) {	Function header for startdragging; has as a parameter an event ev set by JavaScript

---

*(continued)*

**Table 2-2.** *(continued)*

---

var mx;	Variable will hold x coordinate of mouse
var my;	Variable will hold y coordinate of mouse
if ( ev.layerX    ev.layerX == 0) { // Firefox, ???	Does this browser use layer...
mx= ev.layerX;	... set mx
my = ev.layerY;	... set my
} else if (ev.offsetX    ev.offsetX == 0) { // Opera, ???	Does browser use offset...
mx = ev.offsetX;	... set mx
my = ev.offsetY;	... set my
}	End clause
var endpt = stuff.length-1;	Store index of last item in stuff array
for (var i=endpt;i>=0;i--) { //reverse order	Start search from the end
if (stuff[i]. overcheck(mx,my)) {	Is the mouse over this member of stuff
offsetx = mx-stuff[i].x;	Calculate how far the mx was from the x of this object
offsety = my-stuff[i].y;	Calculate how far the my was from the y of this object
var item = stuff[i];	Will now move this item to the end of the array; set item
thingInMotion = stuff.length-1;	Set global variable to be used in the dragging
stuff.splice(i,1);	Remove this item from its original location
stuff.push(item);	Add item to the end
canvas1.style.cursor = "pointer";	Change cursor to finger when dragging

---

*(continued)*

**Table 2-2.** *(continued)*


---

<pre>         canvas1.addEventListener(             'mousemove',moveit,false);         canvas1.addEventListener             ('mouseup',dropit,false);         break;     } } function dropit(ev) {     canvas1.removeEventListener         ('mousemove',moveit,false);     canvas1.removeEventListener         ('mouseup',dropit,false);     canvas1.style.cursor =         "crosshair"; } function moveit(ev) {     var mx;     var my;     if ( ev.layerX    ev.layerX         == 0) { // Firefox, ???         mx= ev.layerX;         my = ev.layerY;     } else if (ev.offsetX            ev.offsetX == 0) { //         Opera, ??? </pre>	<pre> Set up event handling for moving the mouse Set up event handling for releasing mouse button Leave the for loop Close if clause Close for loop Close function Function header for dropit; has as a parameter and event ev set by JavaScript Remove (stop) event handling for moving the mouse Remove (stop) event handling for releasing the mouse button Change cursor back to crosshair close function Function header for moveit; has as a parameter and event ev set by JavaScript Variable will hold x coordinate of mouse Variable will hold y coordinate of mouse Does this browser use layer... ... set mx ... set my Does browser use offset... </pre>
--	--

---

*(continued)*



**Table 2-2.** *(continued)*

---

mx = ev.offsetX;	... set mx
my = ev.offsetY;	... set my
}	End clause
stuff[thingInMotion].x = mx-offsetx; //adjust for flypaper dragging	Set x for the thingInMotion, adjust for flypaper dragging
stuff[thingInMotion].y = my-offsety;	Set y for the thingInMotion, adjust for flypaper dragging
}	Close function
 function drawstuff() {	 Function header for drawstuff
ctx.clearRect(0,0,800,600);	Clear (erase) canvas
ctx.strokeStyle = "black";	Set color for frame
ctx.lineWidth = 2;	Set lineWidth
ctx.strokeRect(0,0,800,600);	Draw frame
for (var i=0;i<stuff. length;i++) {	Iterate through the stuff array
stuff[i].draw();	Invoke the draw method for each member of the array
}	Close for
}	Close function
 function drawrect() {	 Function header drawrect
ctx.fillStyle = this.color;	Set the color
ctx.fillRect(this.x, this.y, this.w, this.h);	Draw a filled rectangle
}	Close function

---

*(continued)*

**Table 2-2** (continued)

---

<code>function saveasimage() {</code>	Function header for <code>saveasimage</code>
<code>  try {</code>	Start try clause
<code>    window.open(canvas1. toDataURL("image/png"));}</code>	Create the image data and use it as contents of new window
<code>  catch(err) {</code>	If that didn't work, that is, threw an error
<code>    alert("You need to change browsers AND/OR upload the file to a server.");</code>	Display alert message
<code>  }</code>	Close catch clause
<code>}</code>	Close function
<code>function removeobj() {</code>	Function header for <code>removeobj</code>
<code>  stuff.pop();</code>	Remove the last member of the <code>stuff</code> array
<code>  drawstuff();</code>	Draw everything
<code>}</code>	Close function
<code>&lt;/script&gt;</code>	Close script element
<code>&lt;/head&gt;</code>	Close head element
<code>&lt;body onLoad="init();"&gt;</code>	Body tag, with <code>onLoad</code> set
Mouse down, move and mouse up to move objects. Double-click for make a copy of any object.	Text giving directions
<code>&lt;br/&gt;</code>	Line break
<code>&lt;canvas id="canvas" width="800" height="600"&gt;</code>	Canvas tag
Your browser doesn't recognize the canvas element	Message for older browsers

---

(continued)

**Table 2-2.** (continued)

---

<code>&lt;/canvas&gt;</code>	Ending canvas tag
<code>&lt;button onClick="saveasimage();"&gt;Open window with image (which you can save into image file) &lt;/button&gt;&lt;/br&gt;</code>	Button for saving image
<code>&lt;button onClick="removeobj();"&gt;Remove last object moved &lt;/button&gt;</code>	Button for removing object
<code>&lt;/body&gt;</code>	Close body tag
<code>&lt;/html&gt;</code>	Close html tag

---

It is obvious how to make this application your own using only the techniques demonstrated in my example: gather photos and videos of your own family or acquire other media and use the `rect`, `oval`, and `heart` to create your own set of shapes.

You can define your own objects, using the coding here as a model. For example, the *Essential Guide to HTML5* book includes coding for displaying polygons. You can make the `overcheck` function for the polygon treat the polygon as a circle, perhaps a circle with smaller radius, and your customers will not object.

The next step could be to build an application that allows the end-user to specify the addresses of image files. You would need to set up a form for doing this. Another enhancement is to allow the end-user to enter text, perhaps a greeting, and position it on the canvas. You would create a new object type and write the `draw` and `overcheck` methods. The `overcheck` method could be `overrect`, that is, the program accepts as being on the text anything in the bounding rectangle.

## Testing and Uploading the Application

The application consists of code files, one with an extension of .html and the other with an extension of .js plus all the media files. You need to gather all the media files you want to include in your application and create the .js file that references the media files and specifies how you want them to be treated. To put it another way, you can keep my .html file, and substitute your own .js file, referencing all of your media. The testing procedure depends on what browser you are using. Actually, it is good practice to test with several browsers. If you are using Firefox, you need to upload the application—the .html file and all image files—to a server to test the feature for creating an image. However, the other aspects of the application can be tested on your own (client) computer.

## Summary

In this chapter, you learned how to build an application involving creating and positioning specific shapes, namely rectangles, ovals, and hearts, along with pictures such as photographs on the canvas. The programming techniques and HTML5 features included:

- Separating content and action
- Dynamic creation of HTML5 elements
- Programming-defined objects
- Mouse events on canvas
- Using `try` and `catch` for trapping errors
- Algebra and geometry for several functions
- Consideration of video autoplay policy

The next chapter describes creating an application showing a video clip bouncing around like a ball in a box.

## CHAPTER 3

# Bouncing Video: Animating and Masking HTML5 Video

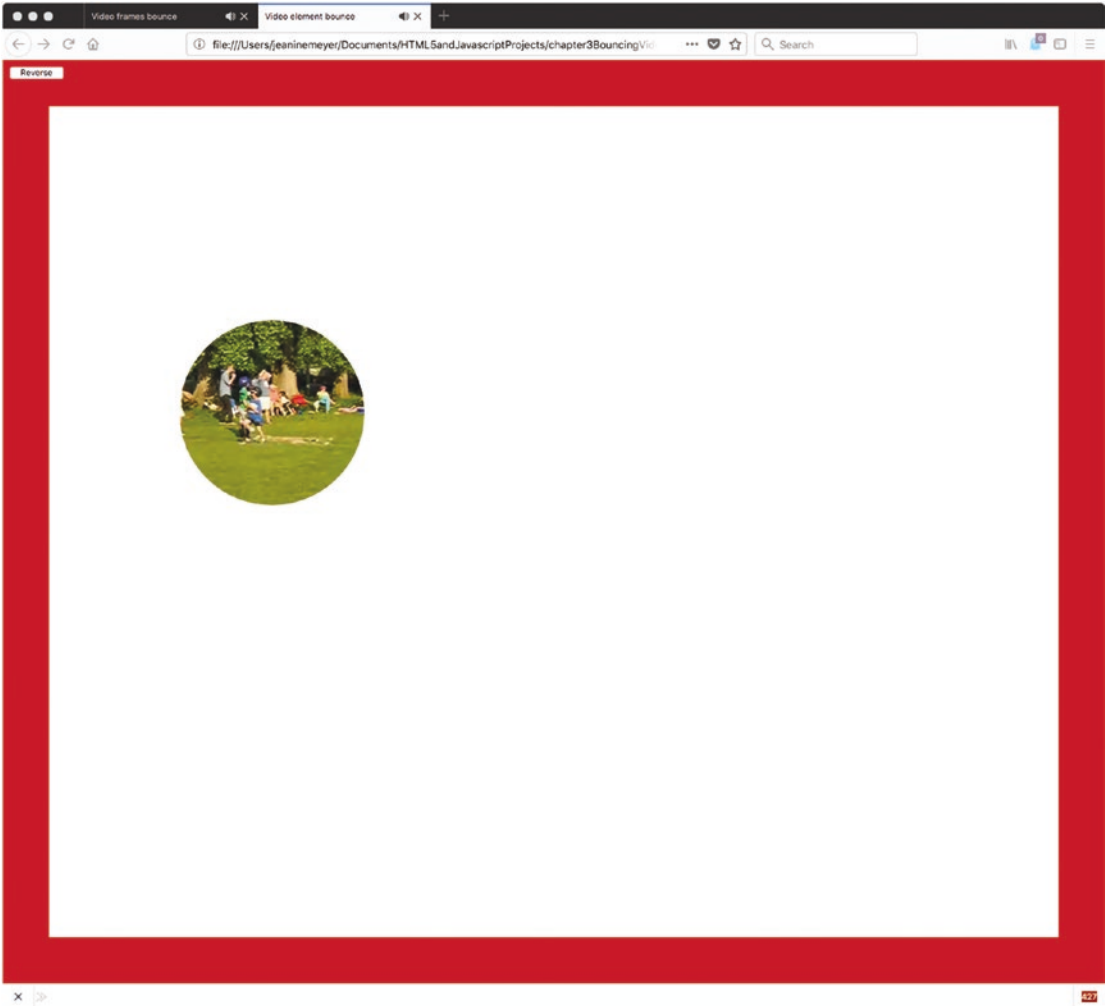
In this chapter, you will learn the following:

- Produce a moving video clip by drawing the current frame of the video at different locations on a canvas
- Produce a moving video clip by repositioning the video element within the document window
- Make the moving video be a circle in the drawing a frame on canvas case by drawing a mask that travels along with the video
- Make the moving video be a circle in the moving element situation by using `clipPath`
- Build an application that will adapt to different window sizes

## Introduction

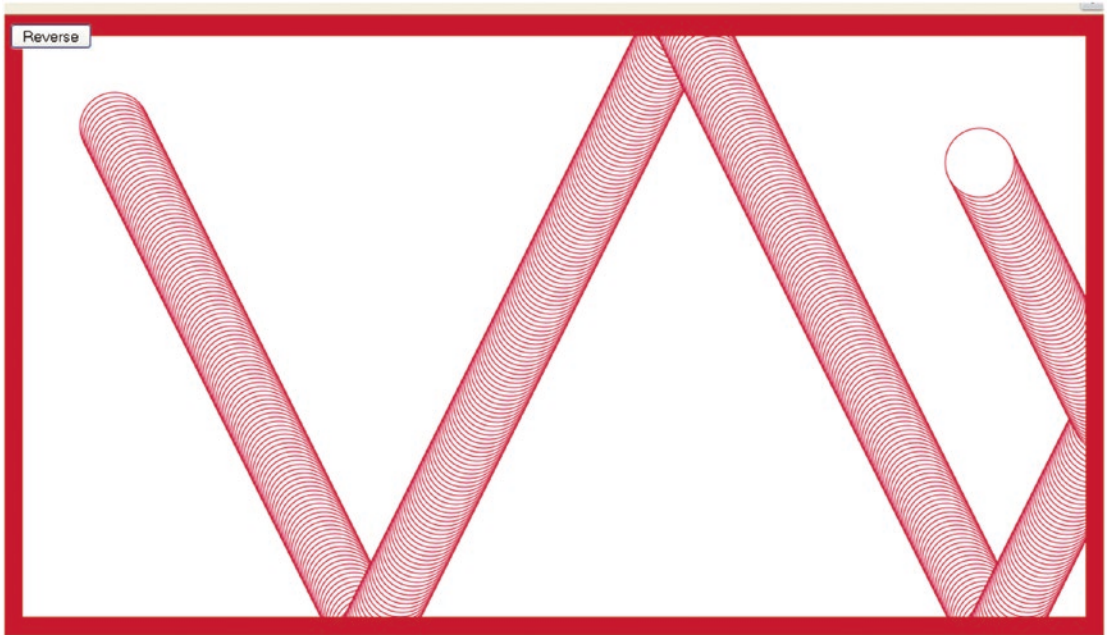
The project for this chapter is a display of a video clip in the shape of a ball bouncing in a box. An important feature in HTML5 is the native support of video (and audio). The book *The Definitive Guide to HTML5 Video*, by Silvia Pfeiffer (Apress, 2010), is an excellent reference. The challenge in this project is making the video clip move on the screen. I will describe two different ways to implement the application. The screenshots do not reveal the differences.

Figure 3-1 shows what the application looks like in the full-window view in Firefox. The video is a standard rectangular video clip. It appears ball-like because of my coding. You can skip ahead to Figure 3-8 and Figure 3-9 to learn about two techniques for producing a ball shaped video. Note: all figures are static screen captures of animations. You need to take my word for it that the video does move and bounce within the box.



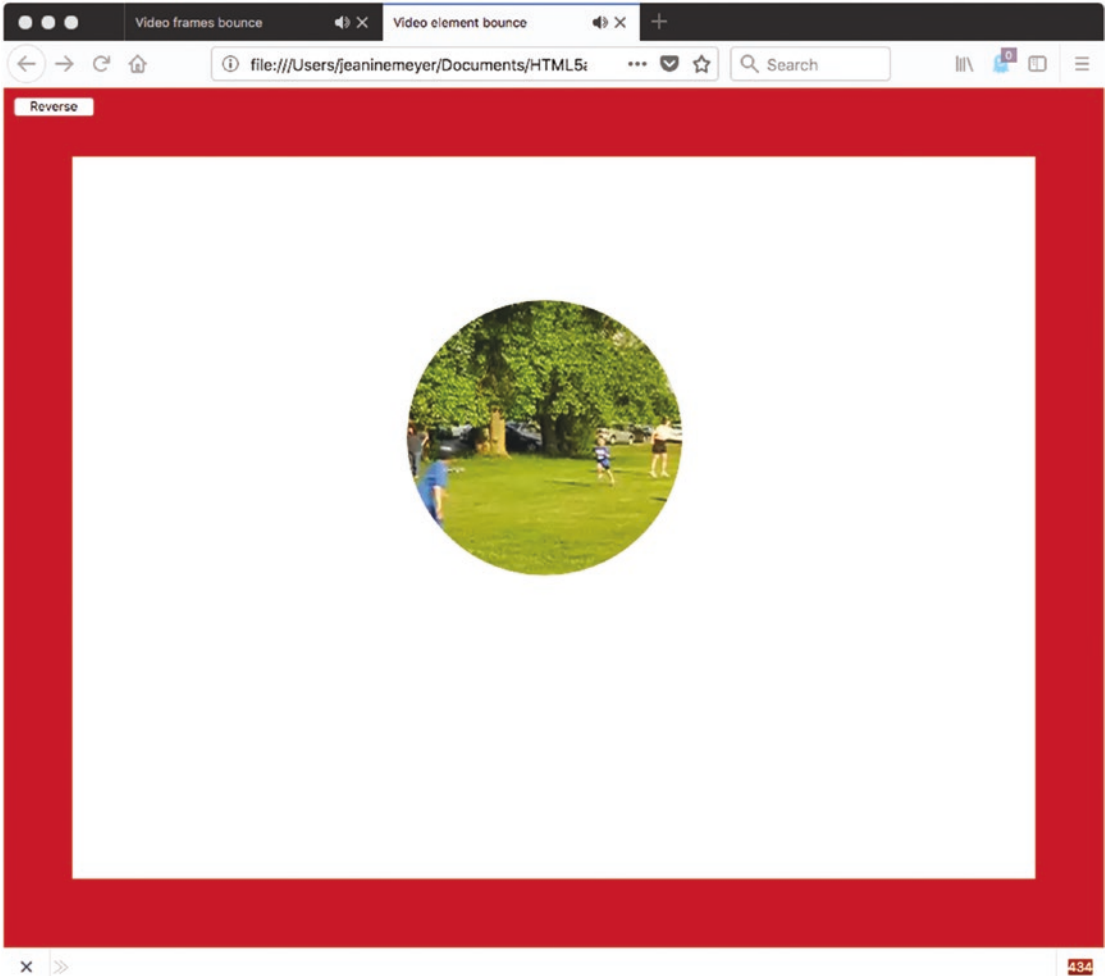
**Figure 3-1.** Screen capture, full window

When the virtual ball hits a wall, it appears to bounce off the wall. If, for example, the virtual ball is moving down the screen and to the right, when it hits the right side of the box, it will head off to the left but still be moving down the screen. When the virtual ball then hits the bottom wall of the box, it will bounce to the left, heading up the screen. The trajectory is shown in Figure 3-2. To produce this image, I changed the virtual ball to be a simple circle and did not write code to erase the canvas at each interval of time. You can think of it as stop-motion photography. Changing the virtual ball was necessary because of its complexity: an image from a video clip and an all-white mask.



**Figure 3-2.** *Trajectory of virtual ball*

If I resize the browser window to be a little bit smaller and reload the application, the code will resize the canvas to produce what is shown in Figure 3-3: a smaller box, but the same size video.



**Figure 3-3.** Application in a smaller window



If the window is made very small, this forces a change in the size of the video clip itself, as well as the canvas and the box, as shown in Figure 3-4.



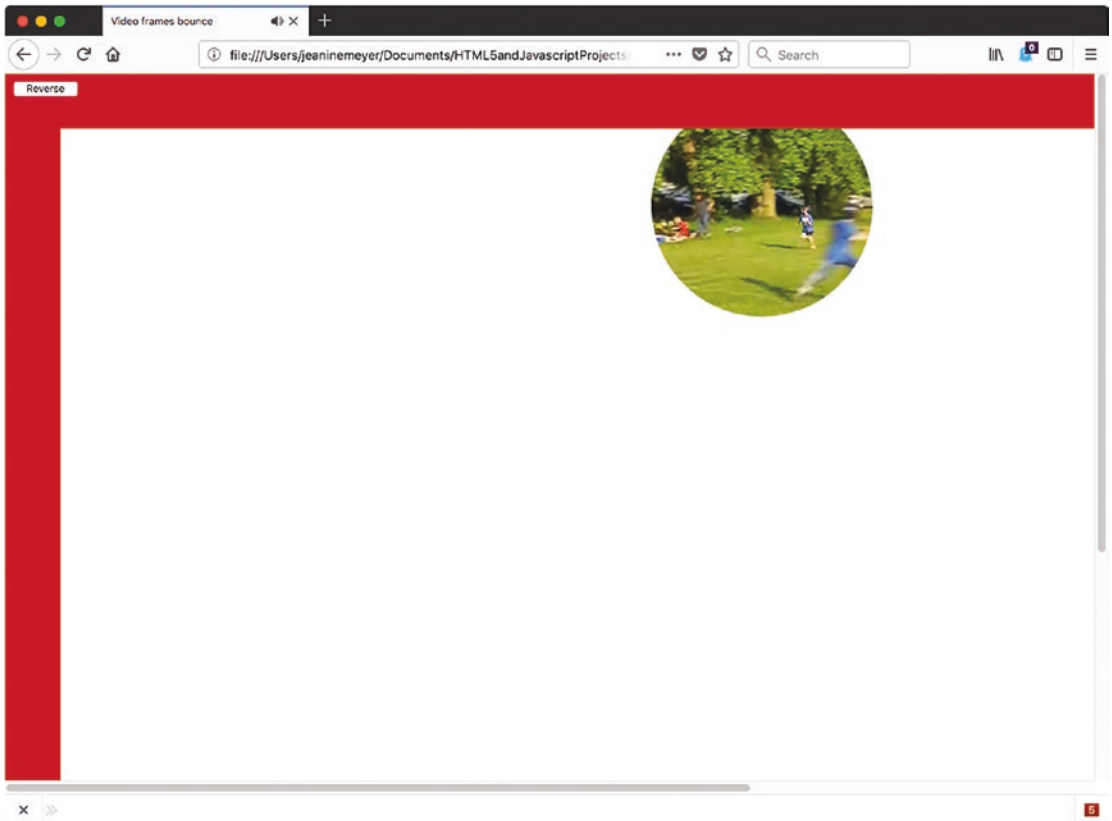
*Figure 3-4. Window resized to very small*

The application adapts the box size, and the virtual video ball size, to the window dimensions at the time that the HTML document is first loaded. If the window is resized by the viewer later, during the running of the application, the canvas and video clip are not resized. In this case, you would see something like Figure 3-5, a small box in a big window.



**Figure 3-5.** *Window resized during running to be larger*

Similarly, if you start the application using a full-size window, or any large window, and resize it to something smaller during the running of the program, you would see something like Figure 3-6, where the scroll bars are displayed by the browser to indicate that the content of the document is wider and longer than the window. The video clip will disappear out of sight periodically for a short period of time before reappearing.



**Figure 3-6.** *Large window resized*

The two applications (I named them `videobounceC` for “video frames drawn on canvas” and `videobounceEwithClipPath` for “video element using `clipPath`”) have been tested successfully in Firefox and Chrome. Note: look back in Chapter 2 for the discussion of Chrome autoplay policy. I have added the muted attribute to the video tag for this project. The project demonstrates coding techniques using HTML5, JavaScript, and CSS for manipulating video and using video together with the canvas for special effects. The project also explains calculations that are helpful in modifying applications to the dimensions of the browser window. More on adapting to different dimensions is discussed in Chapter 10.

## Project History and Critical Requirements

I have always liked the application of simulating a ball bouncing in a box. Chapter 3 in *The Essential Guide to HTML5* features projects showing a ball produced by a path drawing and a ball produced by an image, each bouncing in a two-dimensional enclosure. I decided I wanted to make a video clip do the same thing. My explanation of the coding is complete in this chapter. However, if the first book is available to you (shameless plug), you may benefit from seeing what is the same and what is different among the various versions. In the ball and image applications, the canvas was set to fixed dimensions and was located with other material in the document. Because I did not want my video clip to be too small, I decided to use the whole window in this case. This objective produced the challenge of determining the dimensions of the document window. In the ball and image applications described in the other book, I wanted to demonstrate form validation, so the program provided form elements to change the vertical and horizontal speed. For the bouncing ball video clip, the application just provides one action for the user: a button to reverse direction. After studying this chapter, you should be able to add the other interface operations to the video application.

In Chapter 2, you read about including a video with images and drawings. For that application, I used the technique of drawing the current frame as an image on the canvas. The drawing was done periodically and often enough to get the experience of seeing an uninterrupted video. For this chapter, I used that technique and made a mask—think of a rectangular doughnut—travel along to give the video a ball-like shape. In addition, I built another HTML/JavaScript script using the approach of moving the video element directly. One advantage of the element approach is that I can use the `clipPath` facility to make the rectangular video element appear ball-like. This requires much less coding than drawing the rectangular doughnut mask.

The objective is to simulate a ball-like object bouncing within a box. Therefore, the application must display the walls of the box and perform calculations so that when the video clip appears to collide with any of the walls, the direction of motion changes in the appropriate way. A fancy way to describe the change is that the angle of reflection must equal the angle of incidence. In practical terms, what it means is that when the video clip virtually hits the bottom or top walls, it keeps going in the same direction horizontally (to the left if it was traveling to the left and to the right if it was traveling to the right), but switches direction vertically. When the video clip virtually hits either

the left or the right wall, it keeps going in the same direction vertically (traveling up if it was traveling up and traveling down if it was traveling down), but switches direction horizontally. If you are interested in simulating real-life physics, you can slow down the motion at each virtual hit of a wall.

As is my practice, I describe the coding in increasing detail. You can go to the source.

## HTML5, CSS, and JavaScript Features

Any order of explanation means something is often discussed before the reason for doing it is clear. In this section, I show how certain variables are set that will be shown in use later on. The general plan is to extract the window dimensions to set variables for the canvas and the video clip that will be referenced in the coding for drawing the video and the mask.

### Definition of the Body and the Window Dimensions

The Document Object Model (DOM) provides information about the window in which the HTML document is displayed by the browser. In particular, the attributes `window.innerWidth` and `window.innerHeight` indicate the usable dimensions of the window. My code will use these values when it sets up the application.

Recall that the HTML5 video element can contain as child elements any number of source elements referencing different video files. At this time, this is necessary because the browsers that recognize the video element do not accept the same video formats (codecs). The situation may change in the future. If you know the browser used by *all* your potential customers, you can determine a single video format. If that is not the case, you need to make three versions of the same video clip. The Open Source Miro Video Converter, downloadable from [www.mirovideoconverter.com/](http://www.mirovideoconverter.com/), is a good product to convert a video clip into other formats.

With that reminder, I can present the body element for this application. It contains a video element, a button, and a canvas element:

```
<body onLoad="init();">
<video id="vid" loop="loop" preload="auto" muted>
<source src="joshuahomerun.mp4" type='video/mp4; codecs="avc1.42E01E,
mp4a.40.2"'>
```

```
<source src="joshuahomerun.webmvp8.webm" type='video/webm; codec="vp8, vorbis"'>
<source src="joshuahomerun.theora.ogv" type='video/ogg; codecs="theora, vorbis"'>
```

Your browser does not accept the video tag.

```
</video>
<button id="revbtn" onClick="reverse();">Reverse </button><br/>
<canvas id="canvas" >
This browser doesn't support the HTML5 canvas element.
</canvas>
</body>
```

Style directives will change the location of the three elements: video, canvas, and button. We will discuss the directives later in this chapter.

In the `init` function that's invoked when the document is loaded, the following statements set the dimensions of the canvas to match the dimensions of the window:

```
canvas1 = document.getElementById('canvas');
ctx = canvas1.getContext('2d');
canvas1.width = window.innerWidth;
cwidth = canvas1.width;
canvas1.height = window.innerHeight;
cheight = canvas1.height;
```

These statements set global variables `canvas1`, `ctx`, `cwidth`, and `cheight`, which will be used later. So the task of adapting the canvas to the window is accomplished.

Now the next task takes more thought. How much do I want to adapt the video to the window dimensions? I decided that I wanted to maintain the aspect ratio, but not have the video width exceed half of the window width, nor have the video height exceed half of the window height. I did not want to trigger vertical or horizontal scrolling. I was okay, even happy, with the circles going beyond the box walls, because it looked something like the balls flattening. I do think there is room for improvement here.

The `Math.min` method returns the smallest of its operands, so the statements

```
v = document.getElementById("vid");
var aspect= v.videoWidth/v.videoHeight;
v.width = Math.min(v.videoWidth,.5*cwidth);
```

```

v.height = v.width/aspect;
v.height = Math.min(v.height,.5*cheight);
v.width = aspect*v.height;
var videow = v.width;
var videoh = v.height;

```

start by setting the variable `v` to point to the video element, which you can see I have coded in the body to have the id "vid". It then calculates the aspect ratio to be used to maintain the video's portion. My code first compares the video width to .5 of the canvas width and sets it to be the minimum of the two values and makes the corresponding change to the video height. *Then* the code performs a similar operation on the newly adjusted height, adjusting the width.

Certain other variables are set in the `init` function and used for the drawing of the box and for the mask for one example and the box and the `clipPath` for the other. You can examine this in Table 3-2 and Table 3-4.

## Animation

Animation is the trick by which still images are presented in succession fast enough so that our eye and brain interprets what we see as motion. The exact mechanics of how things are drawn are explained in the next two sections. Keep in mind that there are two animations going on: the presentation of the video and the location of the video in the box. In this section, I talk about the location of the video in the box.

One way to get animation in HTML and JavaScript is to use the `setInterval` function. This function is called with two parameters. The first is the name of a function that we want to call periodically and the second indicates the length of the time interval between each call to the function. The unit of time is milliseconds.

I began by describing the drawing frames example. The moving the element example is similar and I will describe the differences. The following statement, which is in the `init` function, sets up the animation:

```
setInterval(drawscene,50);
```

The parameter `drawscene` refers to a function that will do the bulk of the work. It draws a frame from the video and draws the mask, what I refer to as the rectangular doughnut. I will describe that operation later. The 50 in the `setInterval` call stands for 50 milliseconds. This means that every 50 milliseconds (or 20 times per second), the `drawscene` function will be invoked. Presumably, `drawscene` will do what needs to be

done to display something showing the video clip at a new location. You can experiment with interval duration.

If you want to enhance this application or build another one in which it makes sense to stop the animation, you would declare a local variable for the `setInterval` call (let's call it `tid`) and use the statement

```
tid = setInterval(drawscene,50);
```

At the point you wish to stop the animation, or more formally, stop the interval-timing event, you code

```
clearInterval(tid);
```

If you have more than one timing event, you would assign the output for each of them to a new variable. Be careful not to call `setInterval` multiple times with the same function. Doing so has the effect of adding new timing events and invoking the function multiple times. It is not changing the alarm function on your clock, but setting multiple clocks.

Much of the details of the `drawscene` function will be described in the next sections, but I describe two critical tasks here. One is erasing the canvas and the other is determining the next position of the video clip. The statement for erasing the whole canvas is

```
ctx.clearRect(0,0,cwidth,cheight);
```

Notice that it uses the `cwidth` and `cheight` values calculated based on the window dimensions.

The simulation of bouncing is performed by a function called `checkPosition`. The position of the virtual ball is defined by the variables `ballx` and `bally`. The `(ballx,bally)` position is the upper-left corner of the video. The motion, also termed the *displacement*, is defined by the variables `ballvx` and `ballvy`. These two variables are termed the horizontal and vertical displacements, respectively.

---

**Note** Why did I use two functions, `drawscene` and `checkPosition`, when I could have used just one? The `checkposition` function is just invoked by `drawscene`. The answer is that the operation of these seemed like distinct operations to me and it is a good practice to make distinct functions for distinct tasks.

---



The objective of the `checkPosition` function is to reposition the virtual ball by setting `ballx` and `bally` to expressions involving `ballvx` and `ballvy`, respectively. When appropriate, my code must change the signs of `ballvx` and `ballvy`. The way the code works is to try out new values (see `nballx` and `nbally` in the function) and then set `ballx` and `bally`. Changing the sign of the displacement values has the effect of making the balls bounce by changing the appropriate horizontal or vertical adjustment for the next interval. If the ball hits at a corner, then both displacement values change sign, but generally, just one changes.

The task now is to determine when to do the bounce. You need to accept that as far as the computer's concerned, there are no balls, bouncing or otherwise, and no walls. There are just calculations. Moreover, the calculations are done at discrete intervals of time. There is no continuous motion. The virtual ball jumps from position to position. The trajectory appears smooth because the jumps are small enough and our eye-brain interprets the pictures as continuous motion. Since the walls are drawn after the video (that will be explained later), the effect is that the virtual ball touches and goes slightly behind the wall before changing direction.

My approach is to set up trial or stand-in values for `ballx` and `bally` and do calculations based on these values. You can think of it logically as asking if the video ball were moved, would it be beyond any of the walls? If so, readjust to just hit that wall and change the appropriate displacement value. The new displacement value is not used immediately, but will be part of the calculation made at the next iteration of time. If the trial value is not at or beyond the wall, keep the trial value as it is and keep the corresponding displacement value as it is. Then change `ballx` and `bally` to the possibly adjusted stand-in values.

The function definition for the `checkPosition` function for the `videobounceC` program is

```
function checkPosition() {
    var nballx = ballx + ballvx +.5*videow;
    var nbally = bally + ballvy +.5*videoh;
    if (nballx > cwidth) {
        ballvx =-ballvx;
        nballx = cwidth;
    }
}
```

```

if (nballx < 0) {
    nballx = 0;
    ballvx = -ballvx;
}
if (nbally > cheight) {
    nbally = cheight;
    ballvy =-ballvy;
}
if (nbally < 0) {
    nbally = 0;
    ballvy = -ballvy;
}
ballx = nballx-.5*videow;
bally = nbally-.5*videoh;
}

```

I decided to change the name of the function `drawscene` for the video element example. I wanted to emphasize that the video was moving as opposed to being drawn. The counterpart of `drawscene` is `moveVideo`. This is the function referenced in the `setInterval` call.

```

function moveVideo(){
    checkPosition();
    v.style.left = String(ballx)+"px";
    v.style.top = String(bally)+"px";
}

```

The `checkPosition` function does the calculation to determine when bouncing takes place.

```

function checkPosition() {
    var nballx = ballx + ballvx;
    var nbally = bally + ballvy;

    if ((nballx+v.width) > cwidth) {
        ballvx =-ballvx;
    }
}

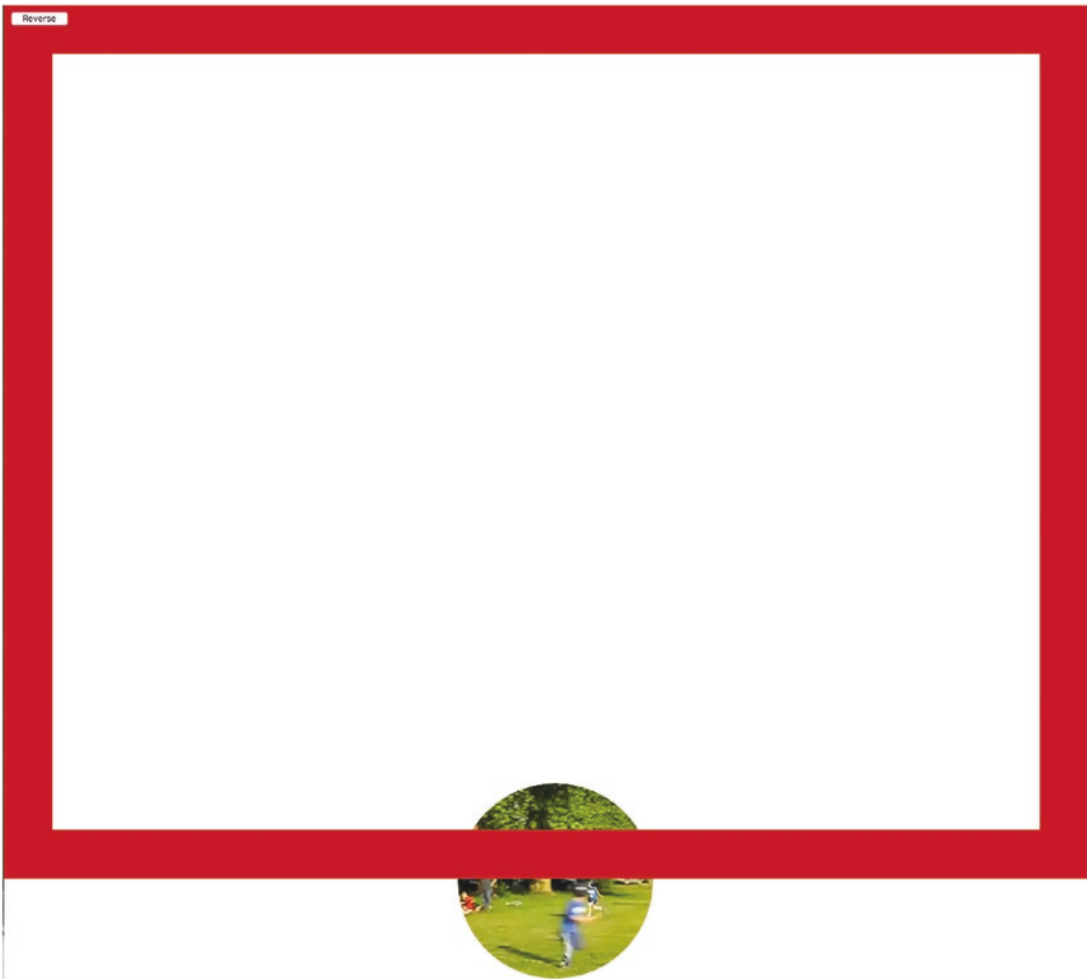
```

```

        nballx = cwidth-v.width;
    }
    if (nballx < 0) {
        nballx = 0;
        ballvx = -ballvx;
    }
    if ((nbally+v.height) > cheight) {
        nbally = cheight-v.height;
        ballvy =-ballvy;
    }
    if (nbally < 0) {
        nbally = 0;
        ballvy = -ballvy;
    }
    ballx = nballx;
    bally = nbally;
}

```

Notice that the `videobounceC` version compares `ballx + ballvx + .5*videow` to `cwidth`, whereas `videobounceEwithClipPath` compares `ballx + ballvx + videow` to `cwidth`. This means the `videobounceE` program will force bouncing sooner—that is, turn around sooner—when compared with the right wall. The same holds true for the checking against the bottom wall. I did this to avoid a problem involving automatic scrolling. The video element is not restricted to the canvas, so if it moves out from under the canvas, it is part of the document and is displayed. Because the new display is bigger than the window, this causes scrolling. The scroll bars would appear, and though you would not see anything, I did not like the effect. If you started with a smaller window and made it larger during the program execution, you could see something like what is shown in Figure 3-7. The video element also can move so fast that it escapes the box. This is an amusing exercise left for the reader.



**Figure 3-7.** *Video element bouncing with less restrictive checking*

To avoid this, you will see that I changed the checking for the video element application. The downside to doing this is that the video ball barely touches the right and bottom walls.

The reason why these effects do not happen in the video-drawn-on-canvas application, `videobounceC`, is that drawing on canvas with coordinates outside of the canvas has no visible effect. You can look back to Chapter 1, Figure 1-6, to see an example of drawing “outside the lines” and producing nothing outside the canvas.

**Note** There may be other ways to avoid the scrolling problem. This would not prevent the unsightliness shown in Figure 3-7. It may be possible to prevent scrolling in the browser. It is possible to stop the users from scrolling, but automatic scrolling appears to be more of a challenge.

---

## Video Drawing Frames on Canvas or As a Movable Element

I now describe two different implementations: one with material from the video drawn on the canvas and the other with the video element moved around the document.

### Video Drawn on Canvas

As I mentioned previously, HTML5 does provide the facility to draw video on the canvas as one would draw an image. This actually is a misnomer. Video clips are made up of sequences of still images called *frames*. Frame rates vary but typically are 15 to 32 frames per second, so you can understand that video files tend to be large. Video is stored using different types of encodings, each of which may make different technical trade-offs in terms of quality and storage size. We do not need to be concerned with these technicalities, but can think of the video as a sequence of frames. Playing a video involves presenting the frames in sequence. What happens in the `drawImage` command is that the current frame of the video clip is the image drawn on the canvas. If this operation is performed through a timed interval event, then the viewer will see a frame at each interval of time. There is no guarantee that the images shown are successive frames from the video clip, but if done fast enough, the frames drawn will be close enough to the actual sequence that our eye and brain experience it as the live action of the video clip.

The command in pseudocode is

```
ctx.drawImage(video element, x position, y position, width, height);
```

This command, formally a method of the `ctx` canvas context, extracts the image corresponding to the current frame of the video and draws it at the `x` and `y` values, with the indicated width and height. If the image does not have the specified width and height, the image is scaled. This will not occur for this situation.

The goal is to make the traveling video clip resemble a ball. For this application, this means we want to mask out all but a circle in the center of the rectangular video clip. I accomplish this by creating a traveling mask. The mask is a drawing in the canvas. Since I want to place the video element on the canvas element, and also position a shape created by drawing a path on top of the image drawn from the video clip, I use CSS directives to make both video and canvas be positioned using absolute positioning. I want the Reverse button to be on top of the canvas. These directives do the trick:

```
#vid {position:absolute; display:none;}
#canvas {position:absolute; z-index:10; top:0px; left:0px;}
#revbtn {position:absolute; z-index:20;}
```

A way to remember how the layering works is to think of the z-axis as coming out of the screen. Elements set at higher values are on top of elements set at lower values. The top and left properties of the canvas are each set to 0 pixels to position the upper-left corner of the canvas in the upper-left corner of the window.

---

**Note** When the z-index is referenced or modified in JavaScript, its name is `zIndex`. Hopefully, you appreciate why the name *z-index* would not work: the hyphen (-) would be interpreted as a minus operator.

---

The video element is set in the style directive to have no display. This is because as an element by itself, it is not supposed to show anything. Instead, the content of the current frame is drawn to the canvas using the following statement:

```
ctx.drawImage(v, ballx, bally, videow,videoh);
```

The `ballx` and `bally` values are initialized in the `init` functions and incremented as described in the last section. The width and height of the video clip have been modified to be appropriate for the window size.

One way to understand this is to imagine that the video is being played somewhere offscreen and the browser has access to the information so it can extract the current frame to use in the `drawImage` method.

## Movable Video Element

The `videobounceE` application moves the actual video element on the document. The video element is not drawn on the canvas, but is a distinct element in the HTML document. To make the video appear as a circle, I use the clip path feature. The style directives are

```
#vid {position:absolute; display:none; z-index: 1;}
#canvas {position:absolute; z-index:10; top:0px; left:0px;}
#revbtn {position:absolute; z-index:20;}
```

In the `init` function, I include code that adjusts the video dimensions to fit the screen.

```
v = document.getElementById("vid");

aspect= v.videoWidth/v.videoHeight;
v.width = Math.min(v.videoWidth,.5*cwidth);
v.height = v.width/aspect;
v.height = Math.min(v.height,.5*cheight);
v.width = aspect*v.height;
videow = v.width;
videoh = v.height;
```

Then I calculate the radius of a circle to be the smaller of half the video width and video height. My code uses this number to produce a string ending in "px". This string is used to set the `clipPath` value.

```
amt = .5*Math.min(videow,videoh);
amtS = String(amt)+"px";
v.style.clipPath="circle("+amtS+" at center)";
```

Moving a video element around requires making the video visible and starting the playing of the video. It also requires positioning. The video element is positioned through references to `style.left` and `style.top`. Furthermore, the settings for the left and top attributes must be in the form of a character string representing a number followed by the string "px", standing for pixels. The following code

```

v.style.left = String(ballx)+"px";
v.style.top = String(bally)+"px";
v.play();
v.style.visibility = "visible";
v.style.display = "block";

```

is executed in the `init` function. Notice also that the initial position of the video is changed to the initial `ballx` and `bally` values. The numeric values need to be converted to strings, and then the "px" needs to be concatenated to the ends of the strings. This is because HTML/JavaScript assumes that style attributes are strings. I write the same code for setting the video element's top and left properties to the values corresponding to `ballx` and `bally` in the `movevideo` function. The statements that replace the `ctx.drawImage` statement are

```

v.style.left = String(ballx)+"px";
v.style.top = String(bally)+"px";

```

Lastly, the rectangle (the box) is drawn. It does not need to be drawn again. The `setInterval` function is called to do the movement of the video element.

```

ctx.strokeRect(0,0,cwidth,cheight); //box
setInterval(moveVideo,50);

```

This program does not stop the movement, so I do not need to store what is called the timing event identifier. You may consider enhancing the program to provide a way to stop movement. I used it to produce some of the figures. All the code for both `videobounceC` and `videobounceEwithClipPath` will be listed with comments in the "Building the Application and Making It Your Own" section.

## Traveling Mask

The objective of the mask is to mask out—that is, cover up—all of the video except for a circle in the center. The style directives ensure that I can use the same variables—namely `ballx` and `bally`—to refer to the video and mask in both situations: video drawn and video element moved. So now the question is how to make a mask that is a rectangular donut with a round hole.



I accomplish this by writing code to draw two paths and filling them in with white. Since the shape of the mask can be difficult to visualize, I have created two figures to show you what it is. Figure 3-8 shows the outline of the two paths.



**Figure 3-8.** *Outline of paths for the mask*

Figure 3-9 shows the outline and the paths filled in. The two small horizontal paths will not be present because there is no stroke in the code.



**Figure 3-9.** *Paths for the mask after a fill and a stroke*

Now, the actual path only has the fill, and the fill color is white. You need to imagine these two white shapes traveling along on top of the video. The effect of the mask is to cover up most of the video clip. The parts of the canvas that have no paint on them, so to speak, are transparent, and the video clip content shows through. Putting it another way, the canvas is on top of the video element, but it is equivalent to a sheet of glass. Each pixel that has nothing drawn in it is transparent.

The first path starts at the upper-left corner, and then goes over to the right, down to the midway point, and finally back left toward the center, but stops. The path then is a semicircular arc. The last parameter indicating the sense of the arc is `true` for counterclockwise. The path continues with a line to the left edge and then back up to the start. The second path starts in the middle of the left edge, proceeds down to the lower-left corner, goes to the lower-right corner, moves up to the middle of the right side, and then moves to the left. The arc this time has `false` as the value of the parameter for direction, indicating the arc is clockwise. The path ends where it started. However, I did need to make some adjustments to prevent certain edges of the frame to show. These are indicated by the presence of `+2` and `-2` in the coding.

```
ctx.beginPath();
ctx.moveTo(ballx,bally);
ctx.lineTo(ballx+videow+2,bally);
ctx.lineTo(ballx+videow+2,bally+.5*videoh+2);
ctx.lineTo(ballx+.5*videow+ballrad, bally+.5*videoh+2);
ctx.arc(ballx+.5*videow,bally+.5*v.height,ballrad,0,Math.PI,true);
ctx.lineTo(ballx,bally+.5*v.height);
ctx.lineTo(ballx,bally);
ctx.fill();
ctx.closePath();

ctx.beginPath();
ctx.moveTo(ballx,bally+.5*v.height);
ctx.lineTo(ballx,bally+v.height);
ctx.lineTo(ballx+v.width+2,bally+v.height);
ctx.lineTo(ballx+v.width+2,bally+.5*v.height-2);
ctx.lineTo(ballx+.5*v.width+ballrad,bally+.5*v.height-2);
ctx.arc(ballx+.5*v.width,bally+.5*v.height,ballrad,0,Math.PI,false);
ctx.lineTo(ballx,bally+.5*v.height);
ctx.fill();
ctx.closePath();
```

You can follow along the coding with my “English” description to see how it works.

By the way, my initial attempt was to draw a path consisting of a four-sided shape representing the outer rectangle and then a circle in the middle. This worked for some browsers, but not others.

For the `videobounceC` application, the mask is on top of the frames of video drawn on canvas because the two white filled-in paths are drawn after the `drawImage` statement draws a frame from the video. The next chapter, which demonstrates a spotlight moving on top of a map from Google Maps, will feature changing the z-index using JavaScript. The z-axis is coming out of the screen and can be used to change what is drawn closer to the viewer and what is drawn farther away. I will mention this in the next section.

## User Interface

The user interface for both versions of the `videobounce` project only includes one action for the user: the user can reverse the direction of travel. The button is defined by an element in the body:

```
<button id="revbtn" onClick="reverse();">Reverse </button><br/>
```

The effect of the `onClick` setting is to invoke the function named `reverse`. This function is defined to change the signs of the horizontal and vertical displacements:

```
function reverse() {
    ballvx = -ballvx;
    ballvy = -ballvy;
}
```

There is one important consideration for any user interface. You need to make sure it is visible. This is accomplished by the following style directive:

```
#revbtn {position:absolute; z-index:20;}
```

The z-index places the button on top of the canvas, which in turn is on top of the video.

Having explained the individual HTML5, CSS, and JavaScript features that can be used to satisfy the critical requirements for bouncing video, I’ll now show the code in the two bouncing video applications: the drawing frames with a mask traveling over the frame and a video element masked by a clip path.

## Building the Application and Making It Your Own

The two applications for simulating the bouncing of a video clip ball in a two-dimensional box contain similar code, as does the program that produced the picture of the trajectory. The moving the video element is shorter because the clip path style feature effectively produces a mask. The clip path style feature has other possibilities, including a polygon, so it is something to research. A quick summary of the applications follows. The video applications are summarized by the following:

1. `init`: initialization, including adapting to fit the window and setting up the timed event for invoking displaying the new scene.
2. `drawscene`
  - a. Erase canvas.
  - b. Determine new location of video (virtual ball) using `moveandcheck`.
  - c. Draw the image from video at a specified location on the canvas.
  - d. Draw paths on canvas to create traveling (rectangular donut) mask.
  - e. Draw the box.
3. `moveVideo`
  - a. Determine new location of video using `checkPosition`.
  - b. `checkPosition`: Check if the virtual ball will hit any wall. If so, change the appropriate displacement value.
  - c. Position video element at current position.

The table describing the invoked/called by and calling relationships for the drawing frames application is shown in Table 3-1.

**Table 3-1.** *Functions in the videobounceC Program*

Function	Invoked/Called By	Calls
init	Invoked by action of the onLoad attribute in the <body> tag	
drawscene	Invoked by action of the setInterval command issued in init	moveAndCheck
moveAndCheck	Invoked in drawscene	
reverse	Invoked by action of onClick in the button	

Table 3-2 shows the code for the videobounceC application, which draws the current frame of the video on the canvas at set intervals of time.

**Table 3-2.** *Complete Code for the videobounceC Application*

Code Line	Description
<!DOCTYPE html>	Header
<html>	Opening html tag
<head>	Opening head tag
<title>Video frames bounce</title>	Complete title
<meta charset="UTF-8">	Meta element
<style>	Opening style
#vid {position:absolute; display:none;}	Set up positioning of video; set display to none; video element never appears
#canvas {position:absolute; z-index:10; top:0px; left:0px;}	Set positioning to absolute and position to be upper-left corner; set z-index so it is under the Reverse button
#revbtn {position:absolute; z-index:20;}	Set positioning to absolute and z-index so it is over the canvas
</style>	Close style
<script type="text/javascript">	Opening script tag
var canvas1;	

*(continued)*

**Table 3-2.** (continued)

Code Line	Description
<code>var ctx;</code>	Used to hold canvas context; used for all drawing
<code>var cwidth;</code>	Used to hold canvas width
<code>var cheight;</code>	Used to hold canvas height
<code>var videow;</code>	Used to hold adjusted video width
<code>var videoh;</code>	Used to hold adjusted video height
<code>var ballrad = 50;</code>	Set ball radius
<code>var ballx = 50;</code>	Initial horizontal coordinate for ball
<code>var bally = 60;</code>	Initial vertical coordinate for ball
<code>var maskrad;</code>	Used for mask radius
<code>var ballvx = 2;</code>	Initial ball horizontal displacement
<code>var ballvy = 4;</code>	Initial ball vertical displacement
<code>var v;</code>	Will hold video element
<code>var videow;</code>	
<code>var videoh;</code>	
<code>function restart() {</code>	Function header for restart
<code>v.currentTime=0;</code>	Reset place in video to the start
<code>v.play();</code>	Play video
<code>}</code>	Close restart function
<code>function init(){</code>	Function header for init
<code>canvas1 = document.</code> <code>getElementById('canvas');</code>	Set reference for canvas
<code>ctx = canvas1.getContext('2d');</code>	Set reference for canvas context
<code>canvas1.width = window.innerWidth;</code>	Set canvas width to match current window width
<code>cwidth = canvas1.width;</code>	Set variable
<code>canvas1.height = window.innerHeight;</code>	Set canvas height to match current window height

(continued)

**Table 3-2.** (continued)

Code Line	Description
<code>cheight = canvas1.height;</code>	Set variable
<code>v = document.getElementById("vid");</code>	Set reference to video element
<code>aspect = v.videoWidth/v.videoHeight;</code>	Compute aspect ratio; the <code>videoWidth</code> and <code>videoHeight</code> values describe the original video and do not change
<code>v.width = Math.min(v.videoWidth,.5*cwidth);</code>	Set video width
<code>v.height = v.width/aspect;</code>	Adjust <code>v.height</code> to maintain proportions
<code>v.height = Math.min(v.height,.5*cheight);</code>	Set video height
<code>v.width = aspect*v.height;</code>	Adjust <code>v.width</code> to maintain proportions
<code>window.onscroll = function () {     window.scrollTo(0,0); };</code>	Stops any user action to scroll, if scroll bars do appear
<code>videow = v.width;</code>	Set variable
<code>videoh = v.height;</code>	Set variable
<code>ballrad = Math.min(.5*videow,.5*videoh);</code>	Modify <code>ballrad</code>
<code>ctx.lineWidth = ballrad;</code>	Set line width for drawing the box
<code>ctx.strokeStyle = "rgb(200,0,50)";</code>	Set color to reddish
<code>ctx.fillStyle="white";</code>	Set fill style for mask to be white
<code>v.play();</code>	Start video
<code>setInterval(drawscene,50);</code>	Set up timed event
<code>}</code>	Close init function
<code>function drawscene(){</code>	Function header for <code>drawscene</code>
<code>    ctx.clearRect(0,0,cwidth,cheight);</code>	Erase canvas

(continued)

**Table 3-2.** (continued)

Code Line	Description
<code>checkPosition();</code>	Check if next move is at a wall, and if so, adjust displacements and position; otherwise, just make the move
<code>ctx.drawImage(v,ballx, bally, videow,videoh);</code>	Draw image from video at indicated position
<code>ctx.beginPath();</code>	Start the path for the top half of the mask
<code>ctx.moveTo(ballx,bally);</code>	Move to starting point
<code>ctx.lineTo(ballx+videow+2,bally);</code>	Move over horizontally
<code>ctx.lineTo(ballx+videow+2,bally+.5*videoh+2);</code>	Move down to halfway
<code>ctx.lineTo(ballx+.5*videow+ballrad, bally+.5*videoh+2);</code>	Move in to the start of where the opening will be
<code>ctx.arc(ballx+.5*videow,bally+.5*videoh,ballrad,0, Math.PI,true);</code>	Make semicircular arc
<code>ctx.lineTo(ballx,bally+.5*videoh);</code>	Move to the left
<code>ctx.lineTo(ballx,bally);</code>	Move to start
<code>ctx.fill();</code>	Fill in the white top of the mask
<code>ctx.closePath();</code>	Close top part of mask
<code>ctx.beginPath();</code>	Start bottom part of mask
<code>ctx.moveTo(ballx,bally+.5*videoh);</code>	Move to start the bottom of the mask; move to point midway down on the left
<code>ctx.lineTo(ballx,bally+videoh);</code>	Move down to the lower left
<code>ctx.lineTo(ballx+videow+2,bally+videoh);</code>	Move over to the right corner
<code>ctx.lineTo(ballx+videow+2,bally+.5*videoh-2);</code>	Move up to the middle on the right
<code>ctx.lineTo(ballx+.5*videow+ballrad, bally+.5*videoh-2);</code>	Move in to the start of the hole in the mask

(continued)



**Table 3-2.** *(continued)*

Code Line	Description
<code>ctx.arc(ballx+.5*videow,bally+.5*video</code>	Make semicircular arc
<code>h,ballrad,0,Math.PI,false);</code>	
<code>ctx.lineTo(ballx,bally+.5*videoh);</code>	Move to the right
<code>ctx.fill();</code>	Fill in the white bottom of the mask
<code>ctx.closePath();</code>	Close the bottom part of mask
<code>ctx.strokeRect(0,0,cwidth,cheight);</code>	Draw the box
<code>}</code>	Close the drawscene function
<code>function checkPosition() {</code>	Header for the checkPosition function
<code>  var nballx = ballx + ballvx+.5*videow;</code>	Set up trial values for x
<code>  var nbally = bally +ballvy+.5*videoh;</code>	Set up trial values for y
<code>  if (nballx &gt; cwidth) {</code>	Compare to right wall, on a hit
<code>    ballvx =-ballvx;</code>	Change sign of the horizontal displacement
<code>    nballx = cwidth;</code>	Set trial value to be exactly at the right wall
<code>  }</code>	Close clause
<code>  if (nballx &lt; 0) {</code>	Compare to left wall, on a hit
<code>    nballx = 0;</code>	Set trial value to be exactly at the left wall
<code>    ballvx = -ballvx;</code>	Change sign of the horizontal displacement
<code>  }</code>	Close clause
<code>  if (nbally &gt; cheight) {</code>	Compare to bottom wall, on a hit
<code>    nbally = cheight;</code>	Set trial value to exact height
<code>    ballvy =-ballvy;</code>	Change the sign of the vertical displacement
<code>  }</code>	Close clause
<code>  if (nbally &lt; 0) {</code>	Compare to top wall on a hit
<code>    nbally = 0;</code>	Change trial value to be exactly at the top wall
<code>    ballvy = -ballvy;</code>	Change the sign of the vertical displacement
<code>  }</code>	Close clause

*(continued)*

**Table 3-2.** *(continued)*

Code Line	Description
ballx = nballx-.5*videow;	Set ballx using trial value, and offset to be the upper-left corner, not the center
bally = nbally-.5*videoh;	Set bally using the trial value, and offset to be the upper-left corner, not the center
}	Close checkPosition function
function reverse() {	Function header for the button action
ballvx = -ballvx;	Change sign of horizontal displacement
ballvy = -ballvy;	Change sign of vertical displacement
}	Close reverse function
</script>	Closing script tag
</head>	Closing head tag
<body onLoad="init();">	Opening body tag; set up call to init
<video id="vid" loop="loop" preload="auto" muted>	Video element header; note muted attribute
<source src="joshuahomerun.mp4" type='video/mp4; codecs="avc1.42E01E, mp4a.40.2"'>	Source for the MP4 video
<source src="joshuahomerun.webmvp8.webm" type='video/webm; codec="vp8, vorbis"'>	Source for the WEBM video
<source src="joshuahomerun.theora.ogg" type='video/ogg; codecs="theora, vorbis"'>	Source for the OGG video
Your browser does not accept the video tag.	Message for noncompliant browsers
</video>	Close video tag

*(continued)*

**Table 3-2.** (continued)

Code Line	Description
<code>&lt;button id="revbtn" onClick="reverse();"&gt;Reverse&lt;/button&gt;&lt;br/&gt;</code>	Button for viewer to reverse direction
<code>&lt;canvas id="canvas"&gt;</code>	Opening canvas tag
This browser doesn't support the HTML5 canvas element.	Message for noncompliant browsers
<code>&lt;/canvas&gt;</code>	Closing canvas tag
<code>&lt;/body&gt;</code>	Closing body tag
<code>&lt;/html&gt;</code>	Closing html tag

The second version of this application moves the video element as opposed to drawing the current frame of the video on the canvas. My research indicates that this may use less computer resources when it is executing. Table 3-3 shows the function relationships.

**Table 3-3.** Function Relationships for the *videobounceEwithClipPath* Program

Function	Invoked/Called By	Calls
init	Invoked by action of the onLoad attribute in the <body> tag	
moveVideo	Invoked by action of the setInterval command issued in init	checkPosition
checkPosition	Invoked in moveVideo	
reverse	Invoked by action of onClick in the button	

The code for the version of the program that re-positions a video element as opposed to drawing frames from a video is shown in Table 3-4. I have omitted the descriptive comments for when the code statements are the same. Do keep in mind that the differences between the two approaches are mainly that the bouncing video element program does not require the generation of the rectangular donut mask for each iteration nor the erasing and then re-drawing of the box.

**Table 3-4.** Complete Code for the VideobounceEwithClipPath Program

Code Line	Description
<code>&lt;!DOCTYPE html&gt;</code>	
<code>&lt;html&gt;</code>	
<code>&lt;head&gt;</code>	
<code>&lt;title&gt;Video element bounce&lt;/title&gt;</code>	
<code>&lt;meta charset="UTF-8"&gt;</code>	
<code>&lt;style&gt;</code>	
<code>#vid {position:absolute; display:none; z-index: 1;</code>	Need to set positioning and z-index because display setting will be changed to make element visible
<code>}</code>	End directive
<code>#canvas {position:absolute; z-index:10; top:0px; left:0px;}</code>	This will be on top of the video and under the button
<code>#revbtn {position:absolute; z-index:20;}</code>	
<code>&lt;/style&gt;</code>	
<code>&lt;script type="text/javascript"&gt;</code>	
<code>var ctx;</code>	
<code>var cwidth;</code>	
<code>var cheight;</code>	
<code>var ballrad = 50;</code>	
<code>var ballx = 80;</code>	Starting point is arbitrary
<code>var bally = 80;</code>	Starting point is arbitrary
<code>var maskrad;</code>	
<code>var ballvx = 2;</code>	
<code>var ballvy = 4;</code>	
<code>var v;</code>	

*(continued)*

**Table 3-4.** (continued)

Code Line	Description
<pre>function init(){   canvas1 = document.   getElementById('canvas');   ctx = canvas1.getContext('2d');   canvas1.width = window.innerWidth;   cwidth = canvas1.width;   canvas1.height = window.innerHeight;   cheight = canvas1.height;   window.onscroll = function () {     window.scrollTo(0,0);   };   v = document.getElementById("vid");   aspect = v.videoWidth/v.videoHeight;   v.width = Math.min(v.   videoWidth,.5*cwidth);   v.height = v.width/aspect;   v.height = Math.min(v.   height,.5*cheight);   v.width = aspect * v.height;   videow = v.width;   videoh = v.height;   amt = .5*Math.min(videow,videoh);   amtS = String(amt)+"px";   v.style.clipPath="circle("+amtS+" at   center)";</pre>	<p>Calculate the radius using the smaller value</p> <p>Turn into string with "px" at the end</p> <p>Set the clipPath, effectively masking the video element to be a circle</p>

(continued)

**Table 3-4.** (continued)

Code Line	Description
ballrad = Math. min(50,.5*videow,.5*videoh); ctx.lineWidth = ballrad; ctx.strokeStyle = "rgb(200,0,50)"; ctx.fillStyle="white"; v.style.left = String(ballx)+"px"; v.style.top = String(bally)+"px"; v.play(); v.style.display = "block"; ctx.strokeRect(0,0,cwidth,cheight);	Make video element visible Draw box; note that this only needs to be drawn once
setInterval(moveVideo,50); } function moveVideo(){ checkPosition(); v.style.left = String(ballx)+"px"; v.style.top = String(bally)+"px"; }	Header for function referenced in setInterval Check on next position; uses global variables Set horizontal position of element Set vertical position of element
function checkPosition() {  var nballx = ballx + ballvx; var nbally = bally +ballvy; if ((nballx+videow) > cwidth) { ballvx =-ballvx;	Header for checkPosition; calculates new position and checks if there is a bounce on the next iteration Trial value Trial value Add total width and compare Change sign of horizontal displacement

*(continued)*

**Table 3-4.** *(continued)*

Code Line	Description
<code>    nballx = cwidth-videow;</code>	Set to exact position
<code>  }</code>	
<code>  if (nballx &lt; 0) {</code>	
<code>    nballx = 0;</code>	
<code>    ballvx = -ballvx;</code>	
<code>  }</code>	
<code>  if ((nbally+videoh) &gt; cheight) {</code>	Compare total length
<code>    nbally = cheight-videoh;</code>	Set to exact position
<code>    ballvy = -ballvy;</code>	Change sign of vertical displacement
<code>  }</code>	
<code>  if (nbally &lt; 0) {</code>	
<code>    nbally = 0;</code>	
<code>    ballvy = -ballvy;</code>	
<code>  }</code>	
<code>  ballx = nballx;</code>	Set to trial position, possibly adjusted
<code>  bally = nbally;</code>	Set to trial position, possibly adjusted
<code>}</code>	
<code>function reverse() {</code>	
<code>  ballvx = -ballvx;</code>	
<code>  ballvy = -ballvy;</code>	
<code>}</code>	
<code>&lt;/script&gt;</code>	
<code>&lt;/head&gt;</code>	
<code>&lt;body onLoad="init();" &gt;</code>	

*(continued)*

**Table 3-4.** (continued)

Code Line	Description
<pre> &lt;video id="vid" loop="loop" preload="auto" muted&gt; &lt;source src="joshuahomerun.webmvp8. webm" type='video/webm; codec="vp8, vorbis"'&gt; &lt;source src="joshuahomerun.mp4" type='video/mp4; codecs="avc1.42E01E, mp4a.40.2"'&gt; &lt;source src="joshuahomerun.theora. ogg" type='video/ogg; codecs="theora, vorbis"'&gt; </pre>	<p>Your browser does not accept the video tag.</p>
<pre> &lt;/video&gt; &lt;button id="revbtn" onClick="reverse();"&gt;Reverse &lt;/button&gt;&lt;br/&gt; </pre>	<p>This browser doesn't support the HTML5 canvas element.</p>
<pre> &lt;canvas id="canvas" &gt; </pre>	
<pre> &lt;/canvas&gt; </pre>	
<pre> &lt;/body&gt; </pre>	
<pre> &lt;/html&gt; </pre>	



To produce Figure 3-2, I made the trajectory function by modifying the `drawscene` in `videobounceC`. Since I wanted the circle to be similar in size to the masked video clip, I added an `alert` statement temporarily to the `videobounceC` function after the video width and height were set. Then I ran the program using those values:

```
v.width = Math.min(v.videoWidth/3,.5*cwidth);
v.height = Math.min(v.videoHeight/3,.5*cheight);
alert("width "+v.width+" height "+v.height);
```

I then used the values, 106 and 80, to be the `videow` and `videoh` values in the trajectory program.

## Making the Application Your Own

The first way to make this application your own is to use your own video. You do need to find something that is acceptable when displayed as a small circle. You also can explore uses of the `clipPath` feature. As mentioned earlier, you need to produce versions using the different video codecs. A next step is adding other user interface actions, including changing the horizontal and vertical speeds, as was done in the bouncing ball projects in *The Essential Guide to HTML5*. Another set of enhancements would be to add video controls. Video controls can be part of the video element, but I don't think that would work for a video clip that needs to be small and is moving! However, you could implement your own controls with buttons modeled after the Reverse button. For example, the statement

```
v.pause();
```

does pause the video.

The attribute `v.currentTime` can be referenced or set to control the position within the video clip. You saw how the range input type works in Chapter 1, so consider building a slider input element to adjust the video.

You may decide you want to change my approach to adapting to the window dimensions. One alternative is to change the video clip dimensions to maintain the aspect ratio. Another alternative is to change the video dimensions all the time. This means that the video dimensions and the canvas directions will be in proportion all the time. Yet another alternative, though I think this will be disconcerting, is to make reference to the window dimensions at each time interval and make changes in the canvas, and possibly the video, each time. There is an event that can be inserted into the body tag:

```
<body onresize="changedims();" ... >
```

This coding assumes that you have defined a function named `changedims` that includes some of the statements in the current `init` function to extract the `window.innerWidth` and `window.innerHeight` attributes to set the dimensions of the canvas and the video.

More generally, the objective of this chapter is to show you ways to incorporate video into your projects in a dynamic fashion, both in terms of position on the screen and timing. In particular, it is possible to combine playing of video with drawings on a canvas for exciting effects.

Screen savers exist in which the screen is filled up by a bouncing object similar to the trajectory program. You can change the `drawscene` function to produce different shapes. Also, as I mentioned before, you can apply the techniques explained in *The Essential Guide to HTML5* to provide actions by the viewer. You can refer to Chapter 1 in this book for the use of a range input (slider). Yet another possibility is to provide the viewer a way to change the color of the circle (or other shape you design) using the input type of `color`. The Opera browser provides a color-picker option.

## Testing and Uploading the Application

As has been mentioned, but is worth repeating, you need to acquire a suitable video clip. At the time of writing this book, you then need to use a program such as Miro to produce the WEBM, MP4, and OGG versions because browsers may recognize different video encodings (codecs). This situation may change. Again, if you are content with implementing this for just one browser, you can check which video encoding works for that browser and just prepare one video file. The video files and the HTML file need to be in the same folder on your computer and in the same folder on your server if and when you upload this application to your server account. Alternatively, you can use a complete web address or the correct relative address in the source elements.

Autoplay policies probably will continue to change, so you need to decide what is essential to your application.

## Summary

In this chapter, you learned different ways to manipulate video. These included the following:

- Drawing the current frame of video as an image onto a canvas
- Repositioning of a video element on the screen by changing the left and top style attributes
- Using style directives to layer a video, a canvas, and a button
- Creating a moving mask on a canvas
- Creating the effect of a mask by using the `clipPath` style attribute
- Acquiring information on the dimensions of the window to adapt an application to different situations

The next chapter shows you how to use the Google Maps Application Programming Interface (API) in an HTML5 project. The project involves using a canvas and changing the z-index so that the canvas is alternatively under and over the material produced by Google Maps.

## CHAPTER 4

# Map Maker: Combining Google Maps and the Canvas

In this chapter, you will learn the following:

- Use the Google Maps API to display a map at a specific location
- Draw graphics on a canvas using transparency (also known as the alpha or opacity level) and a customized cursor icon
- Provide a graphical user interface (GUI) to your users by combining the use of Google Maps and HTML5 features by managing the events and the z-index levels
- Calculate the distance between two geographical locations

## Introduction

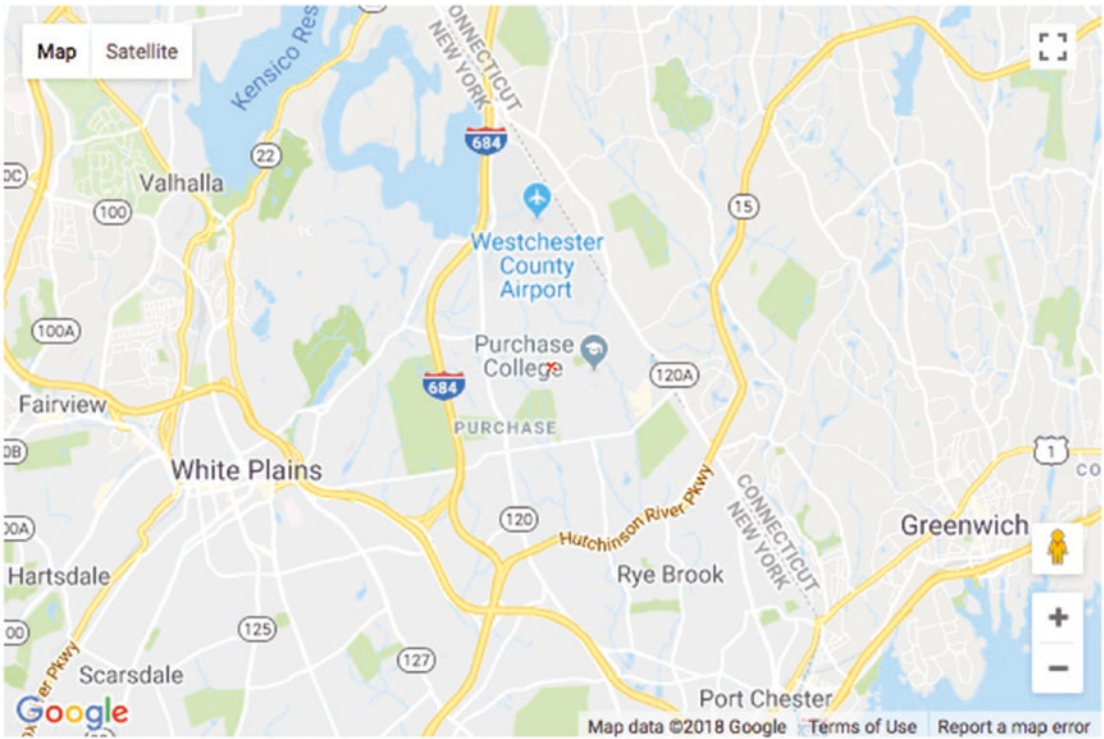
The project for this chapter is an application involving a geographic map. Many applications today involve the use of an Application Programming Interface (API) provided by another person or organization. This chapter will be an introduction to the use of the Google Maps API, and is the first of two chapters using the Google Maps JavaScript Version 3 API. Figure 4-1 shows the opening screen.

Base location (small red x)

Change base location:

- Springer Nature (Apress Publishers) London, UK
- Purchase College/SUNY, NY, USA
- Kyoto, Japan

CHANGE



**Figure 4-1.** Opening screen of map spotlight project

Notice the small red (hand-drawn) x located in the middle of the map and on top of the word *College*. When deciding on map markers, you face a trade-off. A smaller marker is more difficult to see. A larger and/or more intricate marker is easier to see but blocks more of the map or distracts from the map. This map is centered on the Purchase College

campus. For this program, it is the initial base location. The base location is used to calculate distances. Notice the radio buttons showing three choices, on three continents. The middle choice is the starting choice.

Moving the mouse over the map is shown in Figure 4-2.

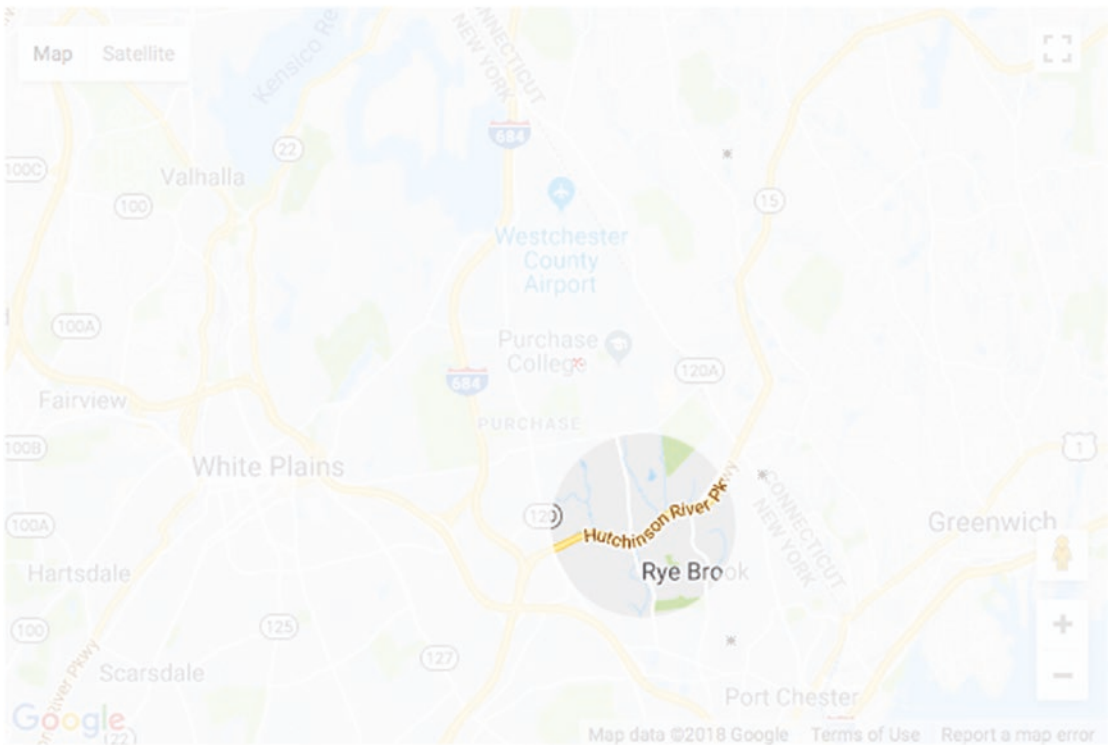
**Base location (small red x)**

The distance from base to most recent marker (41.0089, -73.6769) is 4.96 km.

Change base location:

- Springer Nature (Apress Publishers) London, UK
- Purchase College/SUNY, NY, USA
- Kyoto, Japan

CHANGE



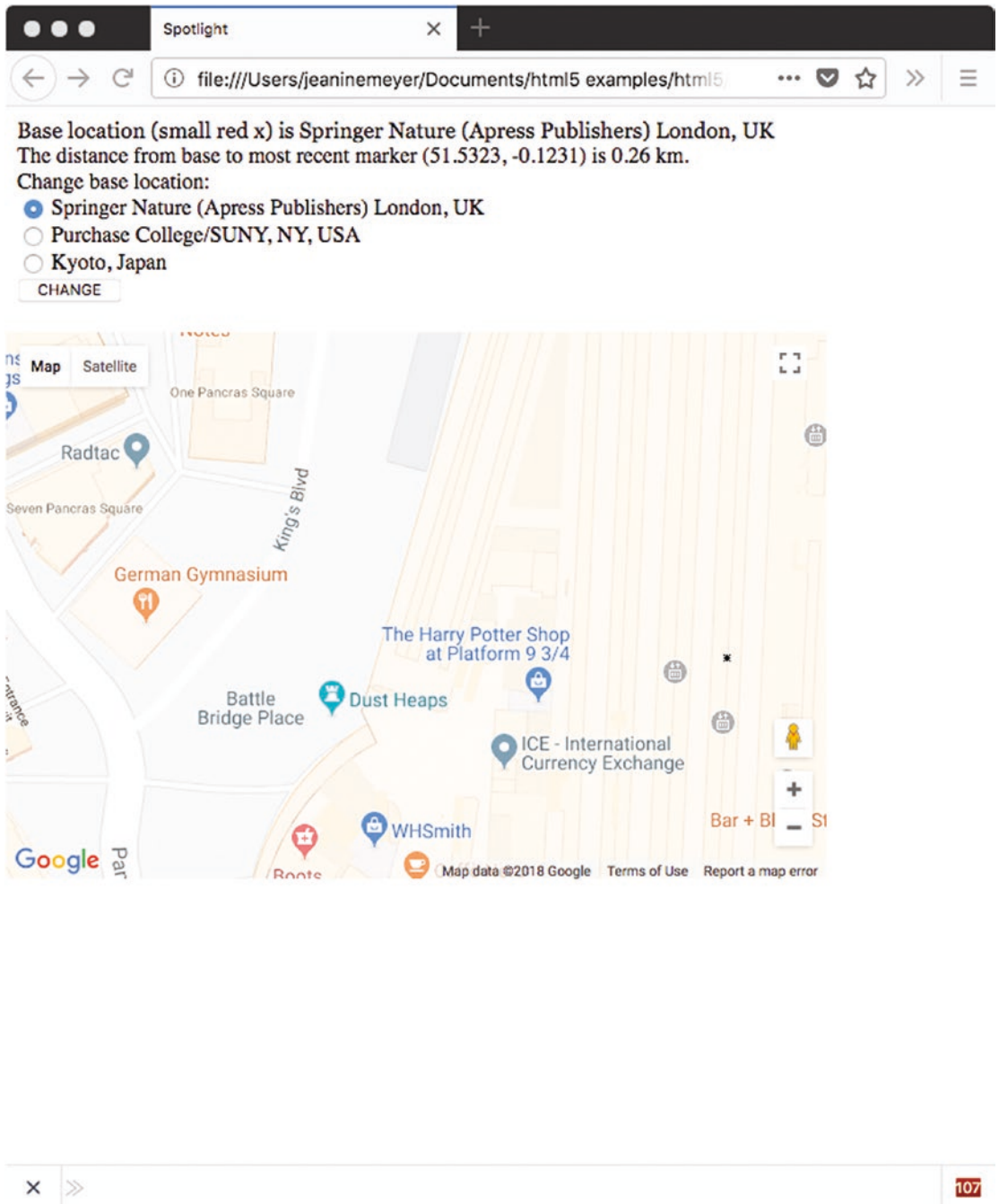
**Figure 4-2.** Shadow/spotlight over map

Notice the shadow and spotlight combination now on the map. Most of the map is covered by a semitransparent shadow. You need to trust me that this screenshot was taken when I had moved the mouse over the map. There is a circle around the mouse position in which the original map shows through. The cursor when moving over the map is not the standard, default cursor but one I created using a small image representing a compact fluorescent light bulb.

The text on the screen shows the distance from the base to the last spot on the map I clicked to be 4.96 kilometers. The marker for all such locations is a hand-drawn *x*. The latitude and longitude of this location is indicated in parentheses.

The interface for changing locations is a set of radio buttons—only one button can be selected at a time—and a button labeled CHANGE to be clicked when the user/viewer/visitor decides to make a change.

The general GUI features provided by Google Maps are available to the users of this project. This includes the + and - buttons for zooming in and out. Figure 4-3 demonstrates the result of using my radio buttons to switch to Springer Nature/Apress Publishers located in London and the Google Maps + to zoom in. It is possible to zoom in even farther. Notice The Harry Potter Shop.



**Figure 4-3.** Zoomed in to London



It also is possible to change the type of map to Satellite and pan the map by clicking the mouse and then pressing down again. Figure 4-4 shows the effects of changing to Satellite and panning.

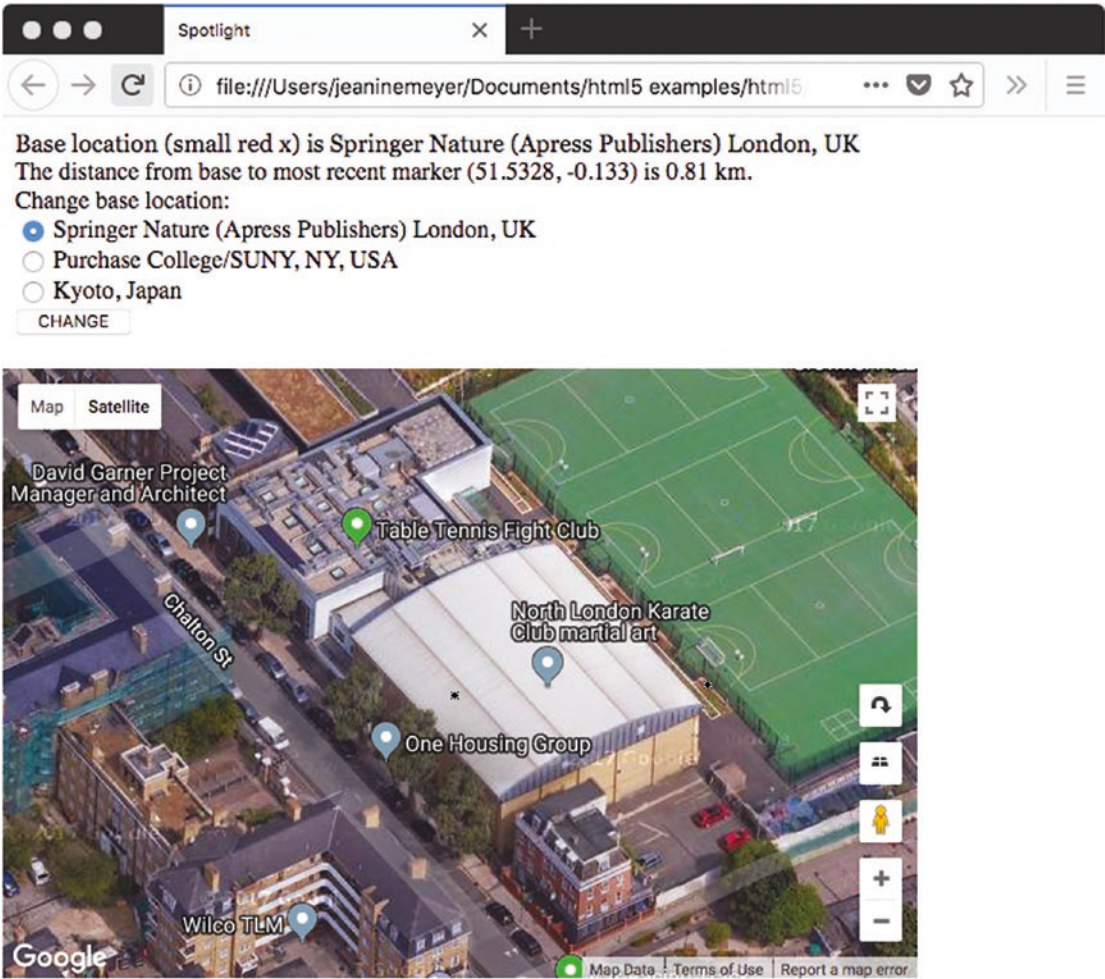


Figure 4-4. Zooming out and moving west, satellite view

Let me use the interface to change to the third possibility: Kyoto, Japan. This is shown in Figure 4-5.

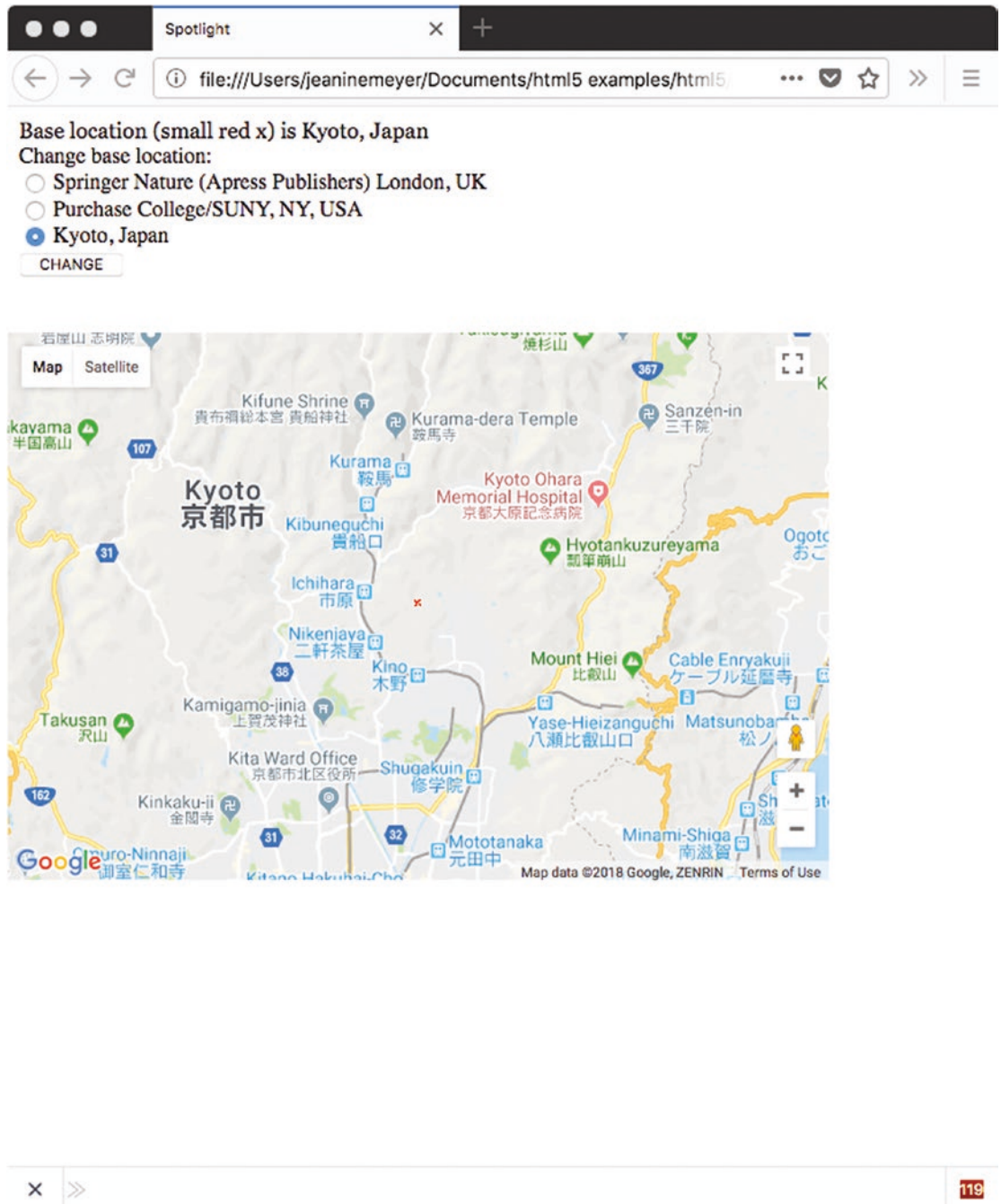


Figure 4-5. Kyoto, Japan

Next, I use the Google Maps feature to change to Map/Terrain in Kyoto. The result is shown in Figure 4-6.

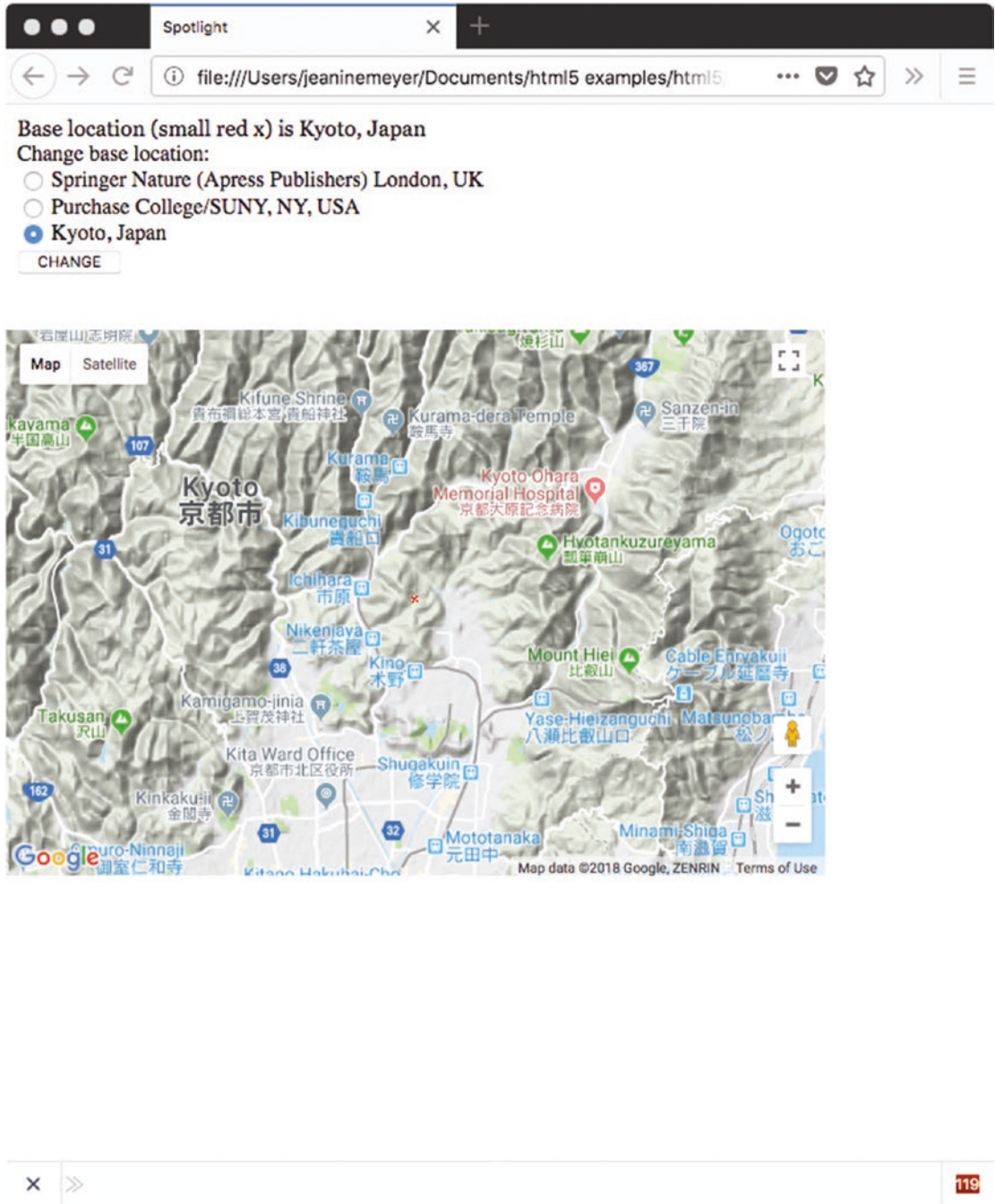
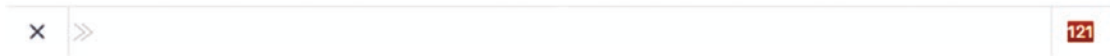
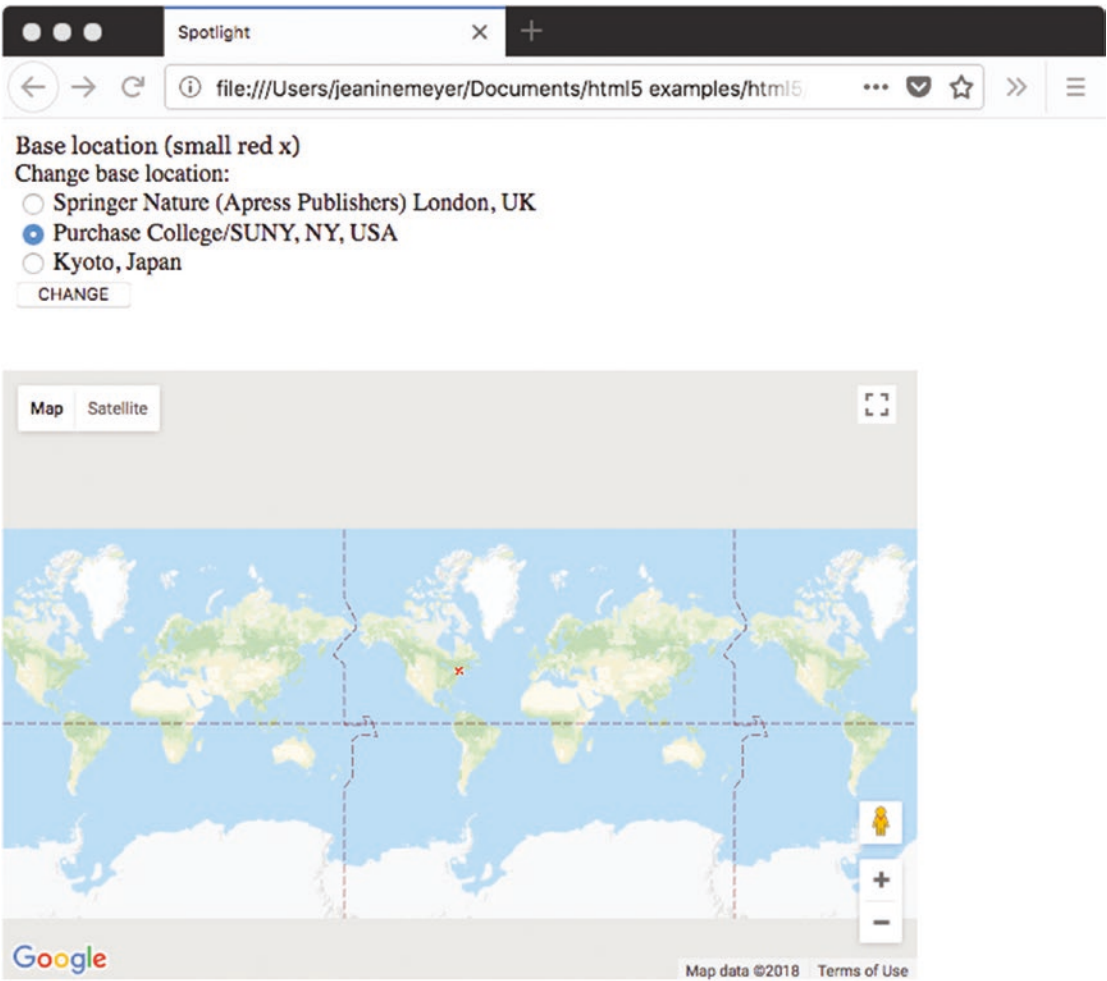


Figure 4-6. Base at Kyoto, Japan, Terrain view

Again, notice the small red  $x$  indicating the base location and the text at the top of the screen with the name of the new base location.

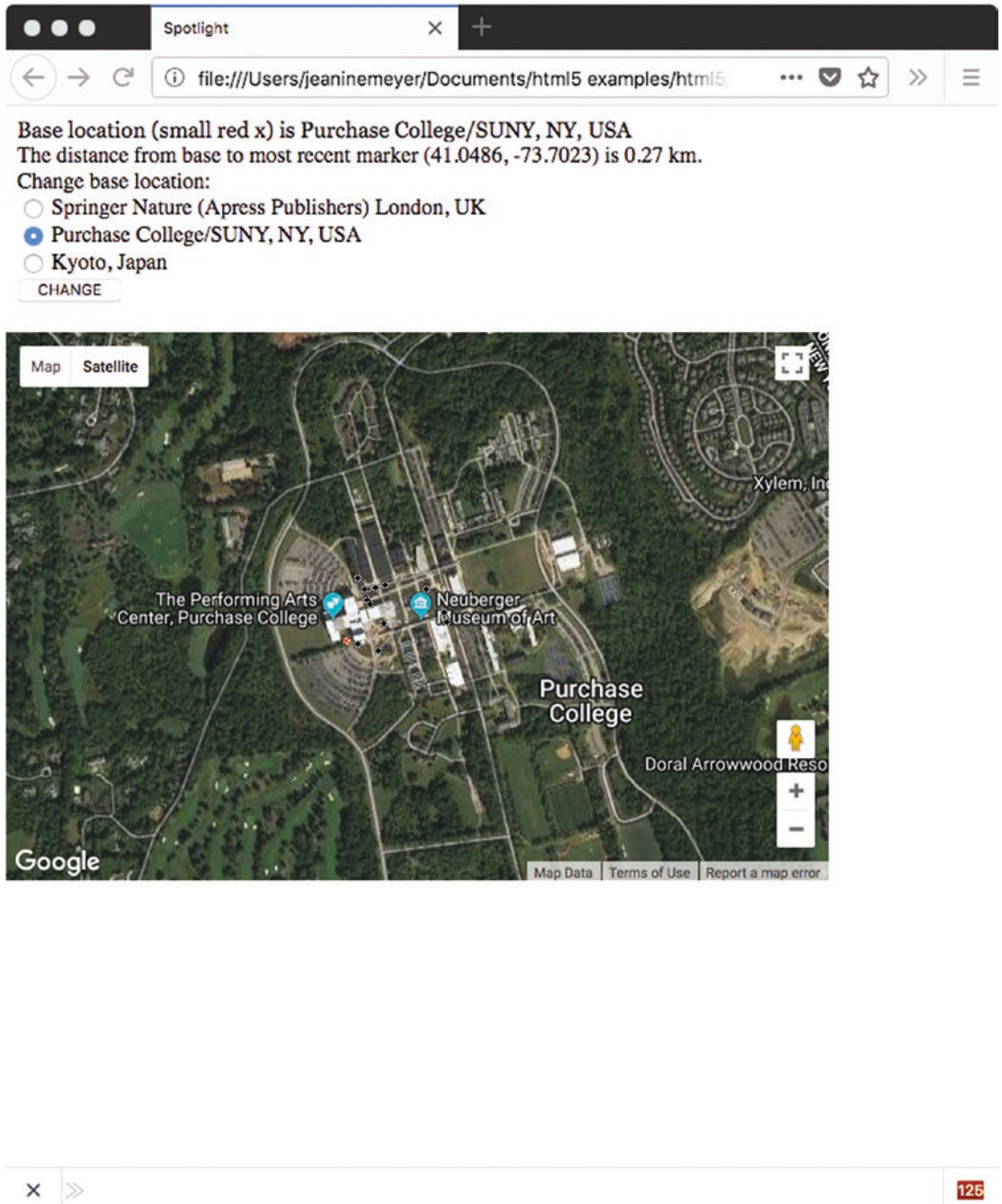
The location of each base is determined by the latitude and longitude values for each of the three values that I have determined. My code is not “asking” Google Maps to find these locations by name. You may get slightly different results if you type the terms “Purchase College, NY” and the other locations into Google or Google Maps. To make this application your own, you would decide on a set of base locations and look up the latitude and longitude values. I will suggest ways to do this in the next section.

Just in case you are curious, zooming out to the farthest out position on the zoom/scale produces what is shown in Figure 4-7. This projection exhibits what is called the Greenland problem. Greenland is not bigger than Africa, but actually about 1/14 times the size.



**Figure 4-7.** Farthest-out view of map

Figure 4-8 shows the map at close to the closest-in limit. The map has also been changed to the satellite view using the buttons in the upper-left corner.



**Figure 4-8.** Zoomed in to where city blocks can be detected, Purchase College base

Lastly, Figure 4-9 shows the map zoomed in to the limit. This is essentially at the building level. The building houses the School of Natural and Social Sciences, which holds my office and my usual computer classroom.

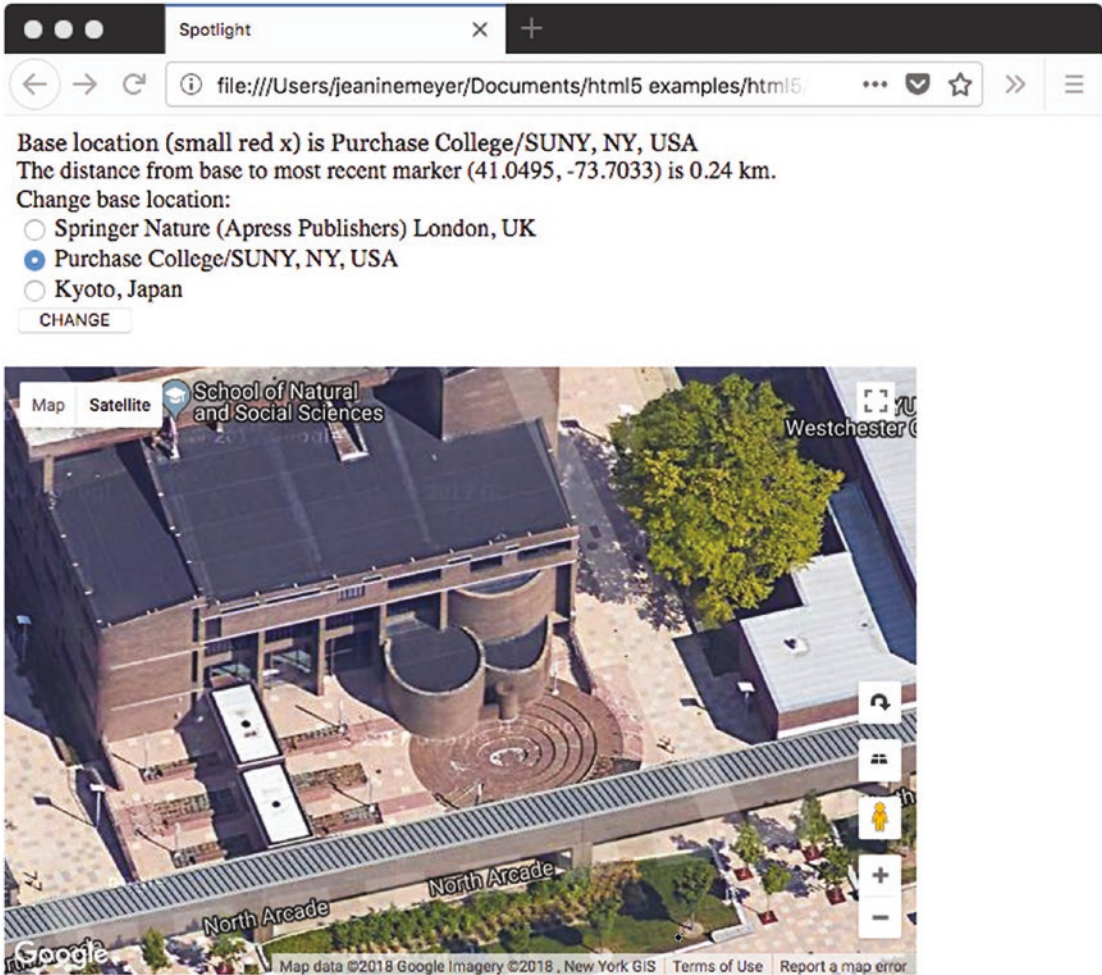


Figure 4-9. Zoomed in all the way

By using the interface to zoom out and pan and zoom in again, I can determine the distance from any of the base locations to any other location in the world! I also can use this application to determine latitude and longitude values of any location. You need to know the latitude and longitude for changing or adding to the list of base locations and for determining locations for the project in Chapter 5. I review latitude and longitude in the next section.

Google Maps by itself is an extremely useful application. This chapter and the next demonstrate how to bring that functionality into your own application. That is, we combine the general facilities of Google Maps with anything, or almost anything, we can develop using HTML5 and JavaScript.

## Latitude and Longitude and Other Critical Requirements

The most fundamental requirement for this project is an understanding of the coordinate system for geography. Just as a coordinate system is required for specifying points on a canvas or positions on the screen, it is necessary to use a system for places on planet Earth. The latitude and longitude system has been developed and standardized over the last several hundred years. The values are angles, with latitude indicating degrees from the equator and longitude indicating degrees from the Greenwich prime meridian in the United Kingdom. The latter is an arbitrary choice that became standard in the late 1800s.

There is a northern hemisphere bias here: latitude values go from 0 degrees at the equator to 90 degrees at the North Pole and -90 degrees at the South Pole. Similarly, longitude values are positive going east from the Greenwich prime meridian and negative going west. Latitudes are parallel to the equator and longitudes are perpendicular. Latitudes are often called *parallels* and typically appear as horizontal lines, and longitudes are called *meridians* and typically appear as verticals. This orientation is arbitrary, but fairly solidly established.

I will use decimal values, which is the default displayed in Google Maps, but you will see combinations of degree, minute (1/60 of a degree), and second (1/60 of a minute). It is not necessary that you memorize latitude-longitude values, but it is beneficial to develop some intuitive sense of the system. You can do this by doing what I call “going both ways.” First, identify and compare latitude-longitude values for places you know,



and second, pick values and see what they are. For example, the base values for my version of the project are as follows:

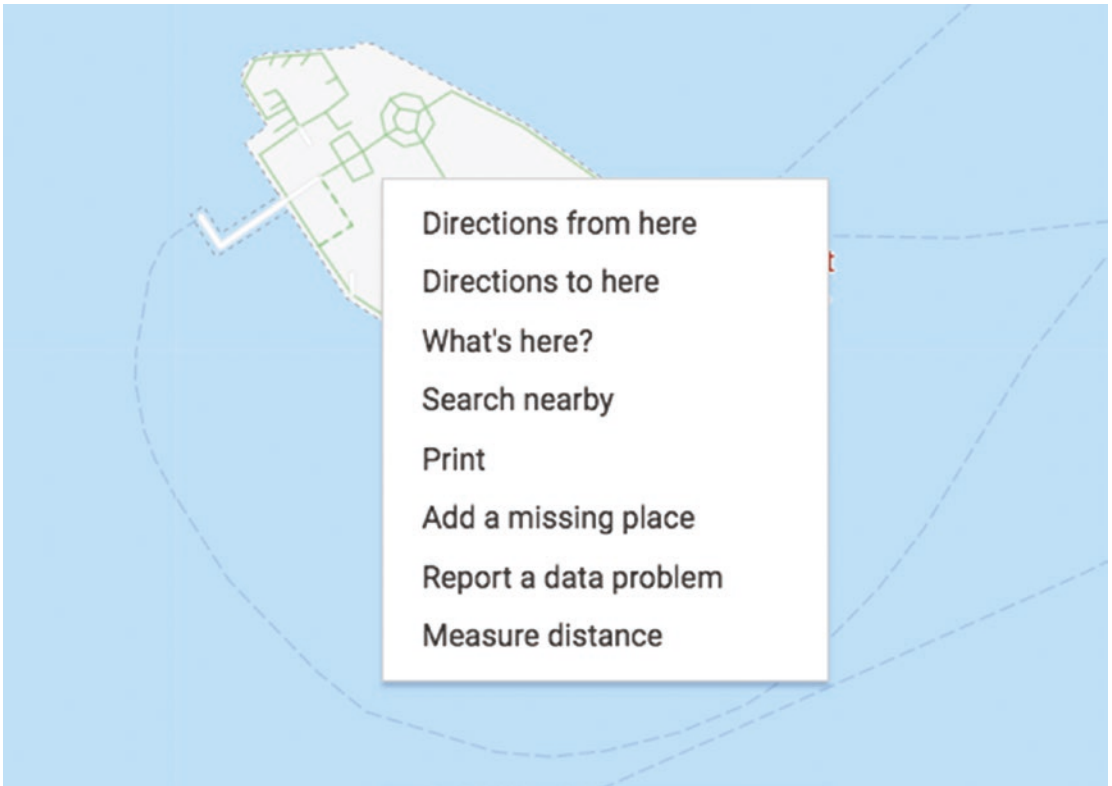
```
var locations = [  
    [51.534467,-0.121631, "Springer Nature (Apress Publishers) London, UK"],  
    [41.04796,-73.70539,"Purchase College/SUNY, NY, USA"],  
    [35.085136,135.776585,"Kyoto, Japan"]  
];
```

The first thing to notice is that the latitude values are fairly close and the longitude values are negative and not quite so close. Because I decided to choose as the base locations, places on three continents, you will need to experiment to see what small changes in latitude and longitude produce. You can see that all three places are north of the equator. In longitude, the value for London is close to zero, being close to the Greenwich prime meridian. You can notice also the longitude for Kyoto is positive and for the others is negative. This all makes sense, but you need to do your own experiments to become comfortable with these units.

There are many ways to find the latitude and longitude of a specific location. You can use Google Maps as follows:

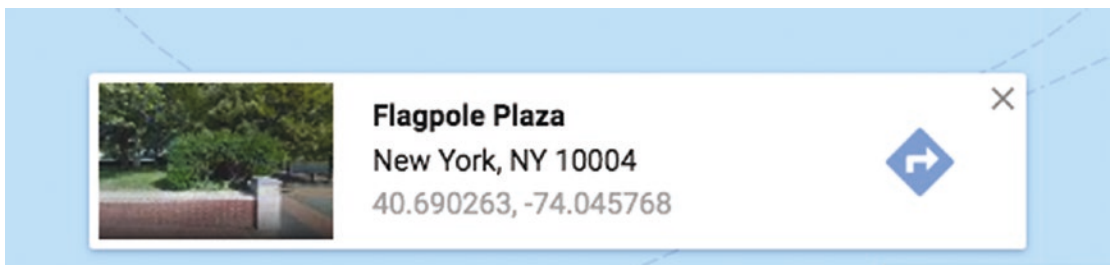
1. Invoke Google Maps from the square array of dots in Gmail or go to <http://.maps.google.com>.
2. Put a location in the location field. I typed in Statue of Liberty.
3. Click to get a menu:

Figure 4-10 shows a small window that appears at the bottom of the map.



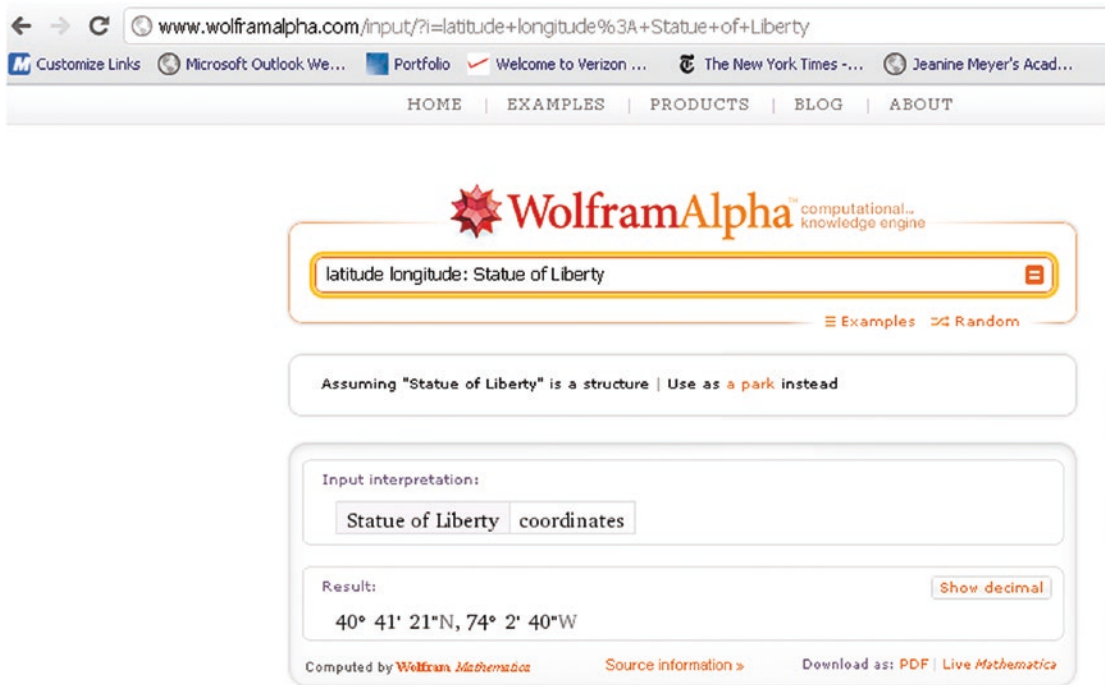
**Figure 4-10.** Getting latitude-longitude values in Google Maps

Click on What's Here to get a small window with the latitude and longitude.



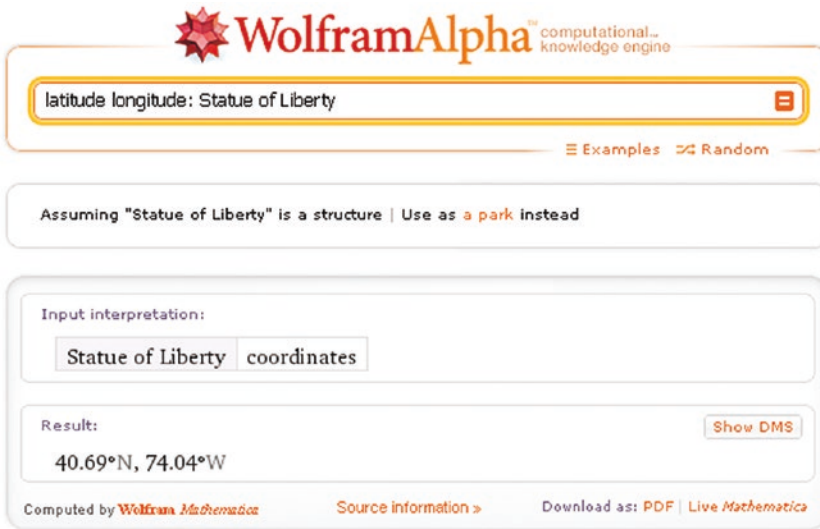
**Figure 4-11.** Box showing latitude and longitude

Another option is to use Wolfram Alpha ([www.wolframalpha.com](http://www.wolframalpha.com)), as shown in Figure 4-12, which provides a way to determine latitude and longitude values as well as many other things.



**Figure 4-12.** Results of a query on Wolfram Alpha

Notice the format of the results. This is the degree/minute/second format, with N for north and W for west. When I click the Show Decimal button, the program displays what is shown in Figure 4-13.



**Figure 4-13.** *Decimal results for a query to Wolfram Alpha*

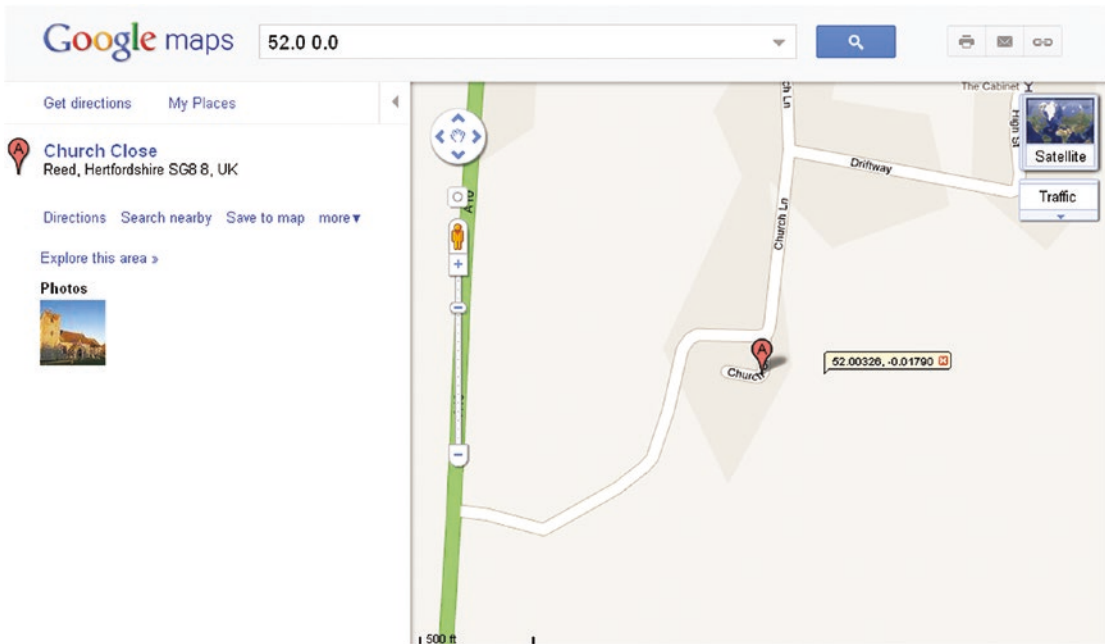
Notice that the longitude still appears with W for West as opposed to the negative value given by Google Maps.

Doing what I call “going in the opposite direction,” you can put latitude and longitude values into Google Maps. Figure 4-14 shows the results of putting in 0.0 and 0.0. It is a point in the ocean south of Ghana. This is a point on the equator *and* on the Greenwich prime meridian.



**Figure 4-14.** *The equator at the Greenwich prime meridian*

I tried to find a place in England on the Greenwich prime meridian and produced the result shown in Figure 4-15 when guessing at the latitude of 52.0 degrees.



**Figure 4-15.** Results near a place on the Greenwich prime meridian

The A marker indicates the closest place in the Google database to the requested location. I used the Drop LatLng marker option to reveal the exact latitude and longitude values.

The critical requirements for this project start off with the task of bringing Google Maps into a HTML5 application using specified latitude and longitude values. An additional requirement is producing the shadow/spotlight combination on top of the map to track the movements of the mouse. I also require a change from the default cursor for the mouse to something of my own choosing.

Next, I added a requirement to drop markers on the map, but again, with graphical icons that I picked, not the upside-down teardrop that is standard in Google Maps. The teardrop marker is nice enough, but my design objective was to be different to show you how to incorporate your own creativity into an application.

Beyond the graphics, I wanted the users to be able to use the Google Maps devices and any GUI features I built using HTML5. This all required managing events set up by the Google Maps API and events set up using HTML5 JavaScript. The responses to events that I wanted to make the user interface included the following:

- Tracking mouse movement with the shadow/spotlight graphic
- Responding to a click by placing an  $x$  on the map
- Retaining the same response to the Google Maps interface (slider, panning buttons, panning by grabbing the map)
- Treating the radio buttons and CHANGE button in the appropriate manner

Google Maps provides a way to determine distances between locations. Since I wanted to set up this project to work in terms of the base location, I needed a way to calculate distances directly.

These are the critical requirements for the map spotlight project. Now I will explain the HTML5 features I used to build the project. The objective is to use Google Maps features and JavaScript features, including events, and not let them interfere with each other. You can use what you learn for this and other projects.

## HTML5, CSS, and JavaScript Features

The challenges for the map-maker project are bringing in the Google Map and then using the map and canvas and buttons together in terms of appearance and in the operation of the GUI. I'll describe the basic Google Maps API and then explain how HTML5 features provide the partial masking and the event handling.

### The Google Maps API

The Google Maps JavaScript API Version 3 Basics has excellent documentation located at <http://code.google.com/apis/maps/documentation/javascript/basics.html>. You do not need to refer to it right now, but it will help you if and when you decide to build your own project. It will be especially helpful in producing applications for mobile devices.

Most APIs are presented as a collection of related objects, each object having attributes (also known as *properties*) and methods. The API also may include events and a method for setting up the event. This is the situation with the Google Maps API. The important objects are Map, LatLng, and Marker. The method to set up an event is `addListener`, and this can be used to set up a response to clicking a map.

The first step to using the Google Maps API is to go to this site to obtain a key: <https://developers.google.com/maps/documentation/javascript/get-api-key>.

The code to get access to the API is to modify and then add the following to your HTML document:

```
<script async defer src="https://maps.googleapis.com/maps/api/js?key=YOUR_
API_KEY&callback=initMap"
  type="text/javascript"></script>
```

---

**Note** The first edition of this text used what is termed a “keyless” API. Though my original code still works on my domain, Google now is stricter. There are quotas in the use of the features, and though the quotas appear very big, you need to study the documentation if you are planning production use.

---

The next step—and this could be all you need if all you want is to bring in a Google Map—is to set up a call to the Map constructor method. The pseudocode for this is

```
map = new google.maps.Map(place you are going to put the map, associative
array with options);
```

Note that there is no harm in making the variable have the name `map`.

Let’s take up the two parameters one at a time. The place to put the map could be a `div` defined in the body of the HTML document. However, I chose to create the `div` dynamically. I did this using code in an `init` function invoked in the usual way, by setting the `onLoad` attribute in the body statement. I also wrote code to create a canvas element inside the `div`. The code is

```
candiv = document.createElement("div");
candiv.innerHTML = ("<canvas id='canvas' width='600'
height='400'>No canvas↵
</canvas>");
document.body.appendChild(candiv);
```

```

can = document.getElementById("canvas");
    pl = document.getElementById("place");
    ctx = can.getContext("2d");

```

The `can`, `pl`, and `ctx` are global variables, each available for use by other functions.

---

**Note** Although I try to use the language “bring access to Google Maps into the HTML document,” I am guilty of describing a function that “makes” a map. The Google Maps connection is a dynamic one in which Google Maps creates what are termed “tiles to be displayed.”

---

The second parameter to the `Map` method is an associative array. An associative array has named elements, not indexed elements. The array for the `Map` method can indicate the zoom level, the center of the map, and the map type, among other things. The zoom level can go from 0 to 18. Level 0 is what is shown in Figure 4-7. Level 18 could show buildings. The types of maps are `ROADMAP`, `SATELLITE`, `HYBRID`, and `TERRAIN`. These are indicated using constants from the Google Maps API. The center is given by a value of type `LatLng`, constructed, as you may expect, using decimal numbers representing latitude and longitude values. The use of an associative array means that we don’t have to follow a fixed order for parameters, and default settings will be applied to any parameter we omit.

The start of my `makemap` function follows. The function is called with two numbers indicating the latitude and longitude on which to center the map. My code constructs a `LatLng` object I name `blatlng`, sets up the array holding the specification for the map, and then constructs the map—that is, constructs the portal to Google Maps.

```

function makemap(mylat,mylong) {
    var marker;
    blatlng = new google.maps.LatLng(mylat,mylong);

myOptions = {
    zoom: 12,
    center: blatlng,
    mapTypeId: google.maps.MapTypeId.ROADMAP
};
map = new google.maps.Map(document.getElementById("place"), myOptions);

```



The Map method constructs access to Google Maps starting with a map with the indicated options in the div with the ID place. The makemap function continues, placing a marker at the center of the map. This is done by setting up an associative array as the parameter for the Marker method. The icon marker will be an image I created, named rxmarker, using an image of my own design, a drawn red x.

```
marker = new google.maps.Marker({
  position: blatlng,
  title: "center",
  icon: rxmarker,
  map: map });
```

There is one more statement in the makemap function, but I will explain the rest later.

## Canvas Graphics

The graphic that we want to move with the mouse over the map is similar to the mask used in Chapter 3 to turn the rectangular video clip into a circular video clip. Both masks can be described as resembling a rectangular donut: a rectangle with a round hole. We draw the graphics for the shadow/spotlight using two paths, just like the mask for the video in the previous chapter. There are two distinct differences, however, between the two situations:

- The exact shape of this mask varies. The outer boundary is the whole canvas, and the location of the hole is aligned with the current position of the mouse. The hole moves around.
- The color of the mask is not solid paint, but a transparent gray.

The canvas starts out on top of the Google Map. I accomplish this by writing style directives that set the z-index values:

```
canvas {position:absolute; top: 165px; left: 0px; z-index:100;}
#place {position:absolute; top: 165px; left: 0px; z-index:1;}
```

The first directive refers to all canvas elements. There is only one in this HTML document. Recall that the z-axis comes out of the screen toward the viewer, so higher values are on top of lower values. Note also that we use zIndex in the JavaScript code and z-index in the CSS. The JavaScript parser would treat the - sign as a minus operator, so the change to zIndex is necessary. I need to write code that changes the zIndex to get the event handling that I want for this project.

Figure 4-16 shows one example of the shadow mask drawn on the canvas. I have set the base location to Kyoto using the radio buttons. I then used the Google Maps controls to zoom out, pan over to Tokyo, and zoom in. The canvas is over the map in terms of the z-index, and the mask is drawn with a gray color that is transparent so the map underneath is visible.

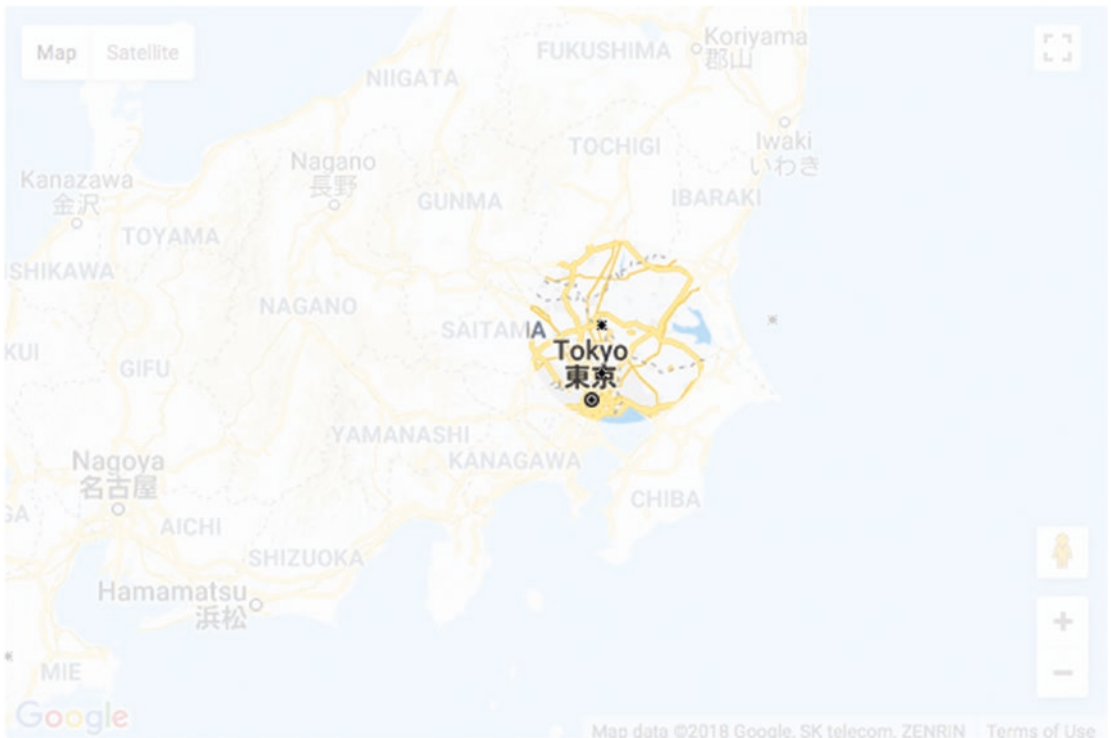
**Base location (small red x) is Kyoto, Japan**

The distance from base to most recent marker (36.0785, 140.8211) is 469.31 km.

Change base location:

- Springer Nature (Apress Publishers) London, UK
- Purchase College/SUNY, NY, USA
- Kyoto, Japan

CHANGE



**Figure 4-16.** Shadow/spotlight on one place on the map

Figure 4-17 shows another example of the shadow mask drawn on the same map. This came about because of movement of the mouse by the user handled by Google Maps and then handled by the JavaScript code to restore the shadow.

Base location (small red x) is Kyoto, Japan  
The distance from base to most recent marker (35.0677, 135.8538) is 7.29 km.  
Change base location:  
 Springer Nature (Apress Publishers) London, UK  
 Purchase College/SUNY, NY, USA  
 Kyoto, Japan



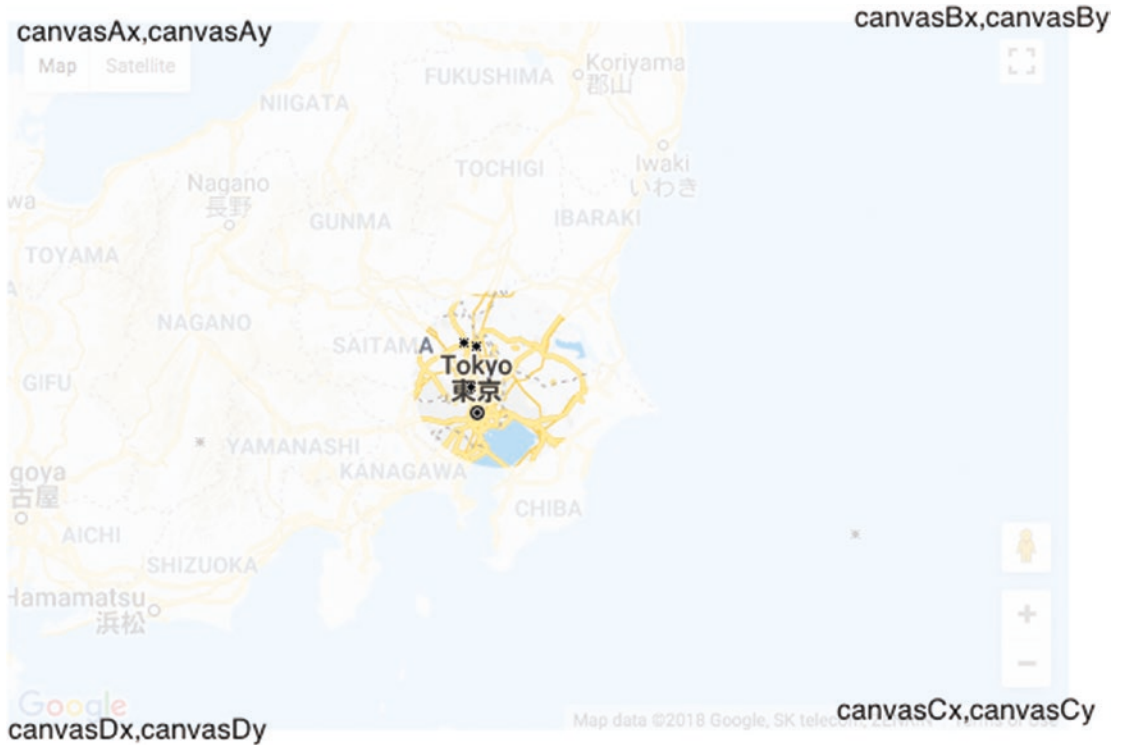
**Figure 4-17.** Shadow mask over another position on the map

Several topics are interlinked here. Let’s assume that the variables `mx` and `my` hold the position of the mouse cursor on the canvas. I will explain how later in this chapter. The function `drawshadowmask` will draw the shadow mask. The transparent gray that is the color of the mask is defined in a variable I named `grayshadow` and constructed using the built-in function `rgba`. The `rgba` stands for red-green-blue-alpha. The alpha refers to the transparency/opacity. A value of 1 for alpha means that the color is fully opaque: solid. A value of 0 means that it is fully transparent—the color is not visible. Recall also that the red, green, and blue values go from 0 to 255, and the combination of 255, 255, and 255

would be white. This is a time for experimentation. I decided on the following setting for the gray/grayish/ghostlike shadow:

```
var grayshadow = "rgba(250,250,250,.8)";
```

The function `drawshadowmask` uses several variables that are constants—they never change. A schematic indicating the values is shown in Figure 4-18.



**Figure 4-18.** Schematic with variable values indicated for mask

The mask is drawn in two parts as was done for the mask for the bouncing video. You may look back to Figure 3-8 and Figure 3-9. The coding is similar:

```
function drawshadowmask(mx,my) {
  ctx.clearRect(0,0,600,400);
  ctx.fillStyle = grayshadow;
  ctx.beginPath();
  ctx.moveTo(canvasAx,canvasAy);
  ctx.lineTo(canvasBx,canvasBy);
```

```

    ctx.lineTo(canvasBx,my);
    ctx.lineTo(mx+holerad,my);
    ctx.arc(mx,my,holerad,0,Math.PI,true);
    ctx.lineTo(canvasAx,my);
    ctx.lineTo(canvasAx,canvasAy);
    ctx.closePath();
    ctx.fill();
    ctx.beginPath();
    ctx.moveTo(canvasAx,my);
    ctx.lineTo(canvasDx,canvasDy);
    ctx.lineTo(canvasCx,canvasCy);
    ctx.lineTo(canvasBx,my);
    ctx.lineTo(mx+holerad,my);
    ctx.arc(mx,my,holerad,0,Math.PI,false);
    ctx.lineTo(canvasAx,my);
    ctx.closePath();
    ctx.fill();
}

```

Now we move on to the red light bulb.

## Cursor

The cursor—the small graphic that moves on the screen when you move the mouse—can be set in the style element or in JavaScript. There are several built-in choices for the graphic (e.g., crosshair and pointer), and we also can refer to our own designs for a custom-made cursor, which is what I demonstrate in this project. I included the statement

```
can.onmousedown = function () { return false; } ;
```

in the `init` function to prevent a change to the default cursor when pressing down on the mouse. This may not be necessary since the default may not be triggered.

To change the cursor for moving the mouse to something that conveyed a spotlight, I created a picture of a red compact fluorescent light bulb and saved it in the file `light.gif`. I then used the following statement in the function `showshadow`. The `showshadow` function has been set as the event handler for `mousemove`

```
can.style.cursor = "url('light.gif'), pointer";
```

to indicate that JavaScript should use that address for the image for the cursor when on top of the `can` element. Furthermore, if the `light.gif` file is not available, the statement directs JavaScript to use the built-in pointer icon. This is similar to the way that fonts can be specified with a priority listing of choices. The variable `can` has been set to reference the canvas element. The cursor will not be used when the canvas has been pushed under the Google Map, as will be discussed in the next section.

## JavaScript Events

The handling of events—namely mouse events, but also events for changing zoom on the Google Map or clicking the radio buttons—seemed the most daunting when I started work on this project. The critical consideration is whether the event is to be handled by Google Maps or by my JavaScript code. However, the actual implementation turned out to be straightforward. In the `init` function and the `makemap` function, I write code to set up event handling for movement of the mouse, mouse button down, and mouse button up, all in terms of the canvas element. For example, in the `init` function, there is

```
can.addEventListener('mousemove', showshadow);
can.addEventListener('mousedown', pushcanvasunder);
can.addEventListener("mouseout", clearshadow);
```

The `showshadow` function, as indicated previously, calls the `drawshadowmask` function. I could have combined these two functions, but dividing tasks into smaller tasks generally is a good practice. The `showshadow` function determines the mouse position, makes an adjustment so the light bulb base is at the center of the spotlight, and then makes the call to `drawshadowmask`:

```
function showshadow(ev) {
    var mx;
    var my;
    if ( ev.layerX || ev.layerX == 0 ) {
        mx= ev.layerX;
        my = ev.layerY;
    }
    else if (ev.offsetX || ev.offsetX == 0) {
        mx = ev.offsetX;
        my = ev.offsetY;
    }
}
```

```

    can.style.cursor = "url('light.gif'), pointer";
    mx = mx+10;
    my = my + 12;
    drawshadowmask(mx,my);
}

```

The `if` statement mentioning `ev.layerX` and `ev.layerY` is for older Firefox browsers. It probably could be removed.

Now I need to determine what I want to do when the user presses down on the mouse. I decide that I want the shadow to go away and the map to be displayed in its full brightness. In addition to the appearance of things, I also want the Google Maps API to resume control. A critical reason for wanting the Google Maps API to take over is that I want to place a marker on the map, as opposed to the canvas, to mark a location. This is because I want the marker to move with the map, and that would be very difficult to do by drawing on the canvas. I would need to synchronize the marker on the canvas with panning and zooming of the map. Instead, the API does all this for me. In addition, I need the Google Maps API to produce latitude and longitude values for the location.

The way to put Google Maps back in control, so to speak, is to “push the canvas under.” The function is

```

function pushcanvasunder(ev) {
    can.style.zIndex = 1;
    pl.style.zIndex = 100;
}

```

The operation of pushing the canvas under or bringing it back on top is not instantaneous. I am open to suggestions on (1) how to define the interface and (2) how to implement what you have defined. There is room for improvement here.

One more situation to take care of is to decide what I want to occur if and when the user moves the mouse off of the canvas? The `mouseout` event is available as something to be listened for, so I wrote the code setting up the event (see the `can.addEventListener` statements shown previously) to be handled by the `clearshadow` function. The `clearshadow` function accomplishes just that—it clears the whole canvas, including the shadow:

```

function clearshadow(ev) {
    ctx.clearRect(0,0,600,400);
}

```

In the function that brings in the Google Map, I set up an event handler for mouseup for maps.

```
listener = google.maps.event.addListener(map, 'mouseup', function(event) {
    checkit(event.latLng);
});
```

The call to `addListener`, a method that is part of the Google Maps API as opposed to JavaScript proper, sets up the call to the `checkit` function. To repeat what has been said in a more informal way: this call to `google.maps.event.addListener` sets up the Google API to listen for a mouseup event on the map. The following statement causes JavaScript to listen for a mouseout event on `can` (the canvas).

```
can.addEventListener("mouseout", clearshadow);
```

The `checkit` function is invoked using an attribute of the event object as a parameter. As you can guess, `event.latLng` is the latitude and longitude values at the position of the mouse when the mouse button was released on the map object. The `checkit` function will use those values to calculate the distance from the base location and to print out the values along with the distance on the screen. The code invokes a function I wrote that rounds the values. I did this to avoid displaying a value with many significant digits, more than is appropriate for this project. The Google Maps API `marker` method provides a way to use an image of my choosing for the marker, this time a black, hand-drawn *x*, and to include a title with the marker. The title is recommended to make applications accessible for people using screen readers, although I cannot claim that this project would satisfy anyone in terms of accessibility. It is possible to produce the screen shown in Figure 4-19. Note the *x* near Mt. Kisco, where I live. The message at the top indicates the length of my commute in miles. The code can be changed to calculate miles or kilometers.



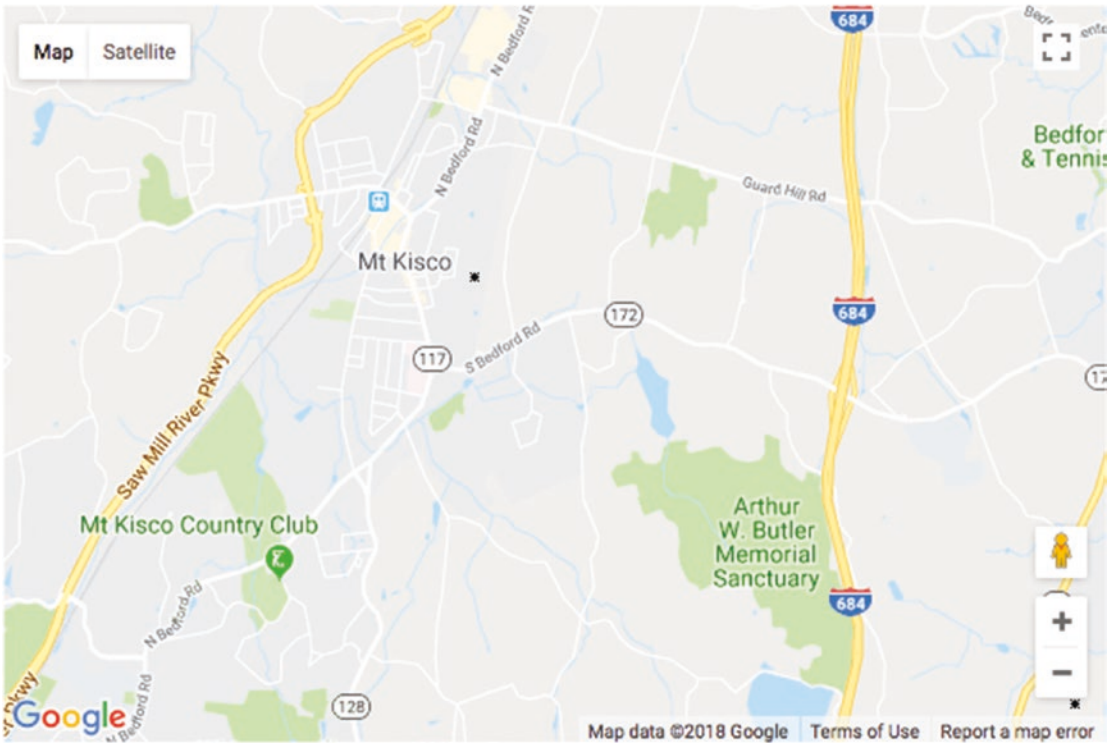
**Base location (small red x)**

The distance from base to most recent marker (41.1729, -73.6645) is 8.89 miles.

Change base location:

- Springer Nature (Apress Publishers) London, UK
- Purchase College/SUNY, NY, USA
- Kyoto, Japan

CHANGE



**Figure 4-19.** Title indicating distance shown on map

The checkit function, called with a parameter holding the latitude and longitude value, follows:

```
function checkit(clatlng) {  
  var distance = dist(clatlng,blatlng);  
  distance = round(distance,2);  
  var distanceString = String(distance)+" km";  
  marker = new google.maps.Marker({  
    position: clatlng,
```

```

    title: distanceString,
    icon: bxmarker,
    map: map });
    var clat = clatlng.lat();
    var clng = clatlng.lng();
    clat = round(clat,4);
    clng = round(clng,4);
    document.getElementById("answer").innerHTML =
"The distance from base to most recent marker (" +clat+", "+clng+") is
"+String(distance) +" miles.";
//change miles to km depending on value used for R in the dist function
    can.style.zIndex = 100;
    pl.style.zIndex = 1;
}

```

Even though I omit most comments in the text, I felt compelled to keep the comments concerning miles versus kilometers. I advise you to do the same for such matters in your work.

Notice that the last thing that the function does is put the canvas back on top of the map.

The CHANGE button and the radio buttons are implemented using standard HTML and JavaScript. The form is produced using the following HTML coding:

```

<form name="f" onSubmit=" return changebase();"
  <input type="radio" name="loc" /> Springer Nature (Apress Publishers)
  London, UK<br/>
  <input id="first" type="radio" name="loc" /> Purchase College/SUNY, NY,
  USA<br/>
  <input type="radio" name="loc" /> Kyoto, Japan<br/>
  <input type="submit" value="CHANGE">
</form>

```

The function `changebase` is invoked when the submit button, labeled CHANGE, is clicked. The `changebase` function determines which of the radio buttons was checked and uses the Locations table to pick up the latitude and longitude values. It then makes a call to `makemap` using these values for parameters. This way of organizing data is called *parallel structures*: the locations array elements correspond to the radio buttons. The last statement sets the `innerHTML` of the header element to display text, including the name of the selected base location.

```
function changebase() {
    var mylat;
    var mylong;
    for(var i=0;i<locations.length;i++) {
        if (document.f.loc[i].checked) {
            mylat = locations[i][0];
            mylong = locations[i][1];
            makemap(mylat,mylong);
            document.getElementById("header").innerHTML =
                "Base location (small red x) is
                "+locations[i][2];
        }
    }
    return false;
}
```

## Calculating Distance and Rounding Values for Display

Google Maps, as many of us know, provides information on distances and even distinguishes between walking and driving. For this application, I needed more control on specifying the two locations for which I wanted the distance calculated, so I decided to develop a function in JavaScript. Determining the distance between two points, each representing latitude and longitude values, is done using the spherical law of cosines. My source was <http://www.movable-type.co.uk/scripts/latlong.html>. Here is the code. Notice that to produce a value in kilometers, you use one value for R and for miles the value that is commented. If and when you switch to miles, you need to make sure the message displayed says miles.

```
function dist(point1, point2) {
    var R = 6371; // km Need to make sure this syncs with the message
    displayed re: distance.
    // var R = 3959; // miles
    var lat1 = point1.lat()*Math.PI/180;
    var lat2 = point2.lat()*Math.PI/180 ;
    var lon1 = point1.lng()*Math.PI/180;
    var lon2 = point2.lng()*Math.PI/180;
```

```

var d = Math.acos(Math.sin(lat1)*Math.sin(lat2) +
Math.cos(lat1)*Math.cos(lat2) *
Math.cos(lon2-lon1)) * R;
return d;
}

```

---

**Caution** I don't include many comments in the code because I annotate each line in the chapter's tables. However, comments are important. I strongly recommend leaving the comments on `km` and `miles` in the `dist` function so you can adjust your program as appropriate. Alternatively, you could display both values or give the user a choice.

---

The last function is for rounding values. When a quantity is dependent on a person moving a mouse, you shouldn't display a value to a great number of decimal places. However, keep in mind that latitude and longitude represent big units. I decided I wanted the distances to be shown with two decimal places and the latitude and longitude with four.

The function I wrote is quite general. It takes two parameters, one the number `num` and the other `places`, indicating how many decimal places to take the value. You can use it in other circumstances. It rounds up or down, as appropriate, by adding the value I call the *increment* and then calculating the biggest integer not bigger than the value. So

- `round(9.147, 2)` will produce 9.15
- `round(9.143, 2)` will produce 9.14

The way the code works is first to determine what I term the *factor*, 10 raised to the desired number of places. For 2, this will be 100. I then calculate the increment. For two places, this will be  $5 / 100 * 10$ , which is  $5 / 1,000$ , which is .005. My code does the following:

1. Adds the increment to the original number.
2. Multiplies the result by the factor.
3. Calculates the largest whole number not bigger than the result (this is called the *floor*)—producing a whole number.
4. Divides the result by the factor.

The code follows:

```
function round (num,places) {
    var factor = Math.pow(10,places);
    var increment = 5/(factor*10);
    return Math.floor((num+increment)*factor)/factor;
}
```

I use the round function to round off distances to two decimal places and latitude and longitude to four decimal places.

---

**Tip** JavaScript has a method called `toFixed` that essentially performs the task of my `round`. If `num` holds a number—say, 51.5621—then `num.toFixed()` will produce 51 and `num.toFixed(2)` will produce 51.56. I've read that there can be inaccuracies with this method, so I chose to create my own function. You may be happy to go with `toFixed()` in your own applications, though.

---

With the explanation of the relevant HTML5 and Google Maps API features, we can now put it all together.

## Building the Application and Making It Your Own

The map spotlight application sets up the combination of Google Maps functionality with HTML5 coding. A quick summary of the application is the following:

1. `init`: Initialization, including bringing in the map (`makemap`) and setting up mouse events with handlers: `showshadow`, `pushcanvasunder`, and `clearshadow`
2. `makemap`: Brings in a map and sets up event handling, including the call to `checkit`
3. `showshadow`: Invokes `drawshadowmask`
4. `pushcanvasunder`: Enables events on the map
5. `checkit`: Calculates distance, adds a custom marker, and displays distance and rounded latitude and longitude

The function table describing the invoked/called by and calling relationships (Table 4-1) is the same for all the applications.

**Table 4-1.** *Functions in the Map Maker Project*

Function	Invoked/Called By	Calls
init	Invoked by action of the onLoad attribute in the <body> tag	makemap
pushcanvasunder	Invoked by action of addEventListener called in init	
clearshadow	Invoked by action of addEventListener called in init	
showshadow	Invoked by action of addEventListener called in init	drawshadowmask
drawshadowmask	Called by showshadow	
makemap	Called by init	
checkit	Called by action of addEventListener called in makemap	round, dist
round	Called by checkit (three times)	
dist	Called by checkit	
changebase	Called by action of onSubmit in <form>	makemap

Table 4-2 shows the code for the Map Maker application, named `mapspotlight.html`.

**Table 4-2.** Complete Code for the *mapspotlight.html* Application

Code Line	Description
<code>&lt;!DOCTYPE html&gt;</code>	Header
<code>&lt;html&gt;</code>	Opening html tag
<code>&lt;head&gt;</code>	Opening head tag
<code>&lt;title&gt;Spotlight &lt;/title&gt;</code>	Complete title
<code>&lt;meta charset="UTF-8"&gt;</code>	Meta tag
<code>&lt;style&gt;</code>	Opening of style element
<code>header {font-family:Georgia,"Times New Roman",serif;</code>	Set fonts for the heading
<code>font-size:16px;</code>	Font size
<code>display:block;}</code>	Line breaks before and after
<code>canvas {position:absolute; top: 165px; left:0px;</code>	Style directive for the single canvas element; position slightly down the page
<code>z-index:100;}</code>	Initial setting for canvas is on top of map
<code>#place {position:absolute; top: 165px; left: 0px;</code>	Style directive for the div holding the Google Map; position exactly the same as the canvas
<code>z-index:1;}</code>	Initial setting to be under canvas
<code>&lt;/style&gt;</code>	Close style element
<code>&lt;script async defer src="https:// maps.googleapis.com/maps/api/js?key= YOUR_API_KEY&amp;callback=initMap" type="text/javascript"&gt;&lt;/script&gt;</code>	Bring in the external script element holding the Google Maps API; Note: you need to get your own key to run the program
<code>&lt;script type="text/javascript" charset="UTF-8"&gt;</code>	Opening script tag
<code>var locations = [</code>	Define set of base locations; Note: you need to coordinate with radio buttons in body

*(continued)*

**Table 4-2.** (continued)

Code Line	Description
[51.534467,-0.121631, "Springer Nature (Apress Publishers) London, UK"],	Latitude, longitude name publisher office in London
[41.04796,-73.70539,"Purchase College/SUNY, NY, USA"],	... Purchase College
[35.085136,135.776585,"Kyoto, Japan"]	... Kyoto
];	Close array of locations
var candiv;	Used to hold div holding the canvas
var can;	Reference canvas element
var ctx;	Reference context of canvas; used for all drawing
var pl;	Reference the div holding the Google Map
function init() {	Function header for init
var mylat;	Will hold latitude value
var mylong;	Will hold longitude value
candiv = document. createElement("div");	Create a div
candiv.innerHTML = (" <canvas </canvas  id='canvas' width='600' height='400'>No canvas </canvas>");	Set its contents to be a canvas element
document.body.appendChild(candiv);	Add to the body
can = document. getElementById("canvas");	Set reference to the canvas
pl = document. getElementById("place");	Set reference to the div holding the Google Map

(continued)



**Table 4-2.** (continued)

Code Line	Description
<code>ctx = can.getContext("2d");</code>	Set the context
<code>can.onmousedown = function ()</code> <code>{ return false; } ;</code>	Prevent change of cursor to default
<code>can.addEventListener('mousemove',</code> <code>showshadow);</code>	Set event handling for mouse moving
<code>can.addEventListener('mousedown',</code> <code>pushcanvasunder);</code>	Set event handling for pushing down on mouse button
<code>can.addEventListener("mouseout",</code> <code>clearshadow);</code>	Set event handling for moving mouse off of the canvas
<code>mylat = locations[1][0];</code>	Set the latitude to be the latitude of the first (middle) location
<code>mylong = locations[1][1];</code>	Set the longitude to be the longitude of the first (middle) location
<code>document.getElementById("first").</code> <code>checked="checked";</code>	Set middle radio button to display as checked
<code>makemap(mylat,mylong);</code>	Invoke function to make a map (bring in Google Maps at specified location)
<code>}</code>	Close init function
<code>function pushcanvasunder(ev) {</code>	Header for pushcanvas function, called with parameter referencing the event
<code>can.style.zIndex = 1;</code>	Push canvas down
<code>pl.style.zIndex = 100;</code>	Set map div up
<code>}</code>	Close pushcanvasunder function
<code>function clearshadow(ev) {</code>	Header for clearshadow function, called with parameter referencing the event
<code>ctx.clearRect(0,0,600,400);</code>	Clear canvas (erase shadow mask)
<code>}</code>	Close clearshadow function

(continued)

**Table 4-2.** (continued)

Code Line	Description
function showshadow(ev) {	Header for showshadow function, called with parameter referencing the event
var mx;	Will be used to hold horizontal position of mouse
var my;	Will be used to hold vertical position of mouse
if ( ev.layerX    ev.layerX == 0) {	Does this browser use layerX? Note: this is for older browsers
mx = ev.layerX;	If so, use it to set mx ...
my = ev.layerY;	... and my
} else if (ev.offsetX    ev.offsetX == 0) {	Try offset. Note: this works on current browsers
mx = ev.offsetX;	If so, use it to set mx ...
my = ev.offsetY;	... and my
}	Close clause
can.style.cursor = "url('light.gif'), pointer";	Set up cursor to be light.gif if available; otherwise use pointer
mx = mx+10;	Make rough correction to make center of light at base of light bulb horizontally and ...
my = my + 12;	... vertically
drawshadowmask(mx,my);	Invoke drawshadowmask function at the modified (mx,my)
}	Close showshadow function
var canvasAx = 0;	Constant for mask: upper-left x
var canvasAy = 0;	Upper-left y
var canvasBx = 600;	Upper-right x
var canvasBy = 0;	Upper-right y
var canvasCx = 600;	Lower-right x

(continued)

**Table 4-2.** (continued)

Code Line	Description
<code>var canvasCy = 400;</code>	Lower-right y
<code>var canvasDx = 0;</code>	Lower-left x
<code>var canvasDy = 400;</code>	Lower-left y
<code>var holerad = 50;</code>	Constant radius for hole in shadow (radius of spotlight)
<code>var grayshadow = "rgba(250,250,250,.8)";</code>	Color for faint shadow; note alpha of .8
<code>function drawshadowmask(mx,my) {</code>	Header for <code>drawshadowmask</code> function; parameters hold center of donut hole
<code>ctx.clearRect(0,0,600,400);</code>	Erase whole canvas
<code>ctx.fillStyle = grayshadow;</code>	Set color
<code>ctx.beginPath();</code>	Start first (top) path
<code>ctx.moveTo(canvasAx,canvasAy);</code>	Move to upper-left corner
<code>ctx.lineTo(canvasBx,canvasBy);</code>	Draw over to upper-right corner
<code>ctx.lineTo(canvasBx,my);</code>	Draw to vertical point specified by my parameter
<code>ctx.lineTo(mx+holerad,my);</code>	Draw over to the left to edge of hole
<code>ctx.arc(mx,my,holerad,0,Math.PI,true);</code>	Draw semicircular arc
<code>ctx.lineTo(canvasAx,my);</code>	Draw to left side
<code>ctx.lineTo(canvasAx,canvasAy);</code>	Draw back to start
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in
<code>ctx.beginPath();</code>	Start of second (lower) path
<code>ctx.moveTo(canvasAx,my);</code>	Start at point on left side indicated by my parameter
<code>ctx.lineTo(canvasDx,canvasDy);</code>	Draw to lower-left corner
<code>ctx.lineTo(canvasCx,canvasCy);</code>	Draw to lower-right corner

(continued)

**Table 4-2.** (continued)

Code Line	Description
<code>ctx.lineTo(canvasBx,my);</code>	Draw to point on right edge
<code>ctx.lineTo(mx+holerad,my);</code>	Draw to left to edge of hole
<code>ctx.arc(mx,my,holerad,0, Math.PI,false);</code>	Draw semicircular arc
<code>ctx.lineTo(canvasAx,my);</code>	Draw to left edge
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in
<code>}</code>	Close drawshadowmask function
<code>var listener;</code>	Variable set by addListener call; <i>not used again</i>
<code>var map;</code>	Holds map
<code>var blatlng;</code>	Holds base latitude-longitude object
<code>var myOptions;</code>	Holds associative array used for map
<code>var rxmarker = "rx1.png";</code>	Holds filename for red x image
<code>var bxmarker = "bx1.png";</code>	Holds filename for black x image
<code>function makemap(mylat,mylong) {</code>	Header for makemap function; parameters hold location of center of the map
<code>var marker;</code>	Will hold marker created for center
<code>blatlng = new google.maps. LatLng(mylat,mylong);</code>	Build a LatLng object (special data type for the API)
<code>myOptions = {</code>	Set associative array
<code>zoom: 12,</code>	Zoom setting (can be 0 to 18)
<code>center: blatlng,</code>	Center
<code>mapTypeId: google.maps.MapTypeId. ROADMAP</code>	Type of map
<code>};</code>	Close myOptions array

(continued)

**Table 4-2.** (continued)

Code Line	Description
map = new google.maps.Map(document. getElementById("place"), myOptions);	Invoke the API to bring in a map at indicated place
marker = new google.maps.Marker(  { position: blatlng, title: "center", icon: rxmarker, map: map }	Place marker in center of map; marker method takes an associative array as its parameter; Note: there is alternative using setMap method of marker object  Start of associative array  Set the position  Set the title  Set the icon  Set the map named parameter to the variable named map
};	Close the call to the Marker method
listener = google.maps.event. addListener( map, 'mouseup', function(event) { checkit(event.latLng); }	Set up event handling (the three following parameters); this is a Google Maps event  The object, namely the map  The specific event  An autonomous function (defined directly as a parameter in addListener)  Call checkit with the indicated latitude-longitude object  Close the function definition
});	Close the call to addListener
}	Close the makemap function

*(continued)*

**Table 4-2.** *(continued)*

<b>Code Line</b>	<b>Description</b>
<code>function checkit(clatlng) {</code>	Function header for <code>checkit</code> ; called with the latitude-longitude object
<code>  var distance = dist   (clatlng,blatlng);</code>	Invoke the <code>dist</code> function to calculate distance between the clicked position and the base
<code>  var marker;</code>	Will hold newly created marker
<code>  distance = round(distance,2);</code>	Round the value
<code>  var distanceString = String   (distance)+" km";</code>	Set <code>distanceString</code> to be the display
<code>  marker = new google.maps.Marker(     {</code>	Invoke the <code>Marker</code> method, which takes an associative array as its parameter
<code>    position: clatlng,</code>	Start of associative array
<code>    title: distanceString,</code>	Set position
<code>    icon: bxmarker,</code>	Set title
<code>    map: map</code>	Set icon to be black x
<code>  }</code>	Set map element of associative array to the value of the variable named <code>map</code>
<code>  });</code>	Close associative array
<code>  var clat = clatlng.lat();</code>	Close call to <code>Marker</code> method
<code>  var clng = clatlng.lng();</code>	Extract the latitude value
<code>  clat = round(clat,4);</code>	Extract the longitude value
<code>  clng = round(clng,4);</code>	Round value to four decimal places
<code>  document.getElementById("answer").   innerHTML =</code>	Round value to four decimal places
	Set up text onscreen . . .

*(continued)*

**Table 4-2.** (continued)

Code Line	Description
"The distance from base to most recent marker (" + clat+", "+cLng+") is "+String(distance) +" km.";	... to be calculated and formatted information
can.style.zIndex = 100;	Set canvas to be on top
pl.style.zIndex = 1;	Set pl (holding map) to be underneath
}	Close checkit function
function round (num,places) {	Header for function to round values
var factor = Math.pow(10,places);	Determine factor from number of places
var increment = 5/(factor*10);	Determine the increment to round up or down
return Math.floor ((num+increment)*factor)/factor;	Do calculation
}	Close round function
function dist(point1, point2) {	Function header for dist (distance) function
// spherical law of cosines, // from <a href="http://www.movable-type.co.uk/scripts/latlong.html">http://www.movable-type.co.uk/ scripts/latlong.html</a>	Attribution for my source; this is standard mathematics
var R = 6371; // km	Factor used to produce answer in kilometers
// var R = 3959; // miles	Commented out, but keep just in case you want to give answer in miles, which I did in Figure 4-19
var lat1 = point1.lat()*Math.PI/180;	Convert value to radians
var lat2 = point2.lat()*Math.PI/180 ;	Convert value to radians
var lon1 = point1.lng()*Math.PI/180;	Convert value to radians
var lon2 = point2.lng()*Math.PI/180;	Convert value to radians
var d =	Calculation ...

*(continued)*

**Table 4-2.** *(continued)*

Code Line	Description
Math.acos(Math.sin(lat1)*Math. sin(lat2) + Math.cos(lat1)*Math. cos(lat2) * Math.cos(lon2-lon1)) * R;	Use trigonometry to determine distance
return d;	Return result
}	Close dist function
function changebase() {	Header for changebase function
var mylat;	Will hold new base location latitude
var mylong;	Will hold new base location longitude
for(var i=0;i<locations. length;i++) {	for loop to determine which radio button is checked
if (document.f.loc[i]. checked) {	Is this one checked?
mylat = locations[i][0];	If so, set mylat
mylong = locations[i][1];	Set mylong
makemap(mylat,mylong);	Invoke makemap
document.getElementById ("header").	Change text in header to show the name
innerHTML = "Base location (small red x) is "+locations[i][2];	
}	Close if true clause
}	Close for loop
return false;	Return false to present refresh
}	Close function
</script>	Closing script tag
</head>	Closing head tag
<body onLoad="init();">	Opening body tag; include onLoad to invoke init

*(continued)*



**Table 4-2.** (continued)

Code Line	Description
<code>&lt;header id="header"&gt;Base location (small red x) &lt;/header&gt;</code>	Semantic header element
<code>&lt;div id="place" style="width:600px; height:400px"&gt;&lt;/div&gt;</code>	div to hold Google Maps
<code>&lt;div id="answer"&gt;&lt;/div&gt;</code>	div to hold information on clicked locations
Change base location: <code>&lt;br/&gt;</code>	Text
<code>&lt;form name="f" onSubmit=" return changebase();"&gt;</code>	Start of form for changing base; Note: you need to coordinate with locations array in the script element
<code>&lt;input type="radio" name="loc" /&gt; Springer Nature (Apress Publishers) London, UK&lt;br/&gt;</code>	Radio button choice
<code>&lt;input id="first" type="radio" name="loc" /&gt; Purchase College&lt;br/&gt;</code>	Radio button choice; given ID to be set as checked at opening
<code>&lt;input type="radio" name="loc" /&gt; Kyoto, Japan&lt;br/&gt;</code>	Radio button choice
<code>&lt;input type="submit" value="CHANGE"&gt;</code>	The button to make the change
<code>&lt;/form&gt;</code>	Closing form tag
<code>&lt;/body&gt;</code>	Closing body tag
<code>&lt;/html&gt;</code>	Closing html tag

You need to decide on your set of base locations. Again, there is nothing special about three. Your choices may be much closer. If your base list is too large, you may consider using `<optgroup>` to produce a drop-down list. In any case, you need to define a set of locations. Each location has two numbers—latitude and longitude—and a string of text comprising the name. Some of the text is repeated in the HTML in the form in the body element.

## Testing and Uploading the Application

This project consists of the HTML file and three image files. For my version of the project, the image files were the light bulb (`light.gif`), the red *x* (`rx1.png`), and the black *x* (`bx1.png`). There is nothing special about these image file types. You can use whatever you like. It could be argued that my *x* markers are too tiny, so think about your customers when deciding what to do.

This application does require you to be online to test since that is the only way to contact Google Maps.

## Summary

In this chapter, you learned how to do the following:

- Use the Google Maps API.
- Combine the use of the Google Maps API with your own JavaScript coding using canvas graphics. That is, produce a GUI that includes Google Maps events and HTML5 events.
- Draw using the alpha setting controlling transparency/opacity.
- Change to a custom-made cursor.
- Calculate distances between geographic points.
- Round off decimal values for suitable display.

The next chapter describes another project using Google Maps. You will learn how to build an application in which you can associate a picture, a video clip, or a picture-and-audio-clip combination with specific geographic locations, and then you'll see how to display and play the specified media when a user clicks at or near the locations on a map.

## CHAPTER 5

# Map Portal: Using Google Maps to Access Your Media

In this chapter, you will learn the following:

- Using the Google Maps API to play and display video, audio, and images
- Creating HTML5 markup dynamically
- Separating the program from descriptions of content
- Building a geography game

## Introduction

The project in this chapter uses the Google Maps API as a way to play video, display images, or play audio *and* display an image, all based on geographic locations. You can use this project as a model to build a study of a geographic area or report on a business or vacation trip, or you can develop it into a more elaborate geography quiz. As was the case with Chapter 4, the main lessons concern integrating use of the Google Maps API with your own JavaScript, in particular, presenting images, audio and video. The example for this chapter is a quiz application. I have acquired media, such as video files, audio files, and image files, and I have defined in the code an association between the media and specific geographic locations. To give you an idea of what I mean, for my projects, the associations between a target location (which is given in latitude and longitude coordinates in the code) and media are shown in Table 5-1.

**Table 5-1.** *Outline of Content*

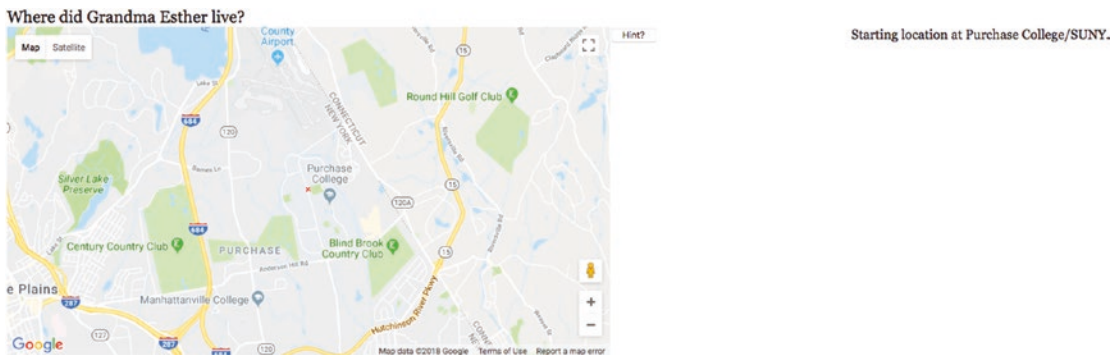
Description of Location	Media
Purchase College, NY, USA (Student Services Building)	Starting location: no media
Mount Kisco, NY, USA	Picture of Esther and an audio file of her playing piano
Purchase College/NY, USA (Natural Sciences Building)	Video of LEGO Robotics
Statue of Liberty, New York City, USA	Video of fireworks
Miyajama, Japan	Picture of the Great Torii

The application proceeds smoothly with the different types of media. This is due to the features of HTML5 and, I say modestly, my programming. (In fact, modesty is called for: I needed to make a small modification to the program because of significant differences in image dimensions when I made a change from a smaller picture to a larger one.) The media information along with the questions and locations are stored in a separate file.

It still is recommended that you supply multiple video and audio formats to make sure your application will work in the different browsers. The media types recognized by browsers may change so that fewer types are required, but this is not the case at this time.

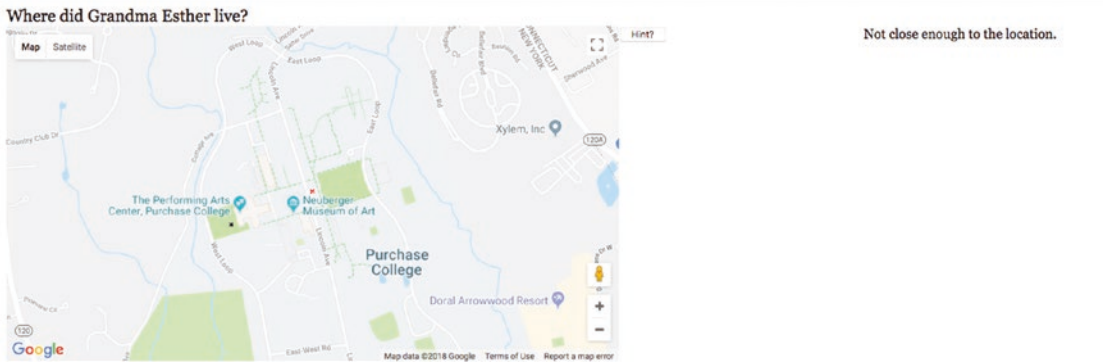
The application is a simple quiz. It consists of two files: `mapmediaquiz.html` and `mediaquizcontent.js`. The `mediaquizcontent.js` file contains information connecting the media to the locations and also contains the text for the questions.

Figure 5-1 shows the opening screen for the quiz.



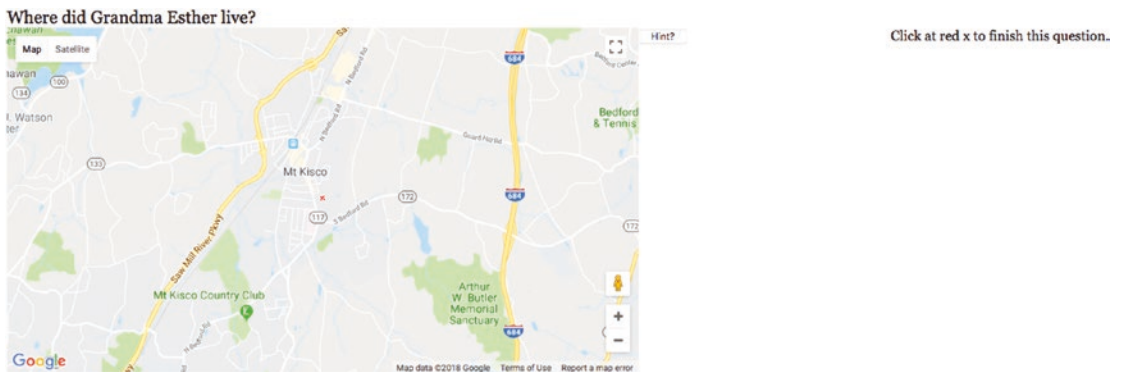
**Figure 5-1.** *Opening screen for quiz*

The player now attempts to answer the question by determining the location and clicking on the map. Figure 5-2 shows what happens when I just make a click on the Purchase campus. This is not a good answer, which the program detects.



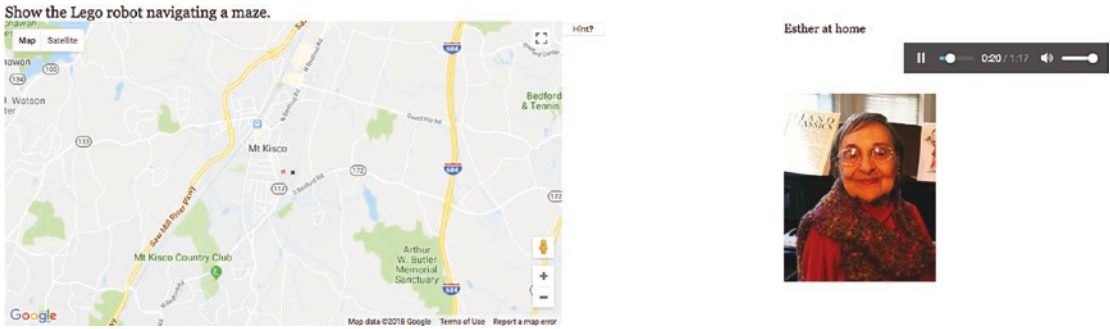
**Figure 5-2.** Result of clicking at Purchase College

Notice that a small x has appeared where I clicked, but it is not sufficiently close to the correct location. I move the map and try again and Figure 5-3 shows the result of clicking the screen, but not sufficiently close to the target location. Notice that I have panned the map, moving it to the north. There is an option for the player to get a hint. When I clicked on the Hint button, Figure 5-3 appeared. This is a very strong hint, and readers are encouraged to devise a way of helping out the player without giving the answer.



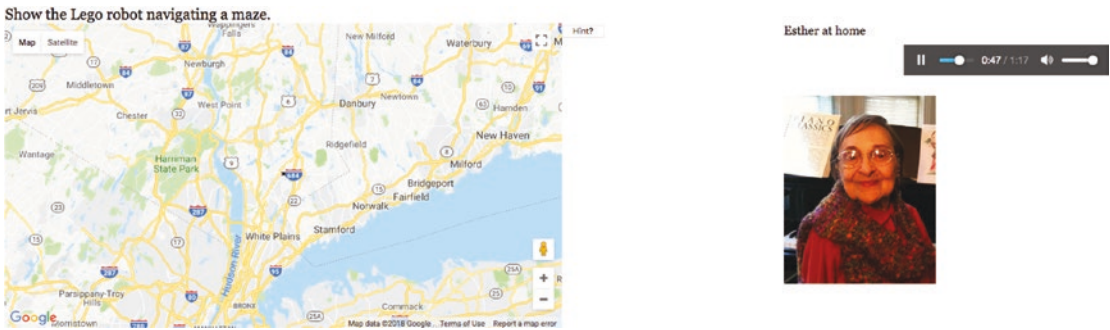
**Figure 5-3.** Result of clicking the Hint button

When I follow the directions to click on the red x, Figure 5-4 shows the result. Notice also the audio control, providing a way to pause and resume playing and also change the speaker volume. The controls for audio (and video) will be different in the different browsers, but the functionality is the same. The audio starts playing immediately. Notice also that the next question appears.



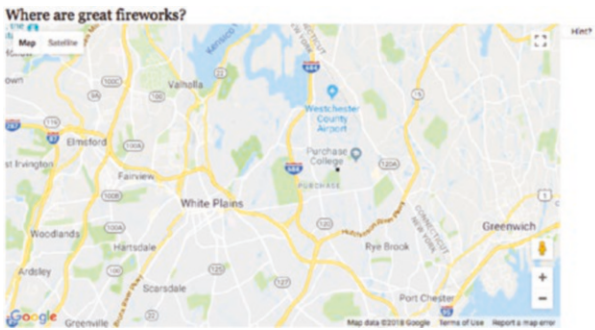
**Figure 5-4.** *Image-and-audio combination*

Because I know where the locations are, I know to zoom out to get to the next location. Figure 5-5 shows the results of using the Google Maps interface to accomplish this. The audio track continues playing and I still see the picture.



**Figure 5-5.** *Zooming out in preparation for a pan south*

Figure 5-6 shows the result of moving the map to the south and then zooming in back to the Purchase campus where a video produced by students shows a LEGO Mindstorms robot traversing a maze.



**Figure 5-6.** Correctly locating (close enough) the LEGO robots, so a video plays

The next location is the Statue of Liberty. Notice that when I click close to that location, a pop-up label set by Google appears.



**Figure 5-7.** Zooming out, panning south, and then zooming in to click at the Statue of Liberty

The last question requires going across country and across to the Pacific to locate Miyajama (which I had been told about by Takashi, also the supplier of the photo). Figure 5-8 shows the results of the first steps.



**Figure 5-8.** Zooming out and then in on Japan

Again, the results of the prior question still appear. I press the Hint button and see what is shown in Figure 5-9.

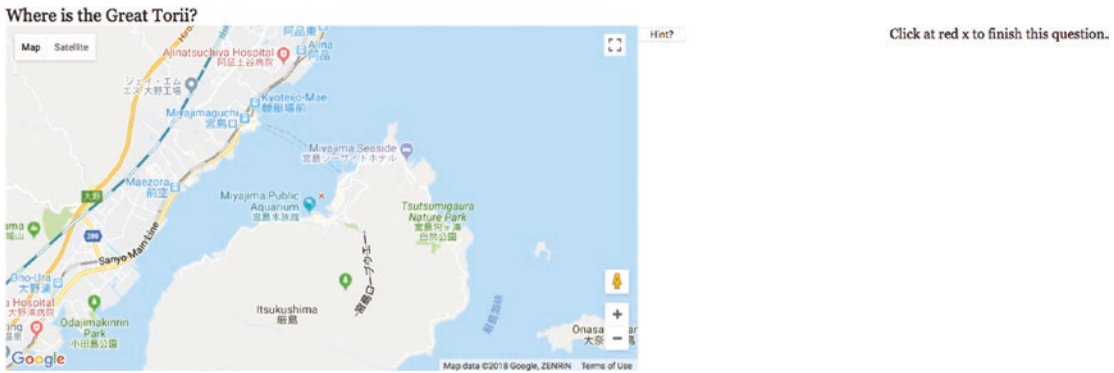


Figure 5-9. Result of clicking on the Hint button

When I click on the screen in the place suggested by the hint, Figure 5-10 appears. This is a major local and global tourist attraction in Japan.

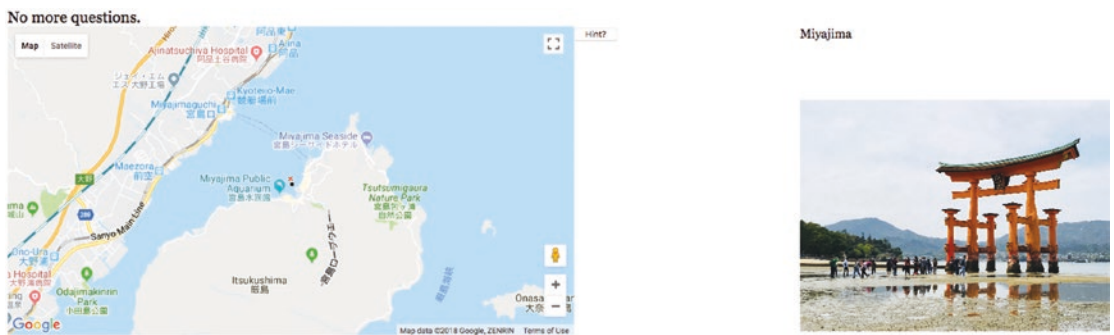
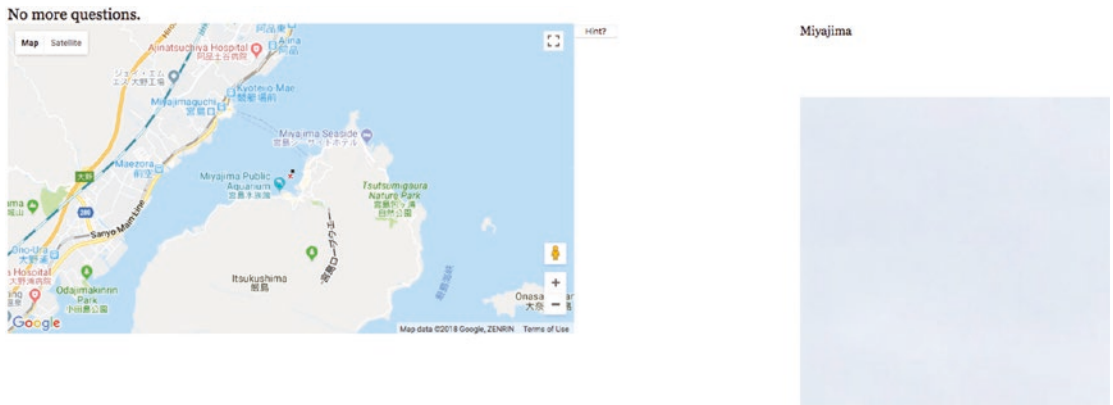


Figure 5-10. The Great Torii

At this point, I need to admit that my original code could not handle the very nice and very large image furnished by Takashi. It was too big for the coding I used, which worked well enough with small images. Figure 5-11 shows what happened when I included the Great Torii question and the photo of Miyajima with my original code. This certainly was disappointing. It was only the upper-left corner of the image.





**Figure 5-11.** Result of original coding for showing images

My original statement:

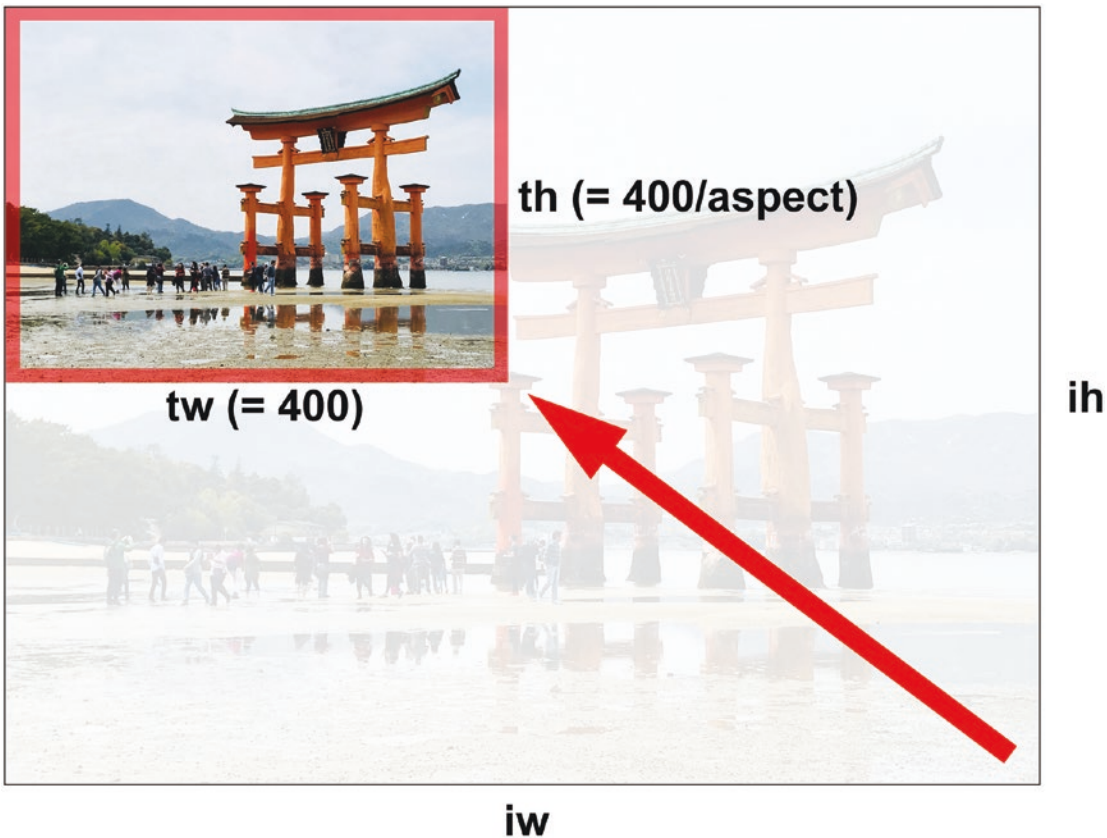
```
ctx.drawImage(img1,0,0);
```

drew only the upper corner from the picture onto the canvas. Instead, I needed to write JavaScript that determined how to scale the picture onto the 400x400 canvas, performing scaling while also preserving the aspect ratio. The following does the trick:

```
var iw = img1.width;
var ih = img1.height;
var aspect = iw/ih;
if (iw>=ih) {
    if (iw>400){
        tw = 400;
        th = 400/aspect;
    }
    else {
        tw = iw;
        th = ih;
    }
}
else {
    if (ih>400){
        th = 400;
        tw = 400*aspect;
    }
}
```

```
else {  
    th = ih;  
    tw = iw;  
}  
    }  
    ctx.drawImage(img1,0,0,iw,ih,0,0,tw,th);
```

Figure 5-12 indicates the action of the code. An image with original width equal to iw and height equal to ih is scaled down to fit in the 400 by 400 canvas. The final dimensions are indicated by tw and th. This code produced what is shown in Figure 5-10.



**Figure 5-12.** Diagram showing relationship of source and target width and height values

With this introduction, I'll go on to discuss the project history and the critical requirements.

## Project History and Critical Requirements

A senior at Purchase College had collected and made video clips and photographs about the ethnic neighborhoods of Queens, New York and wanted a way to present the work. The Google Maps API and the new facilities in HTML5 seemed perfect for the task. Keep in mind that the student only needed a way to present the work on a computer she set up at the senior project show, so the issue of noncompliant browsers was not a concern. The critical requirements include what is supplied by the Google Maps API. As you learned in the previous chapter, we can write code to access a map centered at a specified geographic location, set at an initial zoom level, and showing views of roads or satellite or terrain or a hybrid. In addition, the API provides a way to respond to the event of the viewer clicking the map. We need a way to define specific locations to be compared with the location corresponding to the viewer's click.

My first system for the student just used video and images. I later decided to add the image-and-audio combination. The critical requirement for the application is displaying and playing the designated media at the correct time *and* stopping and removing the media when appropriate, such as when it is time for the next presentation.

After helping with the student project, I thought of changes. The first one was the addition of the image-and-audio combination. I decided I did not want audio just by itself. The next change was to separate the specific content from the general coding. This, in turn, required a way to create markup for video and audio elements dynamically.

I always like games and lessons, and it seemed like a natural step to build an application with questions or prompts for the viewer—now best described as the player or student. The player gives the answer by finding the right position on the map. Any application like this has a requirement to define a tolerance with respect to the answers. The viewer/player/student cannot be expected to click exactly on the correct spot.

When testing the quiz, I realized I needed some way to help the player get past a particularly difficult question. Because I am a teacher, I decided to show the player the answer, rather than just skipping the question. However, as I indicated earlier, you may be able to devise a better way to produce hints.

Although it is not apparent when playing the game, the separation of the questions, locations (the answers), and the media made it easy to put together a totally different quiz. However, as I indicated, I did need to make some adaptation when I decided to incorporate pictures of greatly different sizes and shapes.

Having described the critical requirements, the next section contains an explanation of the specific HTML5 features that can be used to build the projects.

## HTML5, CSS, and JavaScript Features

Like the map maker project in Chapter 4, these projects are implemented by combining the use of the Google Maps API with features of HTML5. The combination for this project is not as tricky. The map stays on the left side of the window and the media is presented on the right. I will review quickly how to get access to a map and how to set up the event handling, and then go on to the HTML5, CSS, and JavaScript features for satisfying the rest of the critical requirements.

### Google Maps API for Map Access and Event Handling

Access to the Google Maps API requires a script element with reference to an external file. As was mentioned in Chapter 4, the first step to using the Google Maps API is to go to this site to obtain a key: <https://developers.google.com/maps/documentation/javascript/get-api-key>.

The code to get access to the API is to modify and then add the following to your HTML document:

```
<script async defer src="https://maps.googleapis.com/maps/api/js?key=YOUR_
API_KEY&callback=initMap"
type="text/javascript"></script>
```

This external script element brings in the definitions of objects, such as `map` and `marker`, that you can now use to include functionality from Google Maps into your HTML and JavaScript project.

I set up the connection to mapping using a function I named `makemap`. It has two parameters: two decimal numbers that represent the latitude and longitude values:

```
function makemap(mylat, mylong)
```

The global variables `zoomlevel`, holding a number from 0 to 18, and `bxmarker` and `rxmarker`, holding the address of image files, are set before the function `makemap` is invoked.

The code to bring in a map is an invocation of the `google.maps.Map` constructor method. It takes two parameters. The first is the location in the HTML document where the map is to appear. I set up a `div` with ID `place` in the body of the document:

```
<div id="place" style="float: left; width:50%; height:400px"></div>
```

The second parameter is an associative array. The following three statements set up the location at which the map is centered as a Google Maps latitude-longitude object, create the associative array `myOptions`, and invoke the `Map` constructor:

```
blatlng = new google.maps.LatLng(mylat,mylong);
myOptions = {
    zoom: zoomlevel,
    center: blatlng,
    mapTypeId: google.maps.MapTypeId.ROADMAP
};
map = new google.maps.Map(document.getElementById("place"), myOptions);
```

For completeness sake, here are screenshots with other settings for the map type. These are `TERRAIN`, `HYBRID`, and `SATELLITE`. The `mapTypeId` can be set with simple strings, for example, `'roadmap'`. Figure 5-13 shows the results of requesting the setting showing the terrain—that is, colors indicating elevations, water, park, and human-constructed areas:

```
mapTypeId: google.maps.MapTypeId.TERRAIN
```

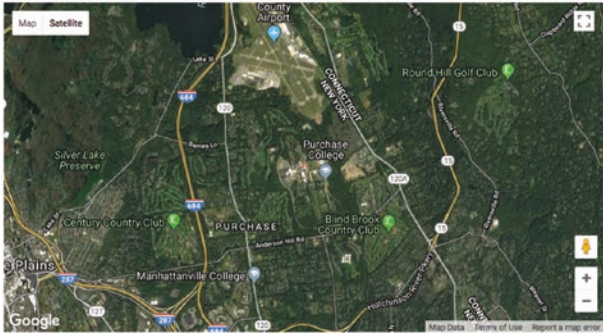


**Figure 5-13.** *The TERRAIN map type*

Figure 5-14 shows the results of requesting the `HYBRID` view, combining satellite and road map imagery.

```
mapTypeId: google.maps.MapTypeId.HYBRID
```

Where did Grandma Esther live?



Starting location at Purchase College/SUNY.

**Figure 5-14.** The HYBRID map type

By the way, the hybrid map is produced by clicking the Satellite option on the interface.

Figure 5-15 shows the results of requesting SATELLITE images. We can think of this as the pure satellite image. Notice that major highways are visible.

```
mapTypeId: google.maps.MapTypeId.SATELLITE
```

Where did Grandma Esther live?



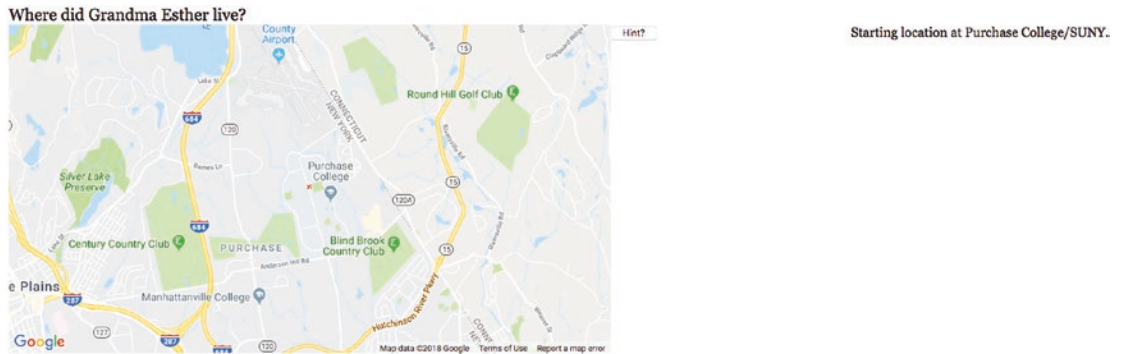
Starting location at Purchase College/SUNY.

**Figure 5-15.** The SATELLITE map type

Lastly, you may have an application in which you do not want the viewer to change the map directly. You can prevent the user from changing the map by disabling the default interface with the use of an additional option in the `myOptions` array. I have included the statement I put before `disableDefaultUI` to communicate that the associative array properties are separated by commas, with *no* comma after the last one.

```
mapTypeId: google.maps.MapTypeId.ROADMAP,  
disableDefaultUI: true
```

Figure 5-16 shows the results. The user can still pan over the map, that is, move it, but the + and - zooming controls, and the Map and Satellite buttons have been removed.



**Figure 5-16.** Map interface removed

There are two more operations for `makemap` to carry out. A custom marker is placed on the map at the indicated center location and event handling is set up for clicking the map:

```
marker = new google.maps.Marker({
  position: blatlng,
  title: "center",
  icon: rxmarker,
  map: map });
listener = google.maps.event.addListener(map, 'click', function(event) {
  checkit(event.latlng);
});
```

The `rxmarker` value references an image object that has its `src` set to an external file named `rx1.png`. This is what produces the small red x at the center of the map. As a reminder: `addListener` is a method setting up an event for Google Maps API. The `addEventListener` is a method setting up an event for JavaScript.

## Project Content in External File

The quiz use three types of media: video, picture, and what I term `pictureaudio`. Note: these are my terms for the three types I have chosen to include in the project. The content of the quiz is specified using two arrays I named `precontent` and `questions`. Each element of the `precontent` array is itself an array of five or six elements. The first

four elements are the same for all the types: the latitude, longitude, title, and type. The fifth or the fifth and the sixth point to the specific media elements. The data for the current quiz, that is, the contents of the external file, is:

```
var base=
    [41.04796,-73.70539,"Purchase College/SUNY"];
var zoomlevel = 13;
var precontent = [
    [41.19991,-73.72353,"Esther at home","pictureaudio","estherT","esther.
    jpg"],
    [41.05079,-73.70448,"Lego robot","video","maze"],
    [40.68992,-74.04460,"Fire works","video","sfire3"],
    [34.298846,132.318359,"Miyajima","picture","miyajima0.JPG"]
];
var questions = [
    "Where did Grandma Esther live?",
    "Show the Lego robot navigating a maze.",
    "Where are great fireworks?",
    "Where is the Great Torii?"
];
var maxdistance = 10;
```

The `base`, `zoomlevel`, and `maxdistance` variables are all what they seem. The `base` is the initial center point for the map. The `zoomlevel` specifies the initial zoom. I say *initial* because the user can use the Google Maps controls to pan or zoom in or out. The `maxdistance` is the number I use to check if the user clicks close enough to one of the locations. You will need to determine the appropriate distance for your application.

The `precontent` array specifies four locations, starting with a picture/audio combination, followed by two videos, followed by one picture. The element in the array for the picture/audio combination includes, as you would expect, two additional pieces of information. It is not obvious from just this section of code, but `esther.jpg` refers to an image element and `estherT` refers to an audio element. Similarly, `maze` and `sfire3` refer to video elements, and `miyajima0.JPG` refers to another image element. An arrangement using two or more arrays like I use `precontent` and `questions` is termed



*parallel structures*. My code produces an array called `content`, which is referenced by the `checkit` function (to be described next), and the appropriate media are presented.

The external scripts are brought into the main document using a `script` element. For the `mapmediaquiz`, this is

```
<script type="text/javascript" src="mediaquizcontent.js"> </script>
```

## Distances and Tolerances

The calculation of distance between two latitude-longitude points was described in the previous chapter. The issue to be explained here concerns how to make comparisons of distances. For the quiz application, I need to write code to determine if the position returned by the Google event handler is close enough to the correct location given for the specified question. The variable `maxdistance` holds the value, sometimes called the tolerance. Here is most of the code for my `checkit` function. I have left out the `switch` statement that does something different for each of the question types once it is determined that the player's guess is close enough.

```
function checkit(clatlng) {
    var marker;
    var latlnga =new google.maps.LatLng(content[nextquestion]
    [0],content[nextquestion][1]);

    var distance = dist(clatlng,latlnga);
        eraseold();
        marker = new google.maps.Marker({
            position: clatlng,
                                title: "Your answer",
                                icon: bxmarker,
            map: map });

        if (distance<maxdistance) {

            switch (content[nextquestion][3]) { ...
                } // end switch
            asknewquestion();
        } // end if (distance<maxdistance)
    else {
```

```

        answer.innerHTML= "Not close enough to the location.";
    }
}

```

## Regular Expressions Used to Create the HTML

Regular expressions are a powerful facility for describing patterns of character strings (text) for checking and for manipulation. It is a whole language for specifying patterns. For example, to give you a flavor of this large topic, the pattern

```
/^5[1-5]\d{2}-?\d{4}-?\d{4}-?\d{4}$/
```

can be used detect MasterCard numbers. These numbers start with 51 to 55, followed by two more digits, and then three groups of four digits. This pattern accepts the dashes, but does not require them. The ^ symbol means the pattern must be present at the start of the string, and the \$ means it must go to the end of the string. The forward slashes (/) are delimiters for the pattern and the backslashes are escape characters. Interpreting this pattern starting at the start goes as follows:

- ^: Start at the start of the string.
- 5: Pattern must contain a 5.
- [1-5]: Pattern must contain one of the numbers 1, 2, 3, 4, or 5.
- \d{2}: Pattern must contain exactly two digits.
- -?: Pattern must contain 0 or 1 -.
- \d{4}: Pattern must contain exactly four digits.
- -?: Pattern must contain 0 or 1 -.
- \d{4}: Pattern must contain exactly four digits.
- -?: Pattern must contain 0 or 1 -.
- \d{4}: Pattern must contain exactly four digits.
- \$: End of string.

MasterCard numbers must obey other rules as well, and you can do the research to find out how to verify them further. Don't worry, we'll be using a much simpler regular expression than that (also known as a *regex*).

The use of regular expressions predates HTML. Regular expressions can be used in forms to specify the format of the input. For this application, we will use the `replace` method for strings to find all instances of a specific small piece of text within a long string and replace it with something else. One of the statements I use is

```
videomarkup = videomarkup.replace(/XXXX/g,name);
```

What this does is find all occurrences (this is what the `g` does) of the string `XXXX` and replace each of them with the value of the variable `name`.

I could and probably should have made even more use of regular expressions to verify the data defining the content of the applications. Maybe that's something you want to experiment with in your own applications.

---

**Note** At some point, the right decision may be to stop using straight JavaScript arrays, including the use of parallel structures, and use XML or a database. I didn't think it was called for in this application, but I could be wrong. Note that the use of server-side programming using a language such as PHP with or without databases does provide a way to hide the data.

---

## Dynamic Creation of HTML5 Markup and Positioning

The external script statements bring in the information for the quiz application. Now is the time to explain how the information is used. The `init` function will invoke a function I named `loadcontent`. This function calls `makemap` to make a map at the indicated base location.

```
makemap(base[0],base[1]);
```

The content array starts off as an empty array.

```
var content = [];
```

By the way, this is different from

```
var content;
```

Your code needs to make `content` an array.

It then uses a `for` loop to iterate over all the elements of `precontent`. The start of the `for` loop adds the *i*th element of `precontent` to the `content` array.

```
for (var i=0;i<precontent.length;i++) {
    content.push(precontent[i]);
    name = precontent[i][4];
```

The next line is the header of a switch statement using as the condition the element of the inner arrays that indicates the type.

```
switch (precontent[i][3]) {
```

For video and pictureaudio, the code creates a div element and positions it so that it floats to the right. It then places inside the div element the right markup for video or audio. What is that markup? I have what I will describe as dummy strings that have XXXX where the actual names of the video or audio files would go. Think of these as templates. I could have used just one string for video, but it was sufficiently complicated that I decided to use three and two for the audio. These strings are

```
var videotext1 = "<video id=\"XXXX\" loop=\"loop\" preload=\"auto\"
controls=\"controls\" width=\"400\"><source src=\"XXXX.webmpv8.webm\"
type='video/webm'>";
```

```
var videotext2="<source src=\"XXXX.theora.ogv\" type='video/
ogg'> <source src=\"XXXX.mp4\" type='video/mp4'>";
```

```
var videotext3="Your browser does not accept the video tag.</video>";
var audiotext1="<audio id=\"XXXX\" controls=\"controls\"
preload=\"preload\"><source
src=\"XXXX.ogg\" type=\"audio/ogg\" />";
var audiotext2="<source src=\"XXXX.mp3\" type=\"audio/mpeg\" /><source
src=\"XXXX.wav\"
type=\"audio/wav\" /></audio>";
```

Notice the use of the backslash (\). It tells JavaScript to use the next symbol as is, and not interpret it as a special operator for regular expressions. This is how the quotation marks inside the screen get carried over to be part of the HTML.

My approach required that I make sure that the names of the video and audio files follow this pattern. This meant that the MP4 files all needed to contain just the name and no internal dots.

I write code using the regular expression function `replace` to take information out of the `precontent` array and put it in the strings in as many places as necessary. The `switch` statement in its entirety is

```
switch (precontent[i][3]) {
    case "video":
        divelement= document.createElement("div");
        divelement.style = "float: right;width:30%;";
        videomarkup = videotext1+videotext2+videotext3;
        videomarkup = videomarkup.replace(/XXXX/g,name);
        divelement.innerHTML = videomarkup;
        document.body.appendChild(divelement);
        videoreference = document.getElementById(name);
        content[i][4] = videoreference;
        break;
    case "pictureaudio":
        divelement = document.createElement("div");
        divelement.style = "float: right;width:30%;";
        audiomarkup = audiotext1+audiotext2;
        audiomarkup = audiomarkup.replace(/XXXX/g,name);
        divelement.innerHTML = audiomarkup;
        document.body.appendChild(divelement);
        audioreference = document.getElementById(name);
        savedimagefilename = content[i][5];
        content[i][5] = audioreference;
        imageobj = new Image();
        imageobj.src= savedimagefilename;
        content[i][4] = imageobj;
        break;
    case "picture":
        imageobj = new Image();
        imageobj.src= precontent[i][4];
        content[i][4] = imageobj;
        break;
}
```

Notice that the `pictureaudio` case does some juggling to create the content element with references to the newly created audio element and the image element.

However, this was not quite enough to ensure that the video and audio end up on the right side for all browsers. That is, it worked for some but not others. I decided to position the audio and video exactly—that is, in absolute terms. This required the following CSS in the style element for all video and audio elements:

```
video {display:none; position:absolute; top: 60px; right: 20px;}
audio {display:none; position:absolute; top: 60px; right: 20px;}
```

The position of the audio is for the audio controls.

There is a potential problem with creating these HTML elements dynamically. You may recall that in Chapter 2 on the family collage, there was code to make sure the videos were loaded before doing anything with them. I have not observed any problems with the quiz probably because responding to the questions takes sufficient time. Still, I urge you to keep the issue in mind and refer back to Chapter 2.

## Hint Button

You can tell from my coding that I was ambivalent about whether to provide a hint or help a player who had given up. In the body element, I included

```
<button onClick="giveup();">Hint? </button>
```

The `giveup` function creates a new map. That is, it uses the `makemap` function to construct access to a different Google Map in the same place. It also erases the old media and puts directions into the answer element.

```
function giveup() {
    makemap(content[nextquestion][0],content[nextquestion][1]);
    eraseold();
    answer.innerHTML="Click at red x to finish this question.";
}
```

## Building the Application and Making It Your Own

The first and critical step in making the application your own is to decide on the content. There are advantages to using a variety of media content and a variety of picture dimensions (and video dimensions), but there is something to be said for having a simpler design.

### The Quiz Application

A quick summary of the quiz application follows:

1. `init`: Performs initialization, including the call to `loadcontent`.
2. `loadcontent`: Uses the variables, most significantly the `precontent` array included in the external script element, to create new markup for the media. It also invokes `makemap`. The `questions` array does not need any more work.
3. `makemap`: Brings in the map and sets up event handling, including the call to `checkit`.
4. `asknewquestion`: Displays the questions.
5. `checkit`: Compares the clicked location with the location for this question.
6. `dist`: Computes the distance between two locations.
7. `giveup`: This is the response to clicking on the Hint button. A new map is brought in. Any media is erased and the player is directed to click near the displayed red x.
8. `eraseold`: Removes any currently showing video, audio, or picture.

Table 5-2 outlines the functions in the quiz application. The function table describing the invoked/called by and calling relationships for the `mapmediabase.html` application is similar for all applications.

**Table 5-2.** *Functions in the Quiz Application*

Function	Invoked/Called By	Calls
init	Invoked by action of the onLoad attribute in the <body> tag	loadcontent, asknewquestion
makemap	Invoked by loadcontent and giveup	
checkit	Invoked by addListener call in makemap	dist, asknewquestion, eraseold
dist	Invoked by checkit	
loadcontent	Invoked by init	makemap
asknewquestion	Invoked by init and checkit	
eraseold	Invoked by checkit and giveup	
giveup	Invoked by action of button	eraseold, makemap

Table 5-3 shows the code for the quiz application.



**Table 5-3.** Complete Code for the Map Quiz Program

Code Line	Description
<b>&lt;!DOCTYPE html&gt;</b>	Doctype for HTML5
<b>&lt;html&gt;</b>	html tag
<b>&lt;head&gt;</b>	head tag
<b>&lt;title&gt;Map Quiz &lt;/title&gt;</b>	Complete title element
<b>&lt;meta charset="UTF-8"&gt;</b>	Meta tag, standard for HTML5
<b>&lt;style&gt;</b>	style tag
<b>header {font-family:Georgia,"Times New Roman",serif;</b>	Set styling for the header, a semantic element; the font family makes Georgia the first choice, with Times New Roman a fallback, and the default serif the next fallback choice of fonts
<b>font-size:20px;</b>	Fairly big font
<b>display:block;</b>	Set line breaks before and afterward
<b>}</b>	Close style directive
<b>video {display:none; position:absolute; top: 60px;</b>	Style directive for video; no display initially
<b>right: 20px;</b>	
<b>}</b>	Close the video directive
<b>audio {display:none; position:absolute; top: 60px;</b>	Style directive for audio; note that this is for the controls; no display initially
<b>right: 20px;}</b>	
<b>canvas {position:relative; top:60px}</b>	Style directive for the canvas element
<b>#answer {position:relative; font-family:Georgia,</b>	Style directive for the message at the upper right
<b>"Times New Roman", Times, serif; font-size:16px;}</b>	
<b>&lt;/style&gt;</b>	Closing style tag

*(continued)*

**Table 5-3.** (continued)

Code Line	Description
<code>&lt;script async defer src="https://maps.googleapis.com/maps/api/js?key=YOUR_API_KEY&amp;callback=initMap" type="text/javascript"&gt;&lt;/script&gt;</code>	Script element bringing in Google Maps API; Note: you need to obtain and use your own API key
<code>&lt;script type="text/javascript" src="mediaquizcontent.js"&gt;&lt;/script&gt;</code>	Bring in the content in <b>mediaquizcontent.js</b>
<code>&lt;script type="text/javascript" charset="UTF-8"&gt;</code>	Opening script tag
<code>var listener;</code>	Used to set up the Google Maps event of clicking on a map
<code>var map;</code>	Used to hold a map
<code>var myOptions;</code>	The options array holding map specifications
<code>var ctx;</code>	Context for the canvas
<code>var blatlng;</code>	Base latlng object
<code>var content = [];</code>	An empty array, to be populated by loadcontent
<code>var answer;</code>	Reference to answers, instructions
<code>var v;</code>	Will hold references to video elements
<code>var audioel;</code>	Will hold references to audio elements (this quiz has just one)
<code>var videotext1 = "&lt;video id=\"XXXX\" preload=\"auto\" controls=\"controls\" width=\"400\"&gt;&lt;source src=\"XXX.mp4\" type='video/mp4; codecs=\"avc1.42E01E, mp4a.40.2\"'\&gt;";</code>	Part 1 of template for video

(continued)

*Table 5-3. (continued)*

Code Line	Description
<b>var videotext2="&lt;source src=\"XXXX.theora.ogv\" type='video/ogg; codecs=\"theora,vorbis\"'\&gt;&lt;source src=\"XXXX.webmvp8.webm\" type='video/webm; codec=\"vp8,vorbis\"'\&gt;";</b>	Part 2 of template for video
<b>var videotext3="Your browser does not accept the video tag.&lt;/video&gt;";</b>	Part 3 of template for video
<b>var audiotext1="&lt;audio id=\"XXXX\" controls=\"controls\" preload=\"preload\"&gt;&lt;source src=\"XXXX.ogg\" type=\"audio/ogg\" /&gt;";</b>	Part 1 of template for audio
<b>var audiotext2="&lt;source src=\"XXXX.mp3\" type=\"audio/mpeg\" /&gt;&lt;source src=\"XXXX.wav\" type=\"audio/wav\" /&gt;&lt;/audio&gt;";</b>	Part 2 of template for audio
<b>var nextquestion = -1;</b>	The question counter needs to start before the 0th one
<b>function init() {</b>	Header for init function
<b>ctx = document.getElementById("canvas").getContext('2d');</b>	Set reference to canvas
<b>answer = document.getElementById("answer");</b>	Set reference to answer
<b>header = document.getElementById("header");</b>	Set reference to header (where question is displayed)
<b>loadcontent();</b>	Create the content using the precontent array
<b>asknewquestion();</b>	Invoke function to ask question, thus starting off the quiz
<b>}</b>	Close init function

*(continued)*

**Table 5-3.** *(continued)*

Code Line	Description
<b>function asknewquestion() {</b>	Header for asknewquestion function
<b>nextquestion++;</b>	Increment the counter
<b>if (nextquestion&lt;questions.length) {</b>	If still more questions
<b>header.innerHTML=questions[nextquestion</b>	Show question
<b>];</b>	
<b>}</b>	Close the if-still-more-questions clause
<b>else {</b>	Else
<b>header.innerHTML="No more questions.";</b>	Display no more questions
<b>}</b>	Close else clause
<b>}</b>	Close asknewquestion function
<b>function loadcontent() {</b>	Header for loadcontent function
<b>var divelement;</b>	Will hold references to newly created div elements
<b>makemap(base[0],base[1]);</b>	Invoke makemap for the base location
<b>var videomarkup;</b>	The complete template for a video element
<b>var videoreference;</b>	Reference to each newly created video element
<b>var audiomarkup;</b>	The complete template for an audio element
<b>var audioreference;</b>	Reference to each newly created audio element
<b>var imageobj;</b>	Image object
<b>var name;</b>	The name obtained from precontent to be used to replace the XXXX in the templates

*(continued)*

*Table 5-3. (continued)*

Code Line	Description
<b>var savedimagefilename;</b>	Saved image file
<b>for (var i=0;i&lt;precontent.length;i++) {</b>	For loop header, going through precontent
<b>content.push(precontent[i]);</b>	Add to content
<b>name = precontent[i][4];</b>	Extract the name
<b>switch (precontent[i][3]) {</b>	Do switch based on the type
<b>case "video":</b>	Video case
<b>divelement= document.createElement("div");</b>	Create a div
divelement.style = "float: right;width:30%;";	Position media to the right
<b>videomarkup = videotext1+videotext2+videotext3;</b>	Create the complete template
<b>videomarkup = videomarkup.replace(/XXXX/g,name);</b>	Do the replace using name
<b>divelement.innerHTML = videomarkup;</b>	Put result into the div
<b>document.body.appendChild(divelement);</b>	Add the div to the body (so it's accessible) but note that it will not be visible until it's made visible
<b>videoreference = document. getElementById(name);</b>	Object a reference
<b>content[i][4] = videoreference;</b>	... and make THAT the fourth element of the subarray
<b>break;</b>	Leave the switch (video case over)
<b>case "pictureaudio":</b>	Pictureaudio case
<b>divelement = document.createElement("div");</b>	Create a div
divelement.style = "float: right;width:30%;";	Position media to the right

*(continued)*

*Table 5-3. (continued)*

Code Line	Description
<b>audiomarkup = audiotext1+audiotext2;</b>	Create the complete template
<b>audiomarkup = audiomarkup.replace(/XXXX/ g,name);</b>	Do the replace using name
<b>divelement.innerHTML = audiomarkup;</b>	Put the result in the div
<b>document.body.appendChild(divelement);</b>	Add the div to the body (so it's accessible) but note that it will not be visible until it's made visible
<b>audioreference = document. getElementById(name);</b>	Object a reference
<b>saveditimagefilename = content[i][5];</b>	Put the current fifth element into saveditimagefilename
<b>content[i][5] = audioreference;</b>	Make the audioreference the fifth element of the subarray
<b>imageobj = new Image();</b>	Create an image object
<b>imageobj.src= saveditimagefilename;</b>	Make its source the saveditimagefilename
<b>content[i][4] = imageobj;</b>	Make this the fourth element of the subarray
<b>break;</b>	Leave the switch (pictureaudio done)
<b>case "picture":</b>	Picture case
<b>imageobj = new Image();</b>	Create an image object
<b>imageobj.src= precontent[i][4];</b>	Set its src
<b>content[i][4] = imageobj;</b>	Set the fourth element of the subarray to point to the image
<b>break;</b>	Leave the switch (picture case done)
<b>}</b>	Close switch

*(continued)*

*Table 5-3. (continued)*

Code Line	Description
}	Close for loop
}	Close loadcontent function
<b>var rxmarker = "rx1.png";</b>	Little red x
<b>var bxmarker = "bx1.png";</b>	Little black x
<b>function makemap(mylat,mylong) {</b>	Header for makemap function
<b>var marker;</b>	Will hold marker object
<b>blatlng = new google.maps.     LatLng(mylat,mylong);</b>	Create latlng object using function parameters
<b>myOptions = { zoom: zoomlevel, center: blatlng, mapTypeId: google.maps. MapTypeId.ROADMAP };</b>	Set the myOptions array
<b>map = new google.maps.Map(document. getElementById("place"), myOptions);</b>	Bring in the map
<b>marker = new google.maps.Marker({ position: blatlng, title: "center", icon: rxmarker, map: map });</b>	Create a marker
<b>listener = google.maps.event.addListener     (map, 'click', function(event) {         checkit(event.latlng);</b>	Set up the event for clicking on the map ... the event handler is an anonymous function that calls checkit
<b>});</b>	Lose the function and close the call to addListener
<b>}</b>	Close makemap
<b>function eraseold() {</b>	Header for eraseold function (same code as in previous example, but now in a function)
<b>if (v != undefined) {</b>	Is there an old v defined?
<b>v.pause();</b>	Pause it

*(continued)*

**Table 5-3.** *(continued)*

Code Line	Description
<code>v.style.display = "none";</code>	Remove from display
<code>}</code>	Close clause
<code>if (audioel != undefined) {</code>	Is there an old audioel defined?
<code>  audioel.pause();</code>	Pause it
<code>  audioel.style.display = "none";</code>	Erase controls for last audio played
<code>}</code>	Close clause
<code>ctx.clearRect(0,0,300,300);</code>	Clear canvas
<code>}</code>	Close eraseold function
 <code>function checkit(clatlng) {</code>	 Header for checkit
<code>  var marker;</code>	Will hold the marker (black x) at the spot set by the player
 <code>  var latlnga =new google.maps.   LatLng(content[nextquestion]   [0],content[nextquestion][1]);</code>	 Build the latitude-longitude object for the answer to this question
<code>  var distance = dist(clatlng,latlnga);</code>	Compute distance
<code>  eraseold();</code>	Invoke the function to erase any media now on display
 <code>var marker = new google.maps.Marker({   position: clatlng,     title: "Your answer",     icon: bxmarker,   map: map });</code>	 Place the marker
 <code>if (distance&lt;maxdistance) {</code>	 Was the user's click close enough?
<code>  switch (content[nextquestion][3]) {</code>	Switch on the type associated with this question
 <code>    case "video":</code>	Video case

*(continued)*



*Table 5-3. (continued)*

Code Line	Description
<b>answer.innerHTML=content[nextquestion][2];</b>	Display the answer (title)
<b>ctx.clearRect(0,0,400,400);</b>	Clear the canvas
<b>v = content[nextquestion][4];</b>	Get reference to the video
<b>v.style.display="block";</b>	Make it visible
<b>v.currentTime = 0;</b>	Set at the start
<b>v.play();</b>	Play the video
<b>break;</b>	Leave switch (video case done)
<b>case "picture":</b>	Picture case (will use some of coding for picture audio case)
<b>case "pictureaudio":</b>	Pictureaudio case
<b>answer.innerHTML=content[nextquestion][2];</b>	Display answer
<b>ctx.clearRect(0,0,400,400);</b>	Clear the canvas
<b>var img1 = content[nextquestion][4];</b>	Get the image
<b>var iw = img1.width;</b>	Determine width
<b>var ih = img1.height;</b>	Determine height
<b>var aspect = iw/ih;</b>	Calculate aspect
<b>if (iw&gt;=ih) {</b>	If wider than tall, then width will be the factor to fit
<b>if (iw&gt;400){</b>	If width is bigger than canvas, calculate the target dimensions
<b>tw = 400;</b>	
<b>th = 400/aspect;</b>	
<b>}</b>	
<b>else {</b>	If width is not bigger than 400, target is the original
<b>tw = iw;</b>	
<b>th = ih;</b>	
<b>}</b>	
<b>}</b>	Ends if width is bigger

*(continued)*

*Table 5-3. (continued)*

Code Line	Description
<b>else {</b>	Else (height is critical dimension)
<b>if (ih&gt;400){</b>	If height is bigger than 400, calculate the target dimensions
<b>th = 400;</b>	
<b>tw = 400*aspect;</b>	
<b>}</b>	
<b>else {</b>	Else target dimensions are the original
<b>th = ih;</b>	
<b>tw = iw;</b>	
<b>}</b>	
<b>}</b>	End outer else
<b>ctx.drawImage(img1,0,0,iw,ih,0,0,tw,th);</b>	Draw image from the whole source to the calculated target
<b>if (content[nextquestion][3]=="picture") {</b>	If this is picture...
<b>break;}</b>	Leave switch
<b>else {</b>	Else need to display and play the audio
<b>audioel = content[nextquestion][5];</b>	Extract the element
<b>audioel.style.display="block";</b>	Display the controls
<b>audioel.currentTime = 0;</b>	Set at the start
<b>audioel.play();</b>	Play
<b>break;</b>	Leave the switch
<b>}</b>	Close else not picture
<b>}</b>	Close switch
<b>asknewquestion();</b>	Ask a new question (only if the user's guess was close enough)
<b>}</b>	Close within maxdistance
<b>else {</b>	Else

*(continued)*

*Table 5-3. (continued)*

Code Line	Description
<code>    <b>answer.innerHTML= "Not close enough to the answer.";</b></code>	Display message
<code>    <b>}</b></code>	Close else
<code><b>}</b></code>	Close checkit
<code><b>function dist(point1, point2) {</b></code>	Header for dist function
<code>    <b>var R = 6371; // km</b></code>	Value used for km
<code>    <b>// var R = 3959; // miles</b></code>	Keep comment in code to easily switch to miles
<code>    <b>var lat1 = point1.lat()*Math.PI/180;</b></code>	Calculate radian
<code>    <b>var lat2 = point2.lat()*Math.PI/180 ;</b></code>	Calculate radians
<code>    <b>var lon1 = point1.lng()*Math.PI/180;</b></code>	Calculate radians
<code>    <b>var lon2 = point2.lng()*Math.PI/180;</b></code>	Calculate radians
<code><b>var d = Math.acos(Math.sin(lat1)*Math.sin(lat2) +</b></code>	Standard calculation using law of cosines
<code><b>Math.cos(lat1)*Math.cos(lat2) *</b></code>	
<code><b>Math.cos(lon2-lon1)) * R;</b></code>	
<code>    <b>return d;</b></code>	Return distance
<code>    <b>}</b></code>	Close function
<code><b>function giveup() {</b></code>	Header for the giveup function (for the hint)
<code>    <b>makemap(content[nextquestion][0],content[nextquestion][1]);</b></code>	Bring in new map centered at the answer
<code>    <b>eraseold();</b></code>	Erase any old media
<code>    <b>answer.innerHTML="Click at red x to finish this question.";</b></code>	Display instructions since players need to click to proceed; this gives the players a way to indicate they have the new map

*(continued)*

**Table 5-3.** *(continued)*

Code Line	Description
<code>}</code>	Close giveup
<code>&lt;/script&gt;</code>	Close script element
<code>&lt;/head&gt;</code>	Close head element
<code>&lt;body onLoad="init();"&gt;</code>	Body tag; invoke init on loading
<code>&lt;header id="header"&gt;Click&lt;/header&gt;</code>	Header element
<code>&lt;div id="place" style="float:left;width:50%; height:400px"&gt;&lt;/div&gt;</code>	The place for the map
<code>&lt;button onClick="giveup();"&gt;Hint? &lt;/button&gt;</code>	Button indicated need for help
<code>&lt;div style="float: right;width:30%;height:400px"&gt;</code>	Hold rest of elements
<code>&lt;div id="answer"&gt;Starting location&lt;/div&gt;</code>	Holds answer, that is title of location
<code>&lt;p&gt; &lt;/p&gt;</code>	Spacing
<code>&lt;canvas id="canvas" width="400" height="400" &gt;</code>	Canvas
<code>Your browser doesn't recognize canvas</code>	Standard for old browsers
<code>&lt;/canvas&gt;</code>	Close canvas element
<code>&lt;/div&gt;</code>	Close div
<code>&lt;/body&gt;</code>	Close body
<code>&lt;/html&gt;</code>	Close html

## Testing and Uploading the Application

This chapter had one application, a geography quiz. It is made up of two files, one (`mapmediaquiz.html`) with HTML, CSS, and the bulk of the coding, and the other (`mediaquizcontent.js`) with JavaScript representing the content. The coding in the `.js` file references the media. I include the standard set of video files for each of the two video clips, the standard audio files for the single audio clip, and two image files. I used the image of a small hand-drawn red *x* and a small hand-drawn black *x* to mark locations on the map, instead of the default teardrop shape for markers in Google Maps. *I repeat: you will not be able to run the source code without acquiring your own API key and changing the script element.* You can and should substitute your own questions, answers (the locations), and media, but do be aware of issues of size and shape and review my handling to accommodate any big image files.

## Summary

In this chapter, you continued using the Google Maps API. You learned how to do the following:

- Manage a geography quiz.
- Use specifications of question, location, and media for dynamic creation of HTML elements.
- Program Google Maps API event handling to detect if the user was close to locations for which you had video, audio with an image, or image alone.
- Separate the definition of media content from the program itself.
- Use a regular expression to produce the right markup.
- Start and stop the display and playing of media.

In the next chapter, you will read about the implementation of a game called Add to 15. It is mainly an exercise in using arrays and strings.

## CHAPTER 6

# Add to 15 Game

In this chapter, you will learn the following:

- Implementing a known real-world game as a digital program with “the computer” as one of the players
- Developing a strategy for “the computer”
- Inserting a pause
- Working with arrays and strings

## Introduction

The two-player game *Add to 15* requires players to take turns choosing from the numbers 1 to 9 with the goal of obtaining a set of three numbers that add up to 15. I first saw this game at the Museum of Mathematics in New York City where it was implemented as an apparatus with the numbers on rods that could be moved from the center to the player’s side. If a player won, there were lights and loud, happy sounds. If no one won, there were shorter and quieter sounds. The game also can be played using a set of 1 to 9 cards from a deck of cards or with paper-and-pencil. The game can be described as one of *perfect knowledge*: the results of past moves and current possibilities are all visible. The game is equivalent to a well-known children’s game and I leave identifying the game and proving the equivalence to the reader. (You can find an explanation on this with the source code for this chapter.)

For the example for this chapter, I chose to have the program manage the game *and* take the role of one of the players. This meant that I needed to formulate a strategy for “the computer”. My strategy is pretty good, but it still is possible for the player to win. Sometime later in my work, I decided that I needed to insert a pause before “the computer” moves in order for the human player to experience the program as a game with an opponent.

Figure 6-1 shows the game’s opening window.

### Player against Computer

Player goes first: click on number. First to have a set of 3 adding to 15 wins. Reload for new game.

Computer

---

Board



---

Player

---

**Figure 6-1.** *Opening window*

Figure 6-2 shows the results after the player and “the computer” each make a move.

### Player against Computer

Player goes first: click on number. First to have a set of 3 adding to 15 wins. Reload for new game.

Computer



---

Board



---

Player

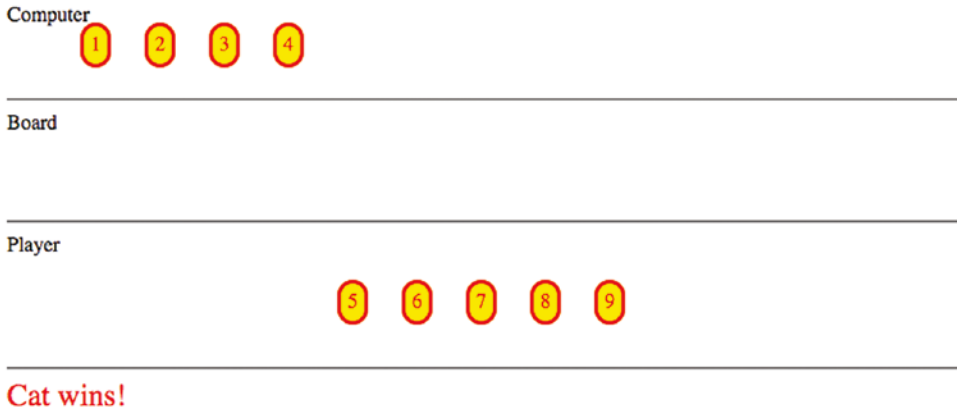


**Figure 6-2.** *After moves by player and computer*

Lastly, I show a screenshot, Figure 6-3, from what appears to be the most common result: the numbers are exhausted and no one wins. In my family, this was described as “The Cat Wins” so that is the term I used for the message telling the results.

## Player against Computer

Player goes first: click on number. First to have a set of 3 adding to 15 wins. Reload for new game.



**Figure 6-3.** Game ends in a tie

This chapter is a case study in implementing games, including implementing a user interface and a strategy. The use of arrays with references between arrays is critical.

## General Requirements for a Game

The requirement for the Add to 15 program and others like it is to present a reasonably intuitive interface to players. The opposing player, which I name “the computer” even though I do not like anthropomorphizing a machine, needs to have a strategy. The program I describe in this chapter has a fairly tough strategy. I think I have beaten it, but not too often. Possible enhancements for this program are to develop the best possible strategy in which “the computer” never loses, although perhaps does tie, as well as other, less skilled strategies. With a set of options, an enhancement would be to present the human players a choice to pick the skill level for their opponent. This requires formulating a sequence of strategies, including, perhaps, making random moves.

My first version of this program had “the computer” move showing up close to instantaneously with the display of the player’s move. I inserted a pause to give the game what I consider a nicer “touch and feel”. This practice would hold for many games. When we are playing a game in the real world, we do not consciously pause, but implementing the game in the digital world may require explicit attention to time.



The Add to 15 is simple enough so that all possible combinations adding up to 15 can be listed. In fact, there are 8 and so my program has an array whose elements are strings holding the numbers of a valid group, for example “3 5 7”. (Actually, the array has nine elements, with the first an empty placeholder so indexing can be 1-based, not 0-based.) The management of the game and the implementing of “the computer” strategy can be built using the information in this array. You will not see any code that adds up numbers!

My program has another array that has nine elements, each an array with elements pointing to which groups in the list of eight that the number belongs to. My program has an array for the board, which starts out with all nine numbers; an array for the player, initially empty; and an array for “the computer”, also initially empty. There are arrays for player and computer that have nine elements, with the first element not used, that indicate how many elements of each of the eight combinations are present.

The program has two arrays that do not change: groups and occupied. It also has one array, numbers, that is created at the start but does not change after that. There are five arrays that do change: board, computer, player, pgrouppcount, and cgrouppcount. You will see these in use in the next section. The use of arrays and the pointing back and forth is typical of these types of applications. There is redundancy, but it eases the coding.

## HTML5, CSS, and JavaScript

In this section, I explain the features used to accomplish the requirements for the Add to 15 project.

### Styling in CSS

The oval-shaped, red border, yellow background elements that hold the nine numbers are created dynamically as span elements. The CSS that sets the appearance is

```
span {
    position: absolute;
    top: 180px;
    border-style: solid;
    color: red;
    border-radius: 25px;
    background-color: yellow;
```

```
padding: 5px;
cursor: pointer;
}
```

Creating these elements dynamically with absolute positioning means that they are easily moved from the board to the player's or "the computer's" section. Making the type span as opposed to div means that there is no forced line break and they can be next to each other. By the way, my trick for distinguishing between padding (inside the element) and margin (outside the element) is to think of a padded cell.

## JavaScript Arrays

As already discussed, a set of arrays is used for the operation of the game. Some of the arrays have an unused slot at the 0-index position, just to make things easier for the coding. The groups array holds the possible combinations adding up to 15:

```
var groups = [
  " ",           //placeholder, not used
  "3 4 8",
  "1 5 9",
  "2 6 7",
  "1 6 8",
  "3 5 7",
  "2 4 9",
  "2 5 8",
  "4 5 6"
];
```

The occupied array, which you can view as redundant information, makes certain calculations easier. I did decide to put up with the zero-based indexing. The occupied array is used to indicate which groups each value from 0 to 9 belongs to. To be more specific, values in the Nth subarray correspond to the indices of the groups holding N+1. Here is the occupied array and I will indicate some examples afterwards.

```
var occupied = [ //indexed subtracting 1
  [2, 4],
  [3, 6, 7],
  [1, 5],
```

```

    [1, 6, 8],
    [2, 5, 7, 8],
    [3, 4, 8],
    [3, 5],
    [1, 4, 7],
    [2, 6]
];

```

So the number 1 is associated with the array [2, 4]. This indicates that 1 belongs to the second group, “1 5 9”, and the fourth group, “1 6 8”. The number 5 belongs to the second, fifth, seventh, and eighth groups. The groups and the occupied arrays do not change.

The board, player and computer array hold the numbers that are on the board, selected by the player, or selected for “the computer”. So the initial declarations are

```

var player = [];
var computer = [];
var board = [1,2,3,4,5,6,7,8,9];

```

The last two arrays keep track of how close the player and “the computer” are to completing each of the eight combinations. So the initial declarations are

```

var pgroupcount = [0,0,0,0,0,0,0,0,0]; //unused first slot
var cgroupcount = [0,0,0,0,0,0,0,0,0]; //unused first slot

```

At the point in the game shown in Figure 6-2, “the computer” holds a 2. Looking at the occupied array, 2 is present in groups 3, 6, and 7. The cgroupcount would be [0,0,0,1,0,0,1,1,0]. The player chose 5 first, so the pgroupcount array was [0,0,1,0,0,1,0,1,1].

If the player then chooses 6, the pgroupcount will be [0,0,1,1,1,1,0,1,2]. The presence of a 2 in either group’s count array indicated the chance to win—if the player has 2 members of a group, getting the third means a win—or the need to block—if “the computer” has 2 members of a group, it can win on the next move. My code must determine the identity of the missing number and check if it is still on the board (in the board array).

With what can be described as the infrastructure of these arrays, I can explain responding to a player move, generating “the computer” move, and determining if the game is won or over.

## Setting Up the Game

The `setUpBoard` function creates the nine `span` elements that represent the nine numbers. References to these nine elements are held in an array called `numbers`. An extra attribute is set for the elements, named `n`, to save the specific number. As part of the creation process, implemented using a `for` loop, the `addEventListener` method is invoked for the “click” event and is set to invoke the `addToPlayer` function when the player clicks on the number.

Once created, this array does not change. What does change is the location of each element, indicated by the `style.left` and `style.top` attributes.

## Responding to a Player Move

The critical function for responding to a player move is `addToPlayer`. You can think of the `addToPlayer` function as performing housekeeping types of operations, updating the various arrays. The number selected is added to the `player` array. The function `take` is invoked, which removes the element from the `board` array. The `span` element corresponding to the number is relocated by changing the `style.top` attribute. Changing the `player` and `board` arrays is required but it does not change where the number element is positioned in the window.

A local variable, `holder`, is set to hold the groups containing the number. Recall that the `occupied` array is the array of arrays with that information. I use a `for` loop to go through `holder` and update `pgroupcount`. My code checks if any of the counts are three. This would indicate a win by the player. If that is not true, the `addToPlayer` function executes a `setTimeout` statement to put in a pause before invoking `computerMove`.

The `addToPlayer` function has a line in which the event of clicking on a piece is stopped:

```
ev.target.removeEventListener("click",addToPlayer);
```

This prevents the bad behavior of a player clicking on a piece that has already been taken by the player. I must admit that I did notice this problem originally.

## Generating the Computer Move

The `computerMove` function is invoked after a pause. I split up the tasks between `computerMove` and `smartChoice`. The `computerMove` function invokes the `smartChoice` function. The `computerMove` function mainly does the similar housekeeping tasks as performed in the `addToPlayer` function. I note that although my program has the player playing first, the `computerMove` code does check if the board is empty.

The `smartChoice` program uses the arrays to go through the following operations:

1. Is there any number still on the board (in the board array) that would win the game for the computer?
2. Assuming that an immediate win is not possible, is there any number on the board that would mean an immediate win by the player? If so, play that number to block the player.
3. Assuming that an immediate block is not required, is there any group with one element already played by the computer, and neither of the other two played by the player? If so, take one of the two available numbers.
4. Assuming none of the previous cases apply, and 5 is available, take it.
5. Assuming none of the previous cases apply, take an even number.
6. Make a random choice from among the numbers remaining.

So enhancing the program by providing better and/or more strategies would involve changing `smartChoice`.

Analogous to the action in `addToPlayer`, the `computermove` function has a line to remove the event handling for clicking on a piece that has already been played:

```
numbers[n-1].removeEventListener("click",addToPlayer);
```

This prevents the bad behavior of a player clicking on a piece that has been played by the computer.

The `computerMove` function, like the `addToPlayer` function, can determine if the game is over either with a win for the computer or a tie.

## Building the Application and Making It Your Own

You can make this application your own by improving the strategy and/or adding different strategies. You can look ahead to Chapter 9 where the HTML5 facility named `localStorage` is described and think about how that can be incorporated into game play. The main objective of this chapter is to provide experience in using arrays with cross-references. Another challenge is to provide a way to repeat the game without reloading. You can look ahead to Chapter 8, at the jigsaw puzzle turning into a video, for an example of how to do that. Yet another enhancement is to record the sequence of moves, possibly using `localStorage`, so you can try different strategies.

Table 6-1 lists all the functions and indicates how they are invoked and what functions they invoke.

**Table 6-1.** *Functions in the Add to 15 Project*

Function	Invoked/Called By	Calls
<code>init</code>	Invoked by action of the <code>onLoad</code> attribute in the <code>&lt;body&gt;</code> tag	<code>setUpBoard</code>
<code>setUpBoard</code>	<code>init</code>	
<code>computerMove</code>	Invoked by action of <code>setTimeout</code> , called in <code>addToPlayer</code>	<code>smartChoice</code> , <code>take</code>
<code>smartChoice</code>	<code>computerMove</code>	
<code>take</code>	<code>addToPlayer</code> , <code>computerMove</code>	
<code>addToPlayer</code>	Invoked by action of <code>addEventListener</code> for click events	<code>take</code>

Table 6-2 shows the code for the Add to 15 game, with comments about each line.

**Table 6-2.** Complete Code for the Add to 15 application

Code Line	Description
<code>&lt;!DOCTYPE html &gt;</code>	Header
<code>&lt;html&gt;</code>	Opening html tag
<code>&lt;head&gt;</code>	Opening head tag
<code>&lt;title&gt;Add to 15&lt;/title&gt;</code>	Complete title
<code>&lt;meta charset="UTF-8"&gt;</code>	Meta tag
<code>&lt;style&gt;</code>	Opening of style element
<code>span {position:absolute; top:180px;</code>	Start of span formatting, initial location is on the board
<code>border-style: solid; color: red;</code>	Solid red border, curved; background is yellow
<code>border-radius: 25px; background-color: yellow;</code>	
<code>padding: 5px; cursor: pointer;</code>	Padding between border and text; cursor will be pointer
<code>}</code>	Close span style directive
<code>#status {</code>	Styling for status message
<code>color: red;</code>	Red color
<code>font-size: x-large;</code>	Large font
<code>}</code>	Close status style directive
<code>&lt;/style&gt;</code>	Close style element
<code>&lt;script language="JavaScript"&gt;</code>	Script tag
<code>var statusref;</code>	Will hold pointer to status
<code>var numbers = [];</code>	Array of pointers to the created span elements
<code>var game = true;</code>	Boolean flag used to control when player can make a move
<code>var player = [];</code>	Will hold all the numbers taken by the player

*(continued)*

**Table 6-2.** *(continued)*

<b>Code Line</b>	<b>Description</b>
<code>var computer = [];</code>	Will hold all the numbers taken by the computer
<code>var board = [1,2,3,4,5,6,7,8,9];</code>	Initial setting for the numbers held on the board
<code>var wedge = 50;</code>	Horizontal space allowed for each number
<code>var startx = 15;</code>	Pieces lined up vertically
<code>var groups = [</code>	Static array holding the valid combinations
<code>  "  ",</code>	Placeholder; not used
<code>  "3 4 8",</code>	
<code>  "1 5 9",</code>	
<code>  "2 6 7",</code>	
<code>  "1 6 8",</code>	
<code>  "3 5 7",</code>	
<code>  "2 4 9",</code>	
<code>  "2 5 8",</code>	
<code>  "4 5 6"</code>	
<code>];</code>	Close groups
<code>var occupied = [</code>	Static array, indexed by subtracting 1 from number N, indicating which groups the number belongs to
<code>  [2, 4],</code>	
<code>  [3, 6, 7],</code>	
<code>  [1, 5],</code>	
<code>  [1, 6, 8],</code>	
<code>  [2, 5, 7, 8],</code>	
<code>  [3, 4, 8],</code>	
<code>  [3, 5],</code>	
<code>  [1, 4, 7],</code>	

*(continued)*



**Table 6-2.** *(continued)*

Code Line	Description
[2, 6]	
];	Close occupied
var pgroupcount = [0,0,0,0,0,0,0,0,0]; //unused first slot	Initial setting showing progress of filling groups by the player
var cgroupcount = [0,0,0,0,0,0,0,0,0]; //unused first slot	Initial setting showing progress of filling groups by the computer
function init() {	Header init function
setUpBoard();	Invoke setUpBoard
statusref=document. getElementById("status");	Get pointer to status area
}	Close init
function smartChoice() {	Header smartChoice (for computer turn)
	First check for immediate win
var boardl = board.length;	Store current length of board (number of numbers still on the board)
for (var i=0;i<boardl;i++) {	For loop through those numbers
var possible = board[i];	Set possible number for a move
for (var j=0;j<occupied [possible-1].length;j++) {	For the groups that possible belongs to...
if (cgroupcount[occupied [possible-1][j]]==2) {	Are there already two numbers in the computer's side?
return (i);	If so, return this number
}	Close if
}	Close inner for loop
}	Close outer for loop

*(continued)*

**Table 6-2.** (continued)

Code Line	Description
	Not returned, now check if need to block
for (var i=0;i<boardl;i++) {	Again, loop through numbers on board
var blocker = board[i];	Set blocker
for (var j=0;j<occupied[blocker-1].length;j++) {	For those groups that blocker belongs to..
if (pgroupcount[occupied[blocker-1][j]]==2) {	..does the player already have two numbers?
return(i);	If so, return index for this number
}	Close if
}	Close inner for
}	Close outer for
	Try for two in a row
	See if there is a possible in a group with one computer played and 0 player presence
for (var i=0;i<boardl;i++) {	For loop through elements on the board
var possible = board[i];	Set possible
for (var j=0;j<occupied[possible-1].length;j++) {	For loop for all the groups that possible belongs to
var whatgroup = occupied[possible-1][j];	Get the group
if ((cgroupcount[whatgroup]==1) &&(pgroupcount[whatgroup]==0 )){	If computer has one number already and the player does not have any
return (i);	Return index for this number
}	Close if

(continued)

**Table 6-2.** (continued)

Code Line	Description
}	Close inner for
}	Close outer for
if (board[i]==5) {	If 5 is available, return its position in board
return (i);	Return its index
}	Close if
}	Close for
for (var i = 0;i<boardl;i++) {	If even number available, 2, 4, 6, or 8, return its position in board
if (0==board[i]%2) {	Use fact that these numbers are the even ones
return (i);	Loop through all the numbers on the board
}	Check if the number is even
}	Return index to this number
}	Close if
}	Close for
var ch = Math.floor(Math.random(0,boardl));	Set up for random move
return (ch);	Return this number
}	Close smartMove
function computerMove() {	Header for computerMove
if (board.length<1) {	If board is exhausted
statusref.innerHTML="Cat wins!";	Set message
return;	return
}	Close if

(continued)

**Table 6-2.** *(continued)*

<b>Code Line</b>	<b>Description</b>
<code>var which = smartChoice();</code>	Get the smartChoice
<code>var n = board[which];</code>	Get the number for that choice
<code>take(n);</code>	Invoke take (which will remove the number from the board)
<code>numbers[n-1].style.top = "150px";</code>	Position the number on the computer's side
<code>numbers[n-1].removeEventListener("click",addToPlayer);</code>	Remove event
<code>computer.push(n);</code>	Add to the computer array
<code>var holder = occupied[n-1];</code>	holder holds groups with n
<code>for (var i=0;i&lt;holder.length;i++) {</code>	Loop through all the groups that holder belongs to
<code>  cgroupcount[holder[i]]++;</code>	Increment the count in cgroupcount
<code>  if (cgroupcount[holder[i]]==3) {</code>	If any group is now at 3
<code>    statusref.innerHTML ="Computer wins "+groups[holder[i]];</code>	Send out message
<code>    game = false;</code>	Turn off play This may not be necessary
<code>    return;</code>	return
<code>  }</code>	Close if
<code>}</code>	Close for
<code>if (board.length&lt;1) {</code>	Check again for end of game, without a win
<code>  statusref.innerHTML="Cat wins!";</code>	Set message
<code>}</code>	Close if
<code>else {</code>	else continue. Turn game back on
<code>  game = true;</code>	Turn game on for player
<code>}</code>	Close else
<code>}</code>	Close computerMove

*(continued)*

**Table 6-2.** *(continued)*

<b>Code Line</b>	<b>Description</b>
<code>function setUpBoard() {</code>	Header for setUpBoard
<code>  var dv;</code>	Will hold each newly created span element
<code>  var xpos;</code>	Used in computation of horizontal position
<code>  for (var i=1; i&lt;10; i++) {</code>	For loop, creating and positioning all the numbers
<code>  dv = document.</code>	Create the span elements
<code>  createElement("span");</code>	
<code>  dv.addEventListener("click",</code>	Set up event handling for clicking on each
<code>  addToPlayer,false);</code>	number
<code>  dv.innerHTML = i.toString();</code>	Set label
<code>  xpos = startx + i*wedge;</code>	Determine horizontal position
<code>  dv.style.left=xpos.toString()+"px";</code>	Set horizontal position
<code>  dv.style.top = "240px";</code>	Set vertical position
<code>  document.body.appendChild(dv);</code>	Add the newly created div to the body
<code>  dv.n = i;</code>	Set an attribute to hold the number
<code>  numbers.push(dv);</code>	Add to the numbers array
<code>  }</code>	Close for loop
<code>}</code>	Close function
<code>function take(n) {</code>	Header for take function
<code>  var nAt = board.indexOf(n);</code>	Find this number in the array
<code>  if (nAt&gt;-1) {</code>	Should always be true
<code>    board.splice(nAt,1);</code>	Removes element from board array; movement is done in the calling program
<code>  }</code>	Close if
<code>}</code>	Close take function

*(continued)*

**Table 6-2.** *(continued)*

<b>Code Line</b>	<b>Description</b>
<code>function addToPlayer(ev) {</code>	Header for addToPlayer, the event handler for clicking on a number
<code>if (game) {</code>	If game is started
<code>var nn = ev.target.n;</code>	Get the number clicked on
<code>ev.target.removeEventListener</code> <code>("click",addToPlayer);</code>	Remove event
<code>player.push(nn);</code>	Add this to the player array
<code>numbers[nn-1].style.top = "350px";</code>	Reposition the element
<code>take(nn);</code>	Remove from the board array
<code>var holder = occupied[nn-1];</code>	holder holds groups with this number
<code>for (i=0;i&lt;holder.length;i++) {</code>	Going through all the groups
<code>pgroupcount[holder[i]]++;</code>	Increment pgroupcount since player now has one more in that group
<code>if (pgroupcount[holder[i]]==3) {</code>	If this count is now 3...
<code>statusref.innerHTML="Player wins</code> <code>" +groups[holder[i]];</code>	The player wins
<code>game = false;</code>	Set game flag to false
<code>return ;</code>	Return (leave loop)
<code>}</code>	Close if true clause
<code>}</code>	Close for loop
<code>game = false;</code>	Temporarily stop player moves
<code>setTimeout(computerMove,1000);</code>	Invoke computermove after a pause
<code>}</code>	Close if(game) true clause
<code>else {</code>	else
<code>statusref.innerHTML="Reload for new</code> <code>game.";</code>	Put out message

*(continued)*

**Table 6-2.** (continued)

Code Line	Description
}	Close the else
}	Close the function
</script>	Close the script tag
<body onLoad="init();">	Body tag
<h1>Player against Computer</h1> 	Header
Player goes first: click on number. First to have a set of 3 adding to 15 wins. Reload for new game.	Instructions
<p>	Spacing
Computer	Computer area
   	Spacing
</p>	Spacing
<hr/>	Horizontal rule
Board	Board area
    	Spacing
<hr/>	Horizontal rule
Player	Player area
     	Spacing
<hr/>	Horizontal rule
<div id="status">	Div for status
</div>	Close div
</body>	Close body tag
</html>	Close html tag

# Testing and Uploading the Application

This source material for this application consists of just one HTML document. The source material contains a Word document on an issue regarding the Add to 15 game.

## Summary

In this chapter, you examined how to implement a two-person game, by providing the single player with an opponent and managing the game. You learned about and gained experience with the following:

- Defining and manipulating arrays
- How to build a user interface for the player, including setting up events for clicking on objects on “the board” and programming a pause
- Taking precautions against bad behavior by a player

In the next chapter, we move on to the spatially fascinating world of paper folding. We explore how to produce directions for an origami model of a talking fish using line drawings, video clips, and the drawing of photographs on canvas. The techniques can be applied to different types of directions.



## CHAPTER 7

# Origami Directions: Using Math-Based Line Drawings, Photographs, and Videos

In this chapter, you will learn the following:

- How to use mathematics to write JavaScript functions to produce precise line drawings
- A methodology for combining line drawings, photographs, and videos, along with text for sequential instructions
- A methodology that facilitates development by letting you proceed in steps, and even go back and insert or change previous work

## Introduction

The project for this chapter is a sequential set of directions for folding an origami model, a talking fish. However, you may read it with any topic in mind in which you want to present to your viewer a sequence of diagrams, including the ability to move forward and back, and with the diagrams consisting of line drawings or images from files or video clips.

**Note** Origami refers to the art of paper folding. It is commonly associated with Japan, but has roots in China and Spain as well. Traditional folds include the water bomb, the crane, and the flapping bird. Lillian Oppenheimer is credited with popularizing origami in the United States and started the organization that became the American national organization OrigamiUSA. She personally taught me the business card frog in 1972. An HTML5 program for the business card frog is included in the downloads for this chapter. Origami is a vibrant art form practiced around the world, as well as a focus of research in mathematics, engineering, and computational complexity.

---

Figure 7-1 shows the opening screen of the Talking Fish application, `origamifish.html`. The screen shows the standard conventions for origami diagrams, modified by me to include color. The standard origami paper, called *kami*, is white on one side and a nonwhite color on the other.

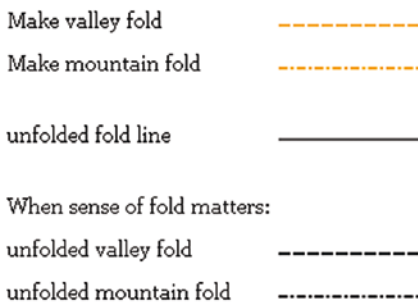


Diagram conventions

---

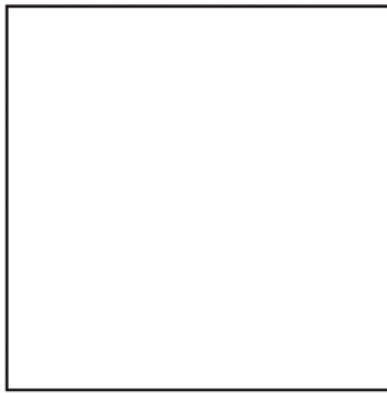
[Go back](#) [Next step](#)

**Figure 7-1.** Opening screen

**Note** I have reduced the set of origami moves. For example, I omitted the representation for a reverse fold, which is used to turn the lips inside out. These folds generally are preceded by what are termed preparation folds, which I describe for the talking fish.

---

The folder can click Next Step (at this point in the sequence, Go Back does nothing) to get to the first actual step of the instructions, shown in Figure 7-2. Of course, it is possible to add programming to remove the Go Back button at the start and the Next Step button at the end.



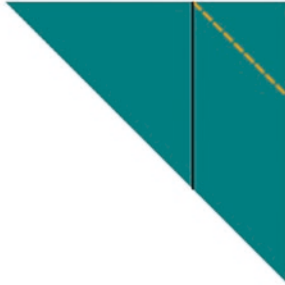
Make quarter turn.

---

[Go back](#) [Next step](#)

**Figure 7-2.** First step, showing the square of paper. The instructions say to turn the paper.

Skipping ahead, Figure 7-3 shows a later step in the folding. Notice that the colored side of the paper is showing. An unfolded fold line is indicated by the skinny vertical line, and the fold to be made next (folding down the corner) is shown by a colored diagonal of dashes in the upper-right corner.



Fold down the right corner to the fold marking a third.

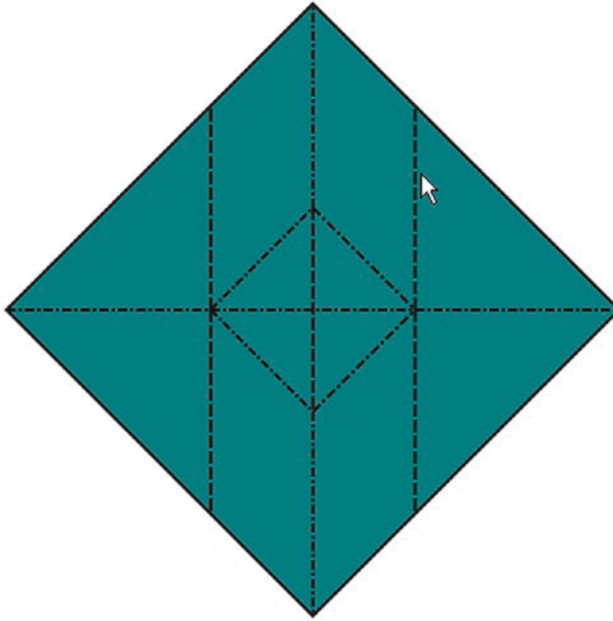
---

[Go back](#)

[Next step](#)

**Figure 7-3.** *Folding a corner down to a fold line*

Later in the construction of the model, the folder must perform a sink fold. This is considered a difficult move. Figure 7-4 shows what is called the crease pattern prior to the sink: the folds are indicated as mountain folds or valley folds.



Push sides to sink middle square.

---

[Go back](#)

[Next step](#)

**Figure 7-4.** Step with standard diagram for sink

I decided to supplement the line drawing with a video clip showing the sink step. Figure 7-5 shows a frame from the video. I (the folder) have used the video controls to pause the action. The folder can replay the video clip and go back to the crease pattern repeated times.



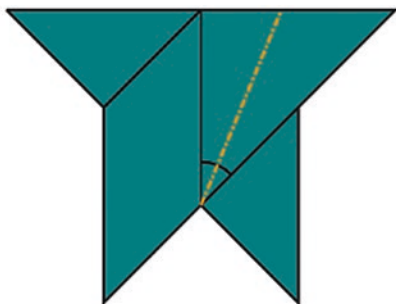
Sink square, collapse model.

---

[Go back](#) [Next step](#)

**Figure 7-5.** Paused video showing sink step

Sinking is still a challenge, but viewing the video clip can help. The folder can replay and pause the video clip. Figure 7-6 shows the next step after the sink. Going from line drawing to video clip to line drawing is easy for the user/folder, and it will turn out to be straightforward for the developer as well.



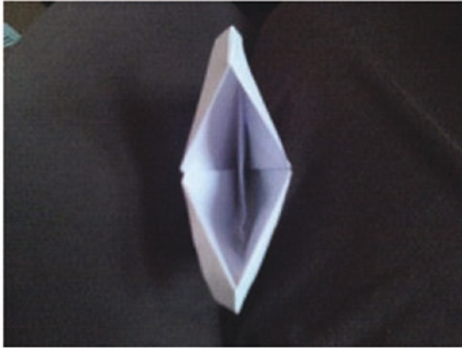
Now fold back the right flap to center valley fold. You are bisecting the indicated angle.

[Go back](#)[Next step](#)

**Figure 7-6.** Step after sink (first video clip)

The next step requires the folder to fold the triangular flap on the right backward, dividing the angle. Notice that the angle is indicated by an arc.

Moving on again in the folding, there is a step for which I decided that a photograph or two was the best way to convey what needs to be done. Figure 7-7 shows a picture of a model in process, viewed from above (looking into the mouth down the throat of the fish).



Stick your finger in its mouth and move the inner folded material to one side

---

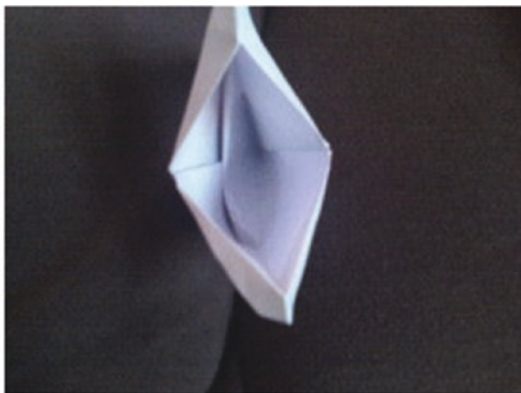
[Go back](#)

[Next step](#)

*Figure 7-7. Photograph showing fish throat*



Figure 7-8 shows the result of moving the folded material to one side, as instructed in the directions shown in Figure 7-7.



Throat fixed.

---

[Go back](#)

[Next step](#)

**Figure 7-8.** *Photograph of the fish with the throat fixed*

The directions end with another video clip, this one showing the fish talking, performed by the folder gently pressing on the top and bottom. Figure 7-9 shows a frame in the video.



Talking fish.

[Go back](#)

[Next step](#)

**Figure 7-9.** Video showing talking fish

## Critical Requirements

There is a standard format for origami directions, commonly referred to as diagrams, and I built on that standard. In this approach, each step shows the next fold to be made using a set typography. The most basic folds either assume a valley shape when unfolded or a mountain shape, and this is indicated by dashed or dotted and dashed lines. Often, folds are unfolded in the process of making an origami model. Sometimes the places where there were folds are indicated by thin lines and sometimes they are indicated by dashes for valley folds and dots and dashes for mountain folds.

My aim was to produce line drawings, similar to those found in books, with calculations for the coordinate positions of the critical points and lines. I did not want to make drawings by hand and scan them, nor did I want to use a typical engineering CAD program. I did not want to measure and record lengths or angles, but have JavaScript do that task for me. This would work even for folds done “to taste,” as the origami jargon goes, because I could determine the exact positions I chose to use. Using basic algebra, geometry, and trigonometry provides a way to achieve exact positions for the line drawings by calculating the coordinates of endpoints of lines.

Steps for origami typically come with text instructions. Also, arrows are sometimes used. I wanted to follow the standard while still taking advantage of the fact that these instructions would be delivered on a computer, with color and the opportunity for other media.

Thinking about the talking fish and some other folds, I decided to use photographs and videos for operations for which line drawings may not be good enough for you.

---

**Note** The challenge I set myself for the origami diagrams was to follow the standard but also take advantage of new technology of HTML5. This is typical when moving to a new medium and technology. You do not want to abandon a standard that your audience may feel is essential, but you also want to use what is available if it solves real problems.

---

A subtler requirement is that I wanted to test the application as I developed it. This meant a flexible but robust way to specify steps.

## HTML5, CSS, JavaScript Features, and Mathematics

I will now describe the HTML5 features and the programming techniques used to address the requirements for the origami directions project. The best approach is to start with the overall mechanism for presenting steps, and then explain how I derived the first set of values for the positions. Then I'll explain the utility functions for drawing the valley, mountain, and arrows, and for calculating intersection points and proportions. Lastly, I will review briefly the display of images and the playing of video.

### Overall Mechanism for Steps

The steps for the origami directions are specified by an array called `steps`. Each element of the array is itself a two-element array holding the name of a function and a piece of text that will appear on the screen. The final value of the `steps` array in `origamifish.html` is the following:

```
var steps= [
  [directions,"Diagram conventions"],
    [showkami,"Make quarter turn."],
  [diamond1,"Fold top point to bottom point."],
  [triangleM,"Divide line into thirds and make valley folds and unfold "],
  [thirds,"Fold in half to the left."],
  [rttriangle,"Fold down the right corner to the fold marking a third. "],
  [cornerdown,"Unfold everything."],
  [unfolded,"Prepare to sink middle square by reversing folds as indicated ..."],
  [changedfolds,"note middle square sides all valley folds, some other
    folds changed.↵
Flip over."],
  [precollapse,"Push sides to sink middle square."],
  [playsink,"Sink square, collapse model."],
  [littleguy,"Now fold back the right flap to center valley fold. You are
    bisecting the ↵
indicated angle."],
  [oneflapup,"Do the same thing to the flap on the left"],
  [bothflapsup,"Make fins by wrapping top of right flap around 1 layer and
    left around ↵
```

```

back layer"],
  [finsp,"Now make lips...make preparation folds"],
  [preparelips,"and turn lips inside out. Turn corners in..."],
  [showcleftlip,"...making cleft lips."],
  [lips,"Pick up fish and look down throat..."],
  [showthroat1,"Stick your finger in its mouth and move the inner folded
    material to one ←
    side"],
  [showthroat2,"Throat fixed."],
  [rotatefish,"Squeeze & release top and bottom to make fish's mouth close
    and open"],
  [playtalk,"Talking fish."]
];

```

I did not come up with the steps array when I began building the application. Instead, I added to the steps array as I went along, including inserting new entries and changing the content and/or the names of the functions. I began with the following definition of the steps array:

```

var steps= [
    [showkami,"Make quarter turn"],
    [diamond,"Fold top point to bottom point."]
];

```

It took me some time to get into the rhythm of showing the last stage of folding, with the addition of markings for the next step. The end result is a presentation using a single HTML page that proceeds through 21 steps containing vector drawings, photographs, and video, following a similar format to a PowerPoint presentation—that is, with the ability to go forward or backward.

Going forward and backward are done by the functions `donext` and `goback`. But first I need to explain how the whole thing starts. As has been the case for all the projects so far, a function called `init` is invoked by the action of the `onLoad` attribute in the `<body>` tag. The code sets global variables and invokes the function for presenting the next step, `donext`. The `init` function is

```
function init() {
  canvas1 = document.getElementById("canvas");
  ctx = canvas1.getContext("2d");
  cwidth = canvas1.width;
  cheight = canvas1.height;
  ta = document.getElementById("directions");
  nextstep = 0;
  ctx.fillStyle = "white";
  ctx.lineWidth = origwidth;
  origstyle = ctx.strokeStyle;
  ctx.font = "15px Georgia, Times, serif";
  donext();
}
```

The variable `nextstep` is the pointer, so to speak, into the `steps` array. I start it off at zero.

The `donext` function has the task of presenting the next step in the progression of steps to produce the origami model. The function starts by checking if it is within range; that is, if it has been incremented to point beyond the end of the `steps` array, the value of `nextstep` is set to the last index. Next, the function pauses and removes from display the last video. It restores the canvas to its full height, which my code would have changed when playing a video clip. The function also sets the `video` variable to `undefined`, so the removal statements do not have to be executed again for that video. In all cases, `donext` clears the canvas and resets the `linewidth`. The `donext` function then displays the next step. The display includes parts: a graphic part consisting of a line drawing, video or image and a text part consisting of the instructions. The `donext` function invokes the drawing function indicated by the first (i.e., 0th) element of the inner array:

```
steps[nextstep][0]();
```

and displays the text, using the second (i.e., first) element of the inner array:

```
ta.innerHTML = steps[nextstep][1];
```

The last statement in the `donext` function is to increment the pointer. The whole `donext` function is

```
function donext() {
  if (nextstep >= steps.length) {
    nextstep = steps.length - 1;
  }
  if (v) {
    v.pause();
    v.style.display = "none";
    v = undefined;
    canvas1.height = 480;
  }
  ctx.clearRect(0, 0, cwidth, cheight);
  ctx.lineWidth = origwidth;
  steps[nextstep][0]();
  ta.innerHTML = steps[nextstep][1];
  nextstep++;
}
```

Coding the `goback` function took much longer in thinking time than its size would suggest. The `nextstep` variable holds the index for the next step. This means that going back requires the variable to be decremented by 2. A check must be made that the pointer is not too low—that is, less than zero. Lastly, the `goback` function invokes `donext` to display what has been set as `nextstep`. The code is

```
function goback() {
  nextstep = nextstep - 2;
  if (nextstep < 0) {
    nextstep = 0;
  }
  donext();
}
```

## User Interface

The user, who I refer to as the folder, has two buttons, labeled **Next Step** and **Go Back**. They are implemented using the HTML5 button element, and invoke the `goback` and `donext` functions, respectively. My choice of two different colors for the buttons—red for `Go Back` and green for `Next Step`—can be debated, as can the fact that the wording is not consistent. However, it does give me a chance to remind you of the significance of the word *Cascading* in the name *Cascading Style Sheets*. I use a directive in the `style` element in the head element and then I also use the following markup in the body element: The last style directive is what is controlling and gives the buttons the colors.

```
<button onClick="goback();" style="color: #F00">Go back </button>
<button onClick="donext();" style="color: #03F">Next step </button>
```

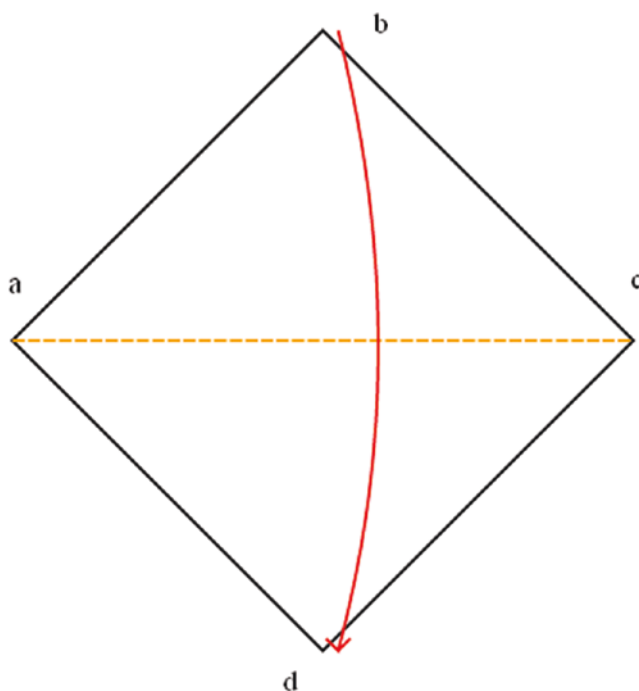
The color designations, each only three characters, are the equivalent of `#FF0000` and `#0033FF`.

These two sections have described the basic mechanism for sequential directions. It assumes that each step is represented by a function and text. The next section will show how the coordinate values are set.

## Coordinate Values

The line drawing is accomplished using HTML5 canvas functions and variables, mostly indicating `x` and `y` values. The variables appear in the code as `var` statements with initializations. I wrote these statements as I worked through making the model step by step, though in terms of JavaScript, they act as constants, and the values are set when the program is loaded. Figure 7-10 shows the third step of the sequence, with annotations for points `a`, `b`, `c`, and `d`.





**Figure 7-10.** Labels for corners

How did I determine the coordinates for the four points? As a foundation, I specified the location of point a. I also specified that the width and height of the paper was four inches and the conversion from inches to pixels was 72. The variable declarations are

```
var kamiw = 4;
var kamih = 4;
var i2p = 72;
var ax = 10;
var ay = 220;
```

The variable names `kamiw` and `kamih` refer to the width and height of the standard square paper for origami. From now on, everything is calculated. The first value required is the size of the diagonal of the paper. For a square, using the Pythagorean theorem, the diagonal is the length of a side times the square root of 2. The following statement setting the variable `diag` multiplies the side (`kamiw`) by the square root of 2 and by the factor indicating the inches-to-pixels conversion.

```
var diag = kamiw* Math.sqrt(2.0)*i2p;
```

Most other programming languages contain built-in code for many standard mathematical functions so programmers do not have to reinvent the wheel. In JavaScript, these generally are supplied as methods of the `Math` class. You can do online searches to determine the exact names and usage.

With this, the values for the positions `b`, `c`, and `d` are expressions using the existing values.

```
var bx = ax + .5*diag;
var by = ay - .5*diag;
var cx = ax + diag;
var cy = ay;
var dx = bx;
var dy = ay + .5*diag;
```

I developed the expressions for the variables by making the model and determining how new positions were based on old ones. These variables are used by the functions specified in the `steps` array to draw lines indicating the edges of the model, fold lines, arrows, and angles. Some calculations used general mathematical formulas. The next two sections cover the utility functions: functions used by the step functions.

## Utility Functions for Display

As shown in Figure 7-1, a valley fold is indicated by a line made up of dashes.

A mountain fold is indicated by a line made up of dots and dashes. This is standard convention for origami directions and makes it possible for folders to follow directions in books in different languages. Either one can be the default color (black) or another color. I need to set up variables for the basics: dash length, dot length, the gap between two dashes, the gap between the dots, and the gap between the last dot and a dash. It is easiest to understand what is needed by looking at the functions first and then defining the necessary values. The `valley` function is defined as follows:

```
function valley(x1,y1,x2,y2,color) {
  var px=x2-x1;
  var py = y2-y1;
  var len = dist(x1,y1,x2,y2);
  var nd = Math.floor(len/(dashlen+dgap));
  var xs = px/nd;
```

```

var ys = py/nd;
if (color) ctx.strokeStyle = color;
ctx.beginPath();
for (var n=0;n<nd;n++) {
  ctx.moveTo(x1+n*xs,y1+n*ys);
  ctx.lineTo(x1+n*xs+dratio*xs,y1+n*ys+dratio*ys);
}
ctx.closePath();
ctx.stroke();
ctx.strokeStyle = origstyle;
}

```

The valley function determines how many dashes there will be. This is done by dividing the length of the valley line by the total length of a dash and the gap between dashes. If this is not a whole number, the last-and-partial-dash-gap combination is dropped. The `Math.floor` method accomplished this for us. `Math.floor(4.3)` returns 4.

The variables `xs` and `ys` are the increments in `x` and `y`, respectively. The `color` parameter may or may not be present. The `if (color)` statement changes the stroke color if the parameter is present. The heart of the function is the `for` loop that draws each dash.

The mountain function is similar, but more complicated because of the nature of the mountain fold typography: combinations of dashes followed by a gap equal to a dot, then a dot, and then another gap. The mountain function is as follows:

```

function mountain(x1,y1,x2,y2,color) {
  var px=x2-x1;
  var py = y2-y1;
  var len = dist(x1,y1,x2,y2);
  var nd = Math.floor(len/ddtotal);
  var xs = px/nd;
  var ys = py/nd;
  if (color) ctx.strokeStyle = color;
  ctx.beginPath();
  for (var n=0;n<nd;n++) {
    ctx.moveTo(x1+n*xs,y1+n*ys);
    ctx.lineTo(x1+n*xs+ddratio1*xs,y1+n*ys+ddratio1*ys);

```

```

    ctx.moveTo(x1+n*xs+ddratio2*xs,y1+n*ys+ddratio2*ys);
    ctx.lineTo(x1+n*xs+ddratio3*xs,y1+n*ys+ddratio3*ys);
  }
  ctx.closePath();
  ctx.stroke();
  ctx.strokeStyle = origstyle;
}

```

With the statements of the functions in mind, here is how I define the variables used by both functions:

```

var dashlen = 8;
var dgap = 2.0;
var ddashlen = 6.0;
var ddot = 2.0;
var dratio = dashlen/(dashlen+dgap);
var ddtotal = ddashlen+3*ddot;
var ddratio1 = ddashlen/ddtotal;
var ddratio2 = (ddashlen+ddot)/ddtotal;
var ddratio3 = (ddashlen+2*ddot)/ddtotal;

```

Lines are used to show the edges of the paper. I set the width for these lines to be 2. For places in which the paper has been folded and then unfolded, I use a skinnier line: line width set to 1. I wrote a function to make skinny lines:

```

function skinnyline(x1,y1,x2,y2) {
  ctx.lineWidth = 1;
  ctx.beginPath();
  ctx.moveTo(x1,y1);
  ctx.lineTo(x2,y2);
  ctx.closePath();
  ctx.stroke();
  ctx.lineWidth = origwidth;
}

```

At one point for the directions for the origami fish, I decided to use short, downward-pointing arrows. I wrote a general function for it, which you can study in the commented code in the “Building the Application and Making It Your Own” section. There were two places when I decided to show a long curved arrow, either horizontal or vertical. This turned out to be the longest function in the project, and I will not go into more detail here. You can study the function in the complete commented code listing. Fortify yourself with the drink of your choice. This is a complex function because of the many cases that need to be handled separately: a vertical arrow going up or down, or a horizontal arrow going left to right or right to left. The arrow is made as an arc of a circle whose center is calculated to be far away from the arc, and two little lines indicating the arrowhead.

## Utility Functions for Calculation

You have seen the first mathematical calculation required for this project in previous chapters. It’s called `dist`, and it calculates the distance between two points:

```
function dist(x1,y1,x2,y2) {
  var x = x2-x1;
  var y = y2-y1;
  return Math.sqrt(x*x+y*y);
}
```

The next function to discuss is determining the intersection point between two lines. The intersection is a point that satisfies the equation for both lines. In the origami fish example, look at Figure 7-14. I (in my program) will need to calculate the intersection of the line from `k` to `n` and the line from `s` to `q`. Look further along in this chapter to Figure 7-17. The `xx` point is the intersection. The code from the program is

```
var xxa = intersect(sx,sy,qx,qy,kx,ky,nx,ny);
var xxx = xxa[0];
var xxy = xxa[1];
```

Lines are defined by two points, and each point is defined by two numbers. This means that the `intersect` function has  $2 \times 2 \times 2$  input parameters. My function is not general; it only works when the lines are not vertical and when there is indeed an intersection. This is acceptable for my use for the origami fish, but if you take this for another application, you may need to do more work.

Let's now focus on the mathematical representation of lines. There are different equations, but the one I use is called the *point slope* form. The slope of a line is the change in  $y$  divided by the change in  $x$  between any two points. Following convention, the slope is named  $m$ . The equation for a line with slope  $m$  going through the point  $(x_1, y_1)$  is

$$y - y_1 = m * (x - x_1)$$

Note that this line is mathematics, not JavaScript. Returning now to programming, I determined the slopes and equations for each of the lines passed to the `intersect` function.

The `intersect` function sets  $m_{12}$  to be the slope of the line going from  $(x_1, y_1)$  to  $(x_2, y_2)$  and  $m_{34}$  to be the slope of the line going from  $(x_3, y_3)$  to  $(x_4, y_4)$ . The code essentially sets the two  $y$  values:

$$y = m_{12} * (x - x_1) + y_1 \text{ and } y = m_{34} * (x - x_3) + y_3$$

The next step is to set these two expressions equal to each other and solve for  $x$ . What this accomplishes is calculating a value for  $x$  that lies on both lines. With that value of  $x$ , I use one of the two equations to get the corresponding  $y$ . The pair  $x, y$  represents a point—in fact, the only point—that is on both lines. This is what is meant by *intersection*. I write the code for the function to return the array  $[x, y]$ . Here is the complete code:

```
function intersect(x1,y1,x2,y2,x3,y3,x4,y4) {
  // only works on line segments that do intersect and
  // are not vertical
  var m12 = (y2-y1)/(x2-x1);
  var m34 = (y4-y3)/(x4-x3);
  var m = m34/m12;
  var x = (x1-y1/m12-m*x3+y3/m12)/(1-m);
  var y = m12*(x-x1)+y1;
  return ([x,y]);
}
```

At this point, you may have had a sudden drop in confidence that whatever you do remember from high school mathematics classes may not apply because the coordinate system for the screen is upside down. The vertical values increase moving down the screen. It turns out that these equations still work (although our interpretation may differ).

For example, a line that starts at (0,0) and goes to (100,100) has a calculated slope of positive 1, even though we may think of it as sloping down. In the upside-down world, it has positive slope.

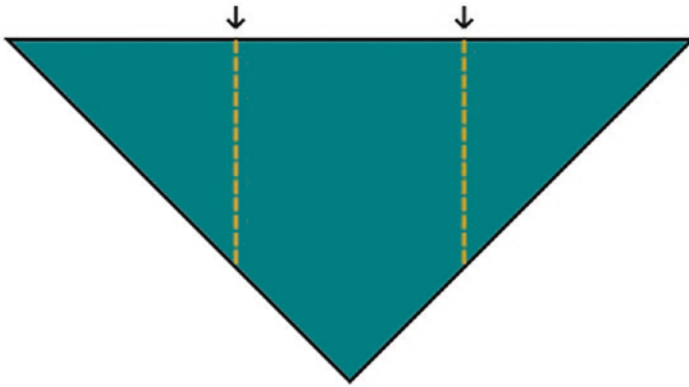
Another calculation required for the origami fish is what I have named *proportion*. This function takes five input parameters. (x1,y1) and (x2,y2) define a line segment. The fifth parameter is p, indicating proportion. The task of the function is to calculate the (x,y) position on the line segment that is p of the way from (x1,y1) to (x2,y2).

```
function proportion(x1,y1,x2,y2,p) {
  var xs = x2-x1;
  var ys = y2-y1;
  var x = x1+ p*xs;
  var y = y1 + p* ys;
  return ([x,y]);
}
```

This covers what I term the utility functions of the origami project. The three calculation functions would be applicable to other applications.

## Step Line Drawing Functions

The functions for producing the diagrams for a step in the sequence use the path-drawing facilities of HTML5 and the variables, which have been set using the calculation utility functions or built-in Math methods. I won't cover all of them in this section, but will explain a couple. For example, the function `triangleM` (more on this function following) has the task of producing the diagram for the step shown in Figure 7-11.



Divide line into thirds and make valley folds and unfold

---

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**Figure 7-11.** *Dividing-into-thirds step*

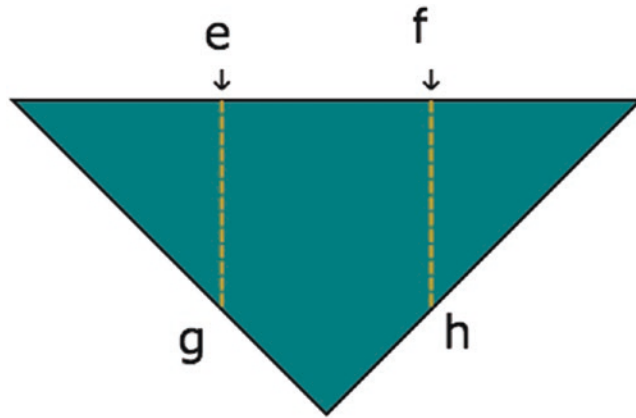
---

**Note** My instructions do not suggest ways to do this. A common way that folders do this is to make a guess for the point one-third of the way from one end—say, the left. Fold the right point to that point and make a tiny pinch. Then fold the left end to the pinch, and repeat until you don't see a change in the pinch marks. This method demonstrates some nice mathematics, namely limits. Whatever error you make in your initial guess will be reduced to one-quarter of its original size. If you keep doing this, you'll quickly get to something acceptable.

---

Figure 7-12 shows the picture annotated with labels for the critical points e, f, g, and h.





**Figure 7-12.** *Dividing a line into thirds and folding*

The variables defining the four points are

```
var e = proportion(ax,ay,cx,cy,.333333);
var ex = e[0];
var ey = e[1];
var f = proportion(ax,ay,cx,cy,.666666);
var fx = f[0];
var fy = f[1];
var g = proportion(ax,ay,dx,dy,.666666);
var gx = g[0];
var gy = g[1];
var h = proportion(cx,cy,dx,dy,.666666);
var hx = h[0];
var hy = h[1];
```

The function `triangleM` is defined as follows:

```
function triangleM() {
  triangle();
  shortdownarrow(ex,ey);
  shortdownarrow(fx,fy);
  valley(ex,ey,gx,gy,"orange");
  valley(fx,fy,hx,hy,"orange");
}
```

The function draws a triangle, then draws two short downward arrows above e and f, and then draws two valley lines of color orange.

The triangle function is defined to be

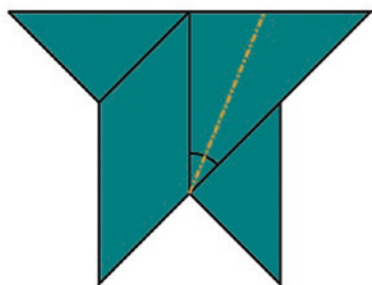
```
function triangle() {
  ctx.fillStyle="teal";
  ctx.beginPath();
  ctx.moveTo(ax,ay);
  ctx.lineTo(cx,cy);
  ctx.lineTo(dx,dy);
  ctx.lineTo(ax,ay);
  ctx.closePath();
  ctx.fill();
  ctx.stroke();
}
```

The triangle function is not general, but draws this specific triangle. A general function would be

```
function generaltriangle(px,py, qx,qy, rx,ry, scolor, fcolor) {
  ctx.fillStyle=fcolor;
  ctx.strokeStyle = scolor;
  ctx.beginPath();
  ctx.moveTo(px,py);
  ctx.lineTo(qx,qy);
  ctx.lineTo(rx,ry);
  ctx.lineTo(px,py);
  ctx.closePath();
  ctx.fill();
  ctx.stroke();
}
```

Also, do not assume that I knew to write this function. I probably put this coding into the first function and then when I got to the next step of the model, realized that I needed a triangle again. I extracted the code I had written and renamed the first function `triangleM` (for “triangle marked”). I had the `triangleM` function and the `thirds` function each invoke the function named `triangle`.

Figure 7-13 shows a step in the model that I will illustrate with a function I named littleguy, because that is what it looks like to me.

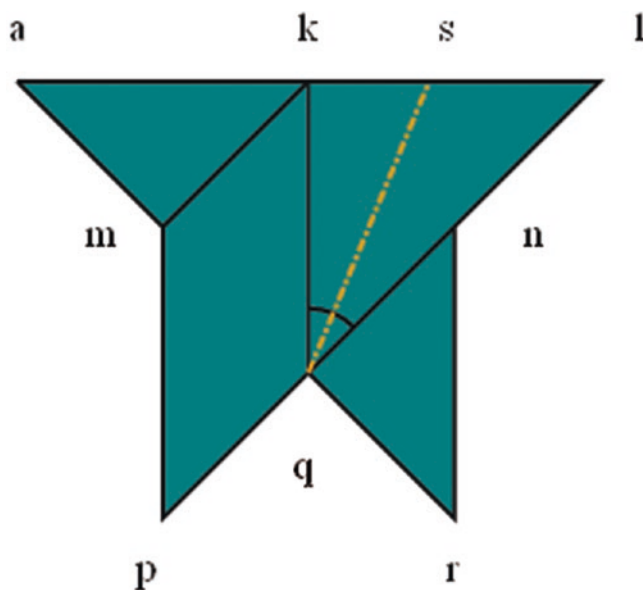


Now fold back the right flap to center valley fold. You are bisecting the indicated angle.

[Go back](#) [Next step](#)

**Figure 7-13.** After sink, what I call littleguy

Figure 7-14 shows the labeling of the critical points.



**Figure 7-14.** Labeling of critical points for littleguy

The definitions of the corresponding variables are

```

var kx = ax+diag/3;
var ky = ay;
var lx = kx + diag/3;
var ly = ay;
var mx = ax + diag/6;
var innersq = Math.sqrt(2)*diag/6;
var my = ay + innersq*Math.sin(Math.PI/4);
var nx = ax+diag/3+diag/6;
var ny = my;
var px = mx;
var py = dy;
var rx = nx;
var ry = py;
var qx = kx;
var qy = hy;
var dkq = qy-ky;
var sx = kx + (dkq/Math.cos(Math.PI/8))*Math.sin(Math.PI/8);
var sy = ay;

```

Notice that I don't try to be sparing with variables. Yes,  $rx$  is the same value as  $nx$ , but it is easier for me to think of them as distinct things.

The code for `littleguy` follows:

```

function littleguy() {
  ctx.fillStyle="teal";
  ctx.beginPath();
  ctx.moveTo(ax,ay);
  ctx.lineTo(kx,ky);
  ctx.lineTo(mx,my);
  ctx.lineTo(ax,ay);
  ctx.moveTo(kx,ky);
  ctx.lineTo(lx,ly);
  ctx.lineTo(px,py);
  ctx.lineTo(mx,my);
  ctx.lineTo(kx,ky);
}

```

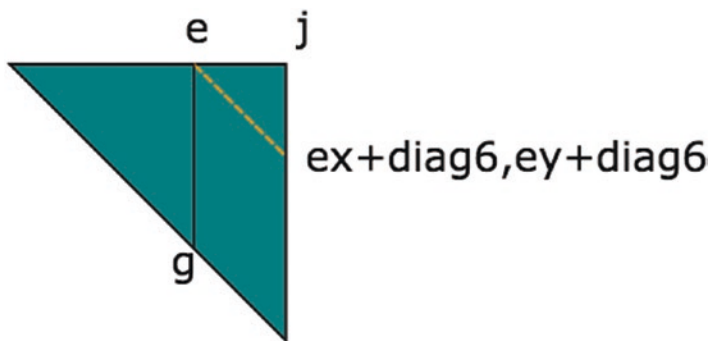
```

ctx.moveTo(nx,ny);
ctx.lineTo(rx,ry);
ctx.lineTo(qx,qy);
ctx.lineTo(nx,ny);
ctx.closePath();
ctx.fill();
ctx.stroke();
skinnyline(qx,qy,kx,ky);
ctx.beginPath();
ctx.arc(qx,qy,30,-.5*Math.PI,-.25*Math.PI,false);
ctx.stroke();
mountain(qx,qy,sx,sy,"orange")
}

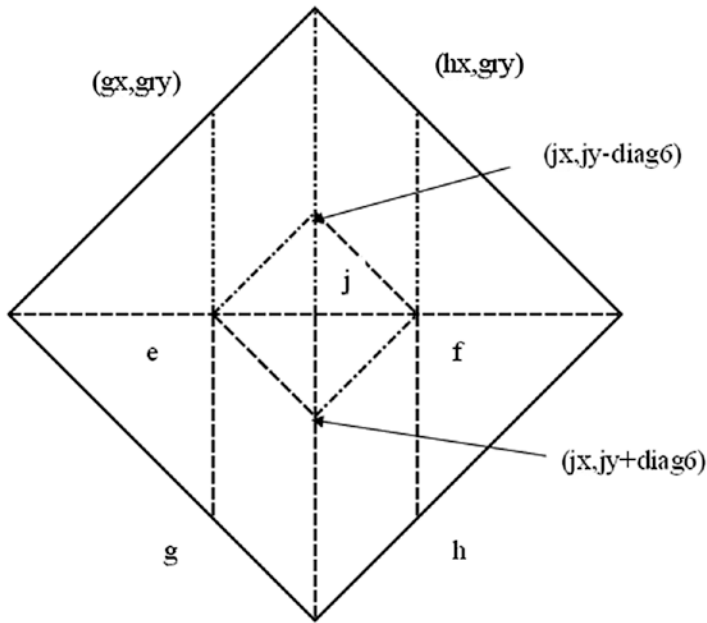
```

The description of the arc in degrees is that it goes from  $-90$  degrees to  $-45$  degrees. Note that zero degrees is horizontal and positive degrees go clockwise.

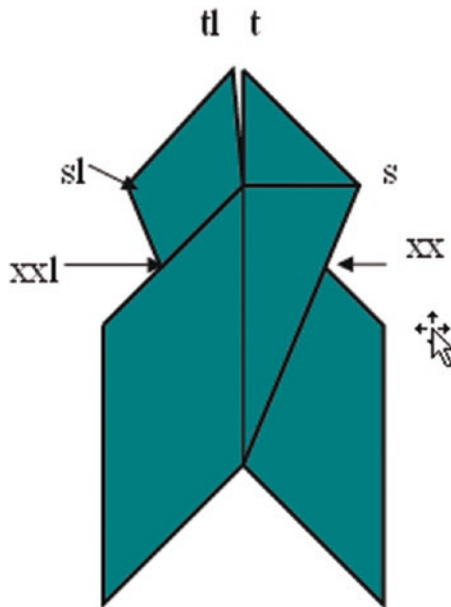
Figures 7-15, 7-16, 7-17, and 7-18 show the locations of the remaining critical positions for the model.



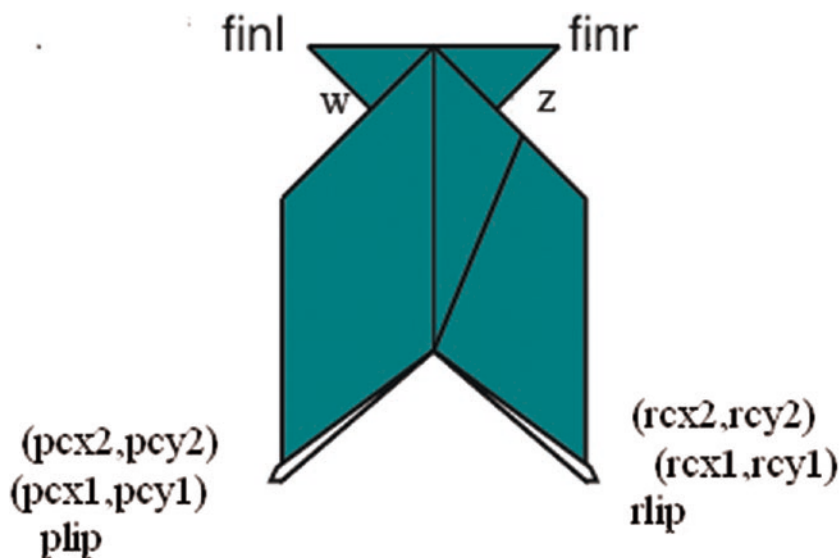
**Figure 7-15.** Labeling at fold in half step



**Figure 7-16.** *Preparing to sink center*



**Figure 7-17.** *After wraparound steps*



**Figure 7-18.** After making lips

Use the figures to help understand the code for setting the values of the variables. For example, as I mentioned in describing the `intersect` function, looking at Figures 7-14 and 7-17, you can see that the point `xx`, represented by `xxx` and `xy`, is the intersection of the line from `s` to `q` and `k` to `n`.

One more of the step functions deserves explanation. The directions right before the end had the fish with the head pointed down the screen. I wanted to make the diagram right before the last video clip be oriented horizontally to match the video clip about to be displayed. This is accomplished using the canvas coordinate transformations of HTML5. The previous function is named `lips`. The `rotatefish` function saves the current, which is the original, coordinate system. It then translates to a point on the fish, invokes a rotation (90 degrees counterclockwise), and then undoes the translation. The `rotatefish` function then invokes the `lips` function, which draws the fish, but now oriented horizontally. Here is the code:

```
function rotatefish() {
  ctx.save();
  ctx.translate(kx, my);
  ctx.rotate(-Math.PI/2);
  ctx.translate(-kx, -my);
  lips();
  ctx.restore();
}
```

## Displaying a Photograph

The steps that display a photograph have the same structure as the ones that produce a line drawing. For each image required for the application, I need to define an `Image` object and set the `src` property to the name of the image file. The following statements relate to the picture shown in Figure 7-7:

```
var throat1 = new Image();
throat1.src = "throat1.jpg";

function showthroat1() {
  ctx.drawImage(throat1,40,40);
}
```

The techniques shown in Chapter 5 to create a separate file defining the media and generating code (including HTML markup) automatically may be appropriate here. I wrote functions for each photograph and, as I explain in the next section, each video clip.

## Presenting and Removing a Video

The `origamifish.html` file has video elements for each of the two video clips, one with the ID `sink` and the other with the ID `talk`. The `style` element has a directive for all videos to not display:

```
video {display: none;}
```

The functions `playsink` and `playtalk` each make the video display, set the current time to zero, play the video, and adjust the canvas height. The definition of `playsink` follows:

```
function playsink() {
  v = document.getElementById("sink");
  v.style.display="block";
  v.currentTime = 0;
  v.play();
  canvas1.height = 178;
}
```

With this discussion of the programming techniques and HTML5 features to use for the origami directions project, we are now ready to look at the application as a whole.



## Building the Application and Making It Your Own

The quickest way to build on what you have learned in this chapter is to create directions for another craft project similar to paper folding in the presence of line drawings and the benefits of some photographs and video clips. You can build it step by step, creating the functions you need. It may turn out that some functions are what I call utility functions: functions used by other functions. You may also build up variables indicating positioning as you need them. An informal summary/outline of the origami fish application follows:

- `init` for initialization
- `donext` and `goback` for moving forward and back through the steps
- Utility functions for drawing specific types of lines
- Utility functions for calculations
- Step functions (functions cited in the `steps` array)

Table 7-1 lists functions and groups of functions and indicates how they are invoked and what functions they invoke.

**Table 7-1.** *Functions in the Origami Directions Project*

Function	Invoked/Called By	Calls
init	Invoked by action of the onLoad attribute in the <body> tag	donext
donext	Invoked by init, goback, and by the onClick attribute in a button tag	
goback	Invoked by the onClick attribute in a button tag	donext
Utility functions for drawing (shortdownarrow, valley, mountain, skinnyline, and curvedarrow)	Invoked by the step functions	
Utility functions for calculations (dist, intersect, and proportion)	Invoked mainly in var statements to set variables representing critical positions in the model	
Step functions	Invoked as elements in the steps array in donext; some (fins, triangle, diamond, rtriangle, diamondc, and lips) are called by other step functions	Utility drawing functions, the other step functions indicated

Table 7-2 shows the code for the basic application, with comments for each line. Much of this code you have seen in previous chapters.

**Table 7-2.** Complete Code for Origami Directions Project

Code Line	Description
<code>&lt;!DOCTYPE html&gt;</code>	Header
<code>&lt;html&gt;</code>	html tag
<code>&lt;head&gt;</code>	head tag
<code>&lt;title&gt;Origami fish&lt;/title&gt;</code>	Complete title
<code>&lt;style&gt;</code>	style tag
<code>button {font-size:large; font-family:Georgia, "Times New Roman", Times, serif;}</code>	Directive for formatting buttons; note that color is specified for each button in the body element
<code>#directions {font-family:"Comic Sans MS", cursive;}</code>	Directive for formatting all directions
<code>video {display:none;}</code>	Turn off display of all video elements until called on
<code>&lt;/style&gt;</code>	Closing style tag
<code>&lt;script&gt;</code>	Starting script tag
<code>var ctx;</code>	Will hold canvas context for all drawing
<code>var cwidth;</code>	Width of canvas
<code>var cheight;</code>	Height of canvas
<code>var ta;</code>	Will hold element for text part of each step
<code>var kamiw = 4;</code>	Set width of paper
<code>var kamih = 4;</code>	Set height of paper
<code>var i2p = 72;</code>	Set inches to pixels
<code>var dashlen = 8;</code>	Set length of dash in valley fold
<code>var dgap = 2.0;</code>	Set gap between dashes
<code>var ddashlen = 6.0;</code>	Set dash length in mountain fold
<code>var ddot = 2.0;</code>	Set dot length in mountain fold
<code>var dratio = dashlen/(dashlen+dgap);</code>	Used for mountain line

*(continued)*

**Table 7-2.** (continued)

Code Line	Description
<code>var ddtotal = ddashlen+3*ddot;</code>	Used for mountain line
<code>var ddratio1 = ddashlen/ddtotal;</code>	Used for mountain line
<code>var ddratio2 = (ddashlen+ddot)/ddtotal;</code>	Used for mountain line
<code>var ddratio3 = (ddashlen+2*ddot)/ ddtotal;</code>	Used for mountain line; all values used for calculation of number of dashes and dots and start and extents of dashes and dots
<code>var kamix = 10;</code>	X position of paper in first step
<code>var kamiy = 10;</code>	Y position of paper in first step
<code>var nextstep;</code>	Pointer into steps array
<code>function dist(x1,y1,x2,y2) {</code>	Header for dist function
<code>var x = x2-x1;</code>	Set difference in x
<code>var y = y2-y1;</code>	Set difference in y
<code>return Math.sqrt(x*x+y*y);</code>	Return square root of sum of squares
<code>}</code>	Close dist function
<code>function intersect(x1,y1,x2,y2,x3,y3, x4,y4) {</code>	Header for intersect function between two lines, indicated by 2 × 2 points
<code>// only works on line segments that     do intersection and</code>	Good comments to keep in code: assumes there is an intersection . . .
<code>// are not vertical</code>	. . . and assumes lines aren't vertical; if they were, the code would be dividing by zero, which would produce an error
<code>var m12 = (y2-y1)/(x2-x1);</code>	Compute slope
<code>var m34 = (y4-y3)/(x4-x3);</code>	Compute slope
<code>var m = m34/m12;</code>	Used in calculation
<code>var x = (x1-y1/m12-m*x3+y3/m12)/(1-m);</code>	Solve for x
<code>var y = m12*(x-x1)+y1;</code>	Solve for y

*(continued)*

**Table 7-2.** (continued)

<b>Code Line</b>	<b>Description</b>
<code>return ([x,y]);</code>	Return pair
<code>}</code>	Close intersect function
<code>function init() {</code>	Header for init function
<code>canvas1 = document. getElementById("canvas");</code>	Set canvas1
<code>ctx = canvas1.getContext("2d");</code>	Set context
<code>cwidth = canvas1.width;</code>	Set cwidth
<code>cheight = canvas1.height;</code>	Set cheight
<code>ta = document. getElementById("directions");</code>	Set ta to hold the element for the text directions
<code>nextstep = 0;</code>	Initialize nextstep
<code>ctx.fillStyle = "white";</code>	Set fill style; will be used for erasing
<code>ctx.lineWidth = origwidth;</code>	Set line width (set earlier)
<code>origstyle = ctx.strokeStyle;</code>	Save stroke color
<code>ctx.font = "15px Georgia, Times, serif";</code>	Set font
<code>donext();</code>	Start with 0th step
<code>}</code>	Close init function
<code>function directions() {</code>	Header for directions, the first "step" shown
<code>ctx.fillStyle = "black";</code>	Change fill style, for use in text
<code>ctx.font = "15px Georgia, Times, serif";</code>	Set font
<code>ctx.fillText("Make valley fold", 10,20);</code>	Output explanation
<code>valley(200,18,300,18,"orange");</code>	Make sample orange valley line
<code>ctx.fillText("Make mountain fold",10,50);</code>	Output explanation
<code>mountain(200,48,300,48,"orange");</code>	Make sample orange mountain line

(continued)

**Table 7-2.** *(continued)*

Code Line	Description
ctx.fillText("unfolded fold line",10,100);	Output explanation
skinnyline(200,98,300,98);	Make sample skinny line for unfolded fold line
ctx.fillText("When sense of fold matters:",10,150);	Output explanation
ctx.fillText("unfolded valley fold",10,180);	Continue
valley(200,178,300,178);	Make sample old valley
ctx.fillText("unfolded mountain fold",10,210);	Output explanation
mountain(200,208,300,208);	Make sample old mountain
ctx.fillStyle = "white";	Change fill style back
}	Close directions function
function donext() {	Header for donext function
if (nextstep>=steps.length) {	Check if nextstep is too big
nextstep=steps.length-1;	Reset
}	Close clause
if (v) {	Check if v is set
v.pause();	Pause the video
v.style.display = "none";	Make it not display
v = undefined;	Set v to undefined
canvas1.height = 480;	Restore height
}	Close clause
ctx.clearRect(0,0,cwidth,cheight);	Clear canvas
ctx.lineWidth = origwidth;	Reset line width

*(continued)*

**Table 7-2.** *(continued)*

<b>Code Line</b>	<b>Description</b>
steps[nextstep][0]();	Invoke the appropriate step function
ta.innerHTML = steps[nextstep][1];	Display the accompanying text
nextstep++;	Increment nextstep
}	Close donext function
function goback() {	Header for goback
nextstep = nextstep -2;	Decrement nextstep by 2 (because it is already one ahead)
if (nextstep<0) {	Check if nextstep is now too low
nextstep = 0;	Reset
}	Close clause
donext();	Invoke donext
}	Close goback function
function shortdownarrow(x,y) {	Header for short-downward-arrow function
ctx.beginPath();	Start path
ctx.moveTo(x,y-20)	Move to right above the (x,y) position
ctx.lineTo(x,y-7);	Draw line to just above the (x,y)
ctx.moveTo(x-5,y-12);	Move to the left and up
ctx.lineTo(x,y-7);	Draw diagonal line
ctx.moveTo(x+5,y-12);	Move to the right and up
ctx.lineTo(x,y-7);	Draw diagonal line
ctx.closePath();	Close path
ctx.stroke();	Draw the complete path: a short arrow
}	Close shortdownarrow function
function proportion(x1,y1,x2,y2,p) {	Header for proportion function
var xs = x2-x1;	Set difference in x

*(continued)*

**Table 7-2.** (continued)

Code Line	Description
<code>var ys = y2-y1;</code>	Set difference in y
<code>var x = x1+ p*xs;</code>	Calculate new x
<code>var y = y1 + p* ys;</code>	Calculate new y
<code>return ([x,y]);</code>	Return pair
<code>}</code>	Close proportion function
<code>function skinnyline(x1,y1,x2,y2) {</code>	Header for skinnyline function
<code>  ctx.lineWidth = 1;</code>	Set line width
<code>  ctx.beginPath();</code>	Start path
<code>  ctx.moveTo(x1,y1);</code>	Move to start
<code>  ctx.lineTo(x2,y2);</code>	Line to finish
<code>  ctx.closePath();</code>	Close path
<code>  ctx.stroke();</code>	Make stroke
<code>  ctx.lineWidth = origwidth;</code>	Reset line width
<code>}</code>	Close skinnyline
<code>var origstyle;</code>	Will hold original color
<code>var origwidth = 2;</code>	Set to line width for most lines
<code>function valley(x1,y1,x2,y2,color) {</code>	Header for valley function
<code>  var px=x2-x1;</code>	Set difference in x
<code>  var py = y2-y1;</code>	Set difference in y
<code>  var len = dist(x1,y1,x2,y2);</code>	Determine length
<code>  var nd = Math.floor(len/(dashlen+dgap));</code>	How many dashes and gaps
<code>  var xs = px/nd;</code>	Call this the x factor
<code>  var ys = py/nd;</code>	Call this the y factor
<code>  if (color) ctx.strokeStyle = color;</code>	If the color parameter was given, set stroke color to this value

*(continued)*



**Table 7-2.** *(continued)*

<b>Code Line</b>	<b>Description</b>
<code>ctx.beginPath();</code>	Begin path
<code>for (var n=0;n&lt;nd;n++) {</code>	Loop for number of dashes
<code>  ctx.moveTo(x1+n*xs,y1+n*ys);</code>	Move to next position
<code>  ctx.lineTo(x1+n*xs+dratio*xs,</code> <code>  y1+n*ys+dratio*ys);</code>	Draw dash
<code>  }</code>	Close for loop
<code>ctx.closePath();</code>	Close path
<code>ctx.stroke();</code>	Draw the path
<code>ctx.strokeStyle = origstyle;</code>	Reset stroke style
<code>}</code>	Close valley function
<code>function mountain(x1,y1,x2,y2,color)</code> <code>{</code>	Header for mountain function
<code>  var px=x2-x1;</code>	Set difference in x
<code>  var py = y2-y1;</code>	Set difference in y
<code>  var len = dist(x1,y1,x2,y2);</code>	Determine length
<code>var nd = Math.floor(len/ddtotal);</code>	Determine number of dash and dot combinations
<code>  var xs = px/nd;</code>	Set x factor
<code>  var ys = py/nd;</code>	Set y factor
<code>if (color) ctx.strokeStyle = color;</code>	If the <code>color</code> parameter was given, set stroke color to this value
<code>  ctx.beginPath();</code>	Begin path
<code>  for (var n=0;n&lt;nd;n++) {</code>	Loop for number of combinations
<code>    ctx.moveTo(x1+n*xs,y1+n*ys);</code>	Move to next one

*(continued)*

**Table 7-2.** (continued)

Code Line	Description
<code>ctx.lineTo(x1+n*xs+ddratio1*xs, y1+n*ys+ddratio1*ys);</code>	Draw the dash
<code>ctx.moveTo(x1+n*xs+ddratio2*xs, y1+n*ys+ddratio2*ys);</code>	Move to start of dot
<code>ctx.lineTo(x1+n*xs+ddratio3*xs, y1+n*ys+ ddratio3*ys);</code>	Draw the dot
<code>}</code>	Close loop
<code>ctx.closePath();</code>	Close path
<code>ctx.stroke();</code>	Draw the path
<code>ctx.strokeStyle = origstyle;</code>	Reset stroke style
<code>}</code>	Close mountain function
<code>function curvedarrow(x1,y1,x2,y2,px,py){</code>	Header for curvedarrow from (x1,y1) to (x2,y2) offset by (px,py)
<code>var arrowanglestart;</code>	Start angle
<code>var arrowanglefinish;</code>	Finish angle
<code>var d = dist(x1,y1,x2,y2);</code>	Distance
<code>var rad=Math.sqrt(4.25*d*d);</code>	The value 4.25 arrived at by experimentation to get an attractive curve to the arrow
<code>var ctrx;</code>	X-coordinate of center of arc that is curved arrow
<code>var ctry;</code>	Y-coordinate
<code>var ex;</code>	For the two little lines that make up the head of the arrow
<code>var ey;</code>	For the two little lines that make up the head of the arrow

(continued)

**Table 7-2.** (continued)

Code Line	Description
<code>var angdel = Math.atan2(d/2,2*d);</code>	Angle of the arc
<code>var fromhorizontal;</code>	Angle where arc starts
<code>ctx.strokeStyle = "red";</code>	Set color
<code>ctx.beginPath();</code>	Begin path
<code>if (y1==y2) {</code>	Horizontal arrow case
<code>  arrowanglestart = 1.5*Math.PI-</code> <code>  angdel;</code>	Set starting angle
<code>  arrowanglefinish = 1.5*Math.</code> <code>  PI+angdel;</code>	Set ending angle
<code>  ctrx = .5*(x1+x2) +px;</code>	Calculate center x
<code>  ctry = y1+2*d +py;</code>	Calculate center y
<code>  if (x1&lt;x2) {</code>	For arrows going left to right
<code>    ctx.arc(ctrx,ctry, rad,arrowangle</code> <code>    start,arrowanglefinish, false);</code>	Draw arc
<code>      fromhorizontal=2*Math.PI-</code> <code>      arrowanglefinish;</code>	Used in calculation
<code>  ex = ctrx+rad*Math.</code> <code>  cos(fromhorizontal);</code>	Set x increment
<code>  ey = ctry - rad*Math.</code> <code>  sin(fromhorizontal);</code>	Set y increment
<code>  ctx.lineTo(ex-8,ey+8);</code>	Draw first little line
<code>  ctx.moveTo(ex,ey);</code>	Move to other end
<code>  ctx.lineTo(ex-8,ey-8);</code>	Draw line
<code>  }</code>	Close arrows left to right

(continued)

**Table 7-2.** (continued)

Code Line	Description
else {	Right to left
ctx.arc(ctrx,ctry, rad,arrowang lefinish,arrowanglestart, true);	Draw arc
fromhorizontal=2*Math.PI- arrowanglestart;	Calculate for the lines
ex = ctrx+rad*Math. cos(fromhorizontal);	Set x for little lines
ey = ctry - rad*Math. sin(fromhorizontal);	Set y for little lines
ctx.lineTo(ex+8,ey+8);	Draw first line
ctx.moveTo(ex,ey);	Move to end of other line
ctx.lineTo(ex+8,ey-8);	Draw line
}	End clause
ctx.stroke();	Do the drawing for either case
}	End horizontal case
else if (x1==x2) {	Vertical line
arrowanglestart = -angdel;	Set starting angle
arrowanglefinish = angdel;	Set finishing angle
ctrx = x1-2*d+px;	Calculate center x
ctry = .5*(y1+y2) + py;	Calculate center y
if (y1<y2) {	If downward arrow
ctx.arc(ctrx,ctry,rad,arrowanglestart, arrowanglefinish,false);	Draw arc
fromhorizontal=- arrowanglefinish;	For calculation

*(continued)*

**Table 7-2.** (continued)

Code Line	Description
<code>ex = ctrx+rad*Math. cos(fromhorizontal);</code>	Calculate x for little lines
<code>ey = ctry - rad*Math.sin (fromhorizontal);</code>	Calculate y for little lines
<code>ctx.lineTo(ex-8,ey-8);</code>	Draw first little line
<code>ctx.moveTo(ex,ey);</code>	Move to end
<code>ctx.lineTo(ex+8,ey-8);</code>	Draw second little line
<code>}</code>	End downward clause
<code>else {</code>	Upward clause
<code>ctx.arc(ctrx,ctry, rad,arrowang lefinish,arrowanglestart, true);</code>	Draw arc
<code>fromhorizontal=- arrowanglestart;</code>	For calculation
<code>ex = ctrx+rad*Math. cos(fromhorizontal);</code>	Calculate x for little lines
<code>ey = ctry - rad*Math. sin(fromhorizontal);</code>	Calculate y for little lines
<code>ctx.lineTo(ex-8,ey+8);</code>	Draw first little line
<code>ctx.moveTo(ex,ey);</code>	Move to end of second line
<code>ctx.lineTo(ex+8,ey+8);</code>	Draw little line
<code>}</code>	End clause
<code>ctx.stroke();</code>	Draw arc
<code>}</code>	Close vertical case
<code>ctx.strokeStyle = "black";</code>	Reset color
<code>}</code>	
<code>// specific to fish</code>	What follows is specific to the fish model

(continued)

**Table 7-2.** *(continued)*

Code Line	Description
<pre> var steps= [   [directions,"Diagram conventions"],   [showkami,"Make quarter turn."],   [diamond1,"Fold top point to bottom point."],   [triangleM,"Divide line into thirds and make valley folds and unfold "],   [thirds,"Fold in half to the left."],   [rttriangle,"Fold down the right corner to the fold marking a third. "],   [cornerdown,"Unfold everything."],   [unfolded,"Prepare to sink middle square by reversing folds as indicated ..."],   [changedfolds,"note middle square sides all valley folds, some other folds changed. Flip over."],   [precollapse,"Push sides to sink middle square."],   [playsink,"Sink square, collapse model."],   [littleguy,"Now fold back the right flap to center valley fold. You are bisecting the indicated angle."],   [oneflapup,"Do the same thing to the flap on the left"], </pre>	<p>Instruction steps: Function name and accompanying text</p>

*(continued)*

**Table 7-2.** (continued)

Code Line	Description
[bothflapsup,"Make fins by wrapping top of right flap around 1 layer and left around back layer"],	
[finsp,"Now make lips...make preparation folds"],	
[preparelips,"and turn lips inside out. Turn corners in..."],	
[showcleftlip,"...making cleft lips."],	
[lips,"Pick up fish and look down throat..."],	
[showthroat1,"Stick your finger in its mouth and move the inner folded material to one side"],	
[showthroat2,"Throat fixed."],	
[rotatefish,"Squeeze & release top and bottom to make fish's mouth close and open"],	
[playtalk,"Talking fish."]	
];	
var diag = kamiw* Math.sqrt(2.0)*i2p;	Length of diagonal
var ax = 10;	Set x for left corner
var ay = 220;	Set y for left corner
var bx = ax+ .5*diag;	Calculate b (top corner)
var by = ay - .5*diag;	
var cx = ax + diag;	Calculate c (right)

(continued)

**Table 7-2.** (continued)

Code Line	Description
<code>var cy = ay;</code>	
<code>var dx = bx;</code>	Calculate d (bottom)
<code>var dy = ay + .5*diag;</code>	
<code>var e = proportion(ax,ay,cx, cy,.333333);</code>	See Figure 7-12 for e through h
<code>var ex = e[0];</code>	
<code>var ey = e[1];</code>	
<code>var f = proportion(ax,ay,cx, cy,.666666);</code>	
<code>var fx = f[0];</code>	
<code>var fy = f[1];</code>	
<code>var g = proportion(ax,ay,dx,dy,.666666);</code>	
<code>var gx = g[0];</code>	
<code>var gy = g[1];</code>	
<code>var h = proportion(cx,cy,dx, dy,.666666);</code>	
<code>var hx = h[0];</code>	
<code>var hy = h[1];</code>	
<code>var jx = ax + .5*diag;</code>	See Figures 7-15 and 7-16
<code>var jy = ay;</code>	
<code>var diag6 = diag/6;</code>	
<code>var gry = ay-(gy-ay);</code>	
<code>var kx = ax+diag/3;</code>	See Figure 7-14 for k through s
<code>var ky = ay;</code>	
<code>var lx = kx + diag/3;</code>	

*(continued)*



**Table 7-2.** (continued)

Code Line	Description
var ly = ay;	
var mx = ax + diag/6;	
var innersq = Math.sqrt(2)*diag/6;	
var my = ay + innersq*Math.sin(Math.PI/4);	
var nx = ax+diag/3+diag/6;	
var ny = my;	
var px = mx;	
var py = dy;	
var rx = nx;	
var ry = py;	
var qx = kx;	
var qy = hy;	
var dkq = qy-ky;	
var sx = kx + (dkq/Math.cos(Math.PI/8))*Math.sin(Math.PI/8);	
var sy = ay;	
var tx = kx;	See Figure 7-17
var ty = qy-dist(qx,qy,lx,ly);	
var xxa = intersect(sx,sy,qx,qy,kx,ky,nx,ny);	
var xxx = xxa[0];	
var xxy = xxa[1];	
var xxlx = kx-(xxx-kx);	
var xxly = xxy;	
var slx = kx- (sx-kx);	

(continued)

**Table 7-2.** *(continued)*

Code Line	Description
var sly = sy;	
var tlx = tx-5;	
var tly = ty;	
var dkt=ky-ty;	
var finlx = kx-dkt;	See Figure 7-18
var finly = ky;	
var finrx = kx+dkt;	
var finry = ky;	
var w = Math.cos(Math.PI/4)*dkt;	
var wx = kx-.5*dkt;	
var wy = w*Math.sin(Math.PI/4)+ky;	
var zx = kx+.5*dkt;	
var zy = wy;	
var plipx = px;	
var plipy = py-10;	
var rlipx = rx;	
var rlipey = ry-10;	
var plipex = px - 10;	
var plihey = plipy;	
var rlipex = rx + 10;	
var rlipey = rlipey;	
var rclipleft1 = proportion(rlipex,r	
lipey,rlipx,rlipey,.5);	
var pclipleft1 = proportion(plipex,	
plihey,plipx,plipy,.5);	

*(continued)*

**Table 7-2.** (continued)

Code Line	Description
<code>var rclipcleft2 = proportion(rlipex, rlipey, qx, qy, .1);</code>	
<code>var pclipcleft2 = proportion(plipex, plipey, qx, qy, .1);</code>	
<code>var rcx1 = rclipcleft1[0];</code>	
<code>var rcy1 = rclipcleft1[1];</code>	
<code>var rcx2 = rclipcleft2[0];</code>	
<code>var rcy2 = rclipcleft2[1];</code>	
<code>var pcx1 = pclipcleft1[0];</code>	
<code>var pcy1 = pclipcleft1[1];</code>	
<code>var pcx2 = pclipcleft2[0];</code>	
<code>var pcy2 = pclipcleft2[1];</code>	
<code>var v;</code>	Will hold video element
<code>var throat1 = new Image();</code>	Define Image object
<code>throat1.src = "throat1.jpg";</code>	Set src
<code>var throat2 = new Image();</code>	Define Image object
<code>throat2.src = "throat2.jpg"</code>	Set src
<code>var cleft = new Image();</code>	Define Image object
<code>cleft.src="cleftlip.jpg";</code>	Set src
<code>function showcleftlip() {</code>	Header for showcleftlip
<code>ctx.drawImage(cleft,40,40);</code>	Draw image
<code>}</code>	Close showcleftlip
<code>function showthroat1() {</code>	Header for showthroat1
<code>ctx.drawImage(throat1,40,40);</code>	Draw image
<code>}</code>	Close showthroat1
<code>function showthroat2() {</code>	Header for showthroat2

(continued)

**Table 7-2.** (continued)

Code Line	Description
<code>ctx.drawImage(throat2,40,40);</code>	Draw image
<code>}</code>	Close showthroat2
<code>function playtalk() {</code>	Header for playtalk
<code>  v = document.</code>	Set to the talk video
<code>  getElementById("talk");</code>	
<code>  v.style.display="block";</code>	Make visible
<code>  v.currentTime = 0;</code>	Set at start
<code>  v.play();</code>	Play
<code>  canvas1.height = 126;</code>	Adjust for height of video
<code>}</code>	Close playtalk
<code>function playsink() {</code>	Header for playsink
<code>  v = document.getElementById("sink");</code>	Set to the sink video
<code>  v.style.display="block";</code>	Make visible
<code>  v.currentTime = 0;</code>	Set at start
<code>  v.play();</code>	Play
<code>  canvas1.height = 178;</code>	Adjust for height of video
<code>}</code>	Close playsink
<code>function lips() {</code>	Header for lips
<code>  ctx.fillStyle = "teal";</code>	Set color
<code>  ctx.beginPath();</code>	Begin path
<code>  ctx.moveTo(finlx,finly);</code>	Move to left corner of left fin
<code>  ctx.lineTo(kx,ky);</code>	Draw to center
<code>  ctx.lineTo(wx,wy);</code>	Draw back and down
<code>  ctx.lineTo(finlx,finly);</code>	Draw up to start (left corner, left fin)
<code>  ctx.moveTo(finrx,finry);</code>	Move to right fin

*(continued)*

**Table 7-2.** (continued)

<b>Code Line</b>	<b>Description</b>
<code>ctx.lineTo(kx,ky);</code>	Draw to center
<code>ctx.lineTo(zx,zy);</code>	Draw down and right
<code>ctx.lineTo(finrx,finry);</code>	Draw up to right corner, right fin
<code>ctx.moveTo(mx,my);</code>	Move to m
<code>ctx.lineTo(kx,ky);</code>	Draw to k
<code>ctx.lineTo(xxx,xy);</code>	Draw to xx
<code>ctx.lineTo(qx,qy);</code>	Draw down, center to q
<code>ctx.lineTo(plipx,plipy);</code>	Draw down, right
<code>ctx.lineTo(mx,my);</code>	Draw straight up to m
<code>ctx.moveTo(xxx,xy);</code>	Move to xx
<code>ctx.lineTo(nx,ny);</code>	Draw right and down
<code>ctx.lineTo(rlipx,rlipy);</code>	Draw down to rlip
<code>ctx.lineTo(qx,qy);</code>	Draw to center q
<code>ctx.lineTo(xxx,xy);</code>	Draw back to xx
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in shape
<code>ctx.stroke();</code>	Outline shape
<code>ctx.fillStyle="white";</code>	Set to white
<code>ctx.beginPath();</code>	Begin path
<code>ctx.moveTo(qx,qy);</code>	Start at lower center
<code>ctx.lineTo(pcx2,pcy2);</code>	Draw to left top of lip
<code>ctx.lineTo(pcx1,pcy1);</code>	Draw to left outer lip
<code>ctx.lineTo(plipx,plipy);</code>	Draw over right slightly to bottom-corner plip
<code>ctx.lineTo(qx,qy);</code>	Draw back to center
<code>ctx.lineTo(rcx2,rcy2);</code>	Draw to right top of lip

(continued)

**Table 7-2.** (continued)

Code Line	Description
<code>ctx.lineTo(rcx1,rcy1);</code>	Draw to right outer lip
<code>ctx.lineTo(rlipx,rlipy);</code>	Draw to bottom-corner rlip
<code>ctx.lineTo(qx,qy);</code>	Draw back to center
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in white shape (two parts)
<code>ctx.stroke();</code>	Outline shapes
<code>skinnyline(kx,ky,qx,qy);</code>	Draw vertical center line
<code>ctx.fillStyle="teal";</code>	Reset to color
<code>}</code>	Close lips
<code>function rotatefish() {</code>	Header for rotatefish
<code>  ctx.save();</code>	Save current coordinate system
<code>  ctx.translate(kx,my);</code>	Move to a center point
<code>  ctx.rotate(-Math.PI/2);</code>	Rotate 90 degrees
<code>  ctx.translate(-kx,-my);</code>	Undo translation
<code>  lips();</code>	Draw lips (the model up to this point)
<code>  ctx.restore();</code>	Restore old coordinate system
<code>}</code>	Close rotatefish
<code>function preparelips() {</code>	Header for preparelips
<code>  ctx.fillStyle="teal";</code>	Set color
<code>  fins();</code>	Draw fins
<code>  valley(qx,qy,rlipx,rlipy);</code>	Mark valley line
<code>  valley(qx,qy,plipx,plipy);</code>	Mark valley line
<code>}</code>	Close preparelips
<code>function finsp() {</code>	Header for finsp
<code>  ctx.fillStyle="teal";</code>	Set color

(continued)

**Table 7-2.** (continued)

<b>Code Line</b>	<b>Description</b>
<code>fins();</code>	Draw fins
<code>valley(qx,qy,rlipx,rlipy,"orange");</code>	Draw valley fold
<code>valley(qx,qy,plipx,plipy,"orange");</code>	Draw valley fold
<code>}</code>	Close finsp
<code>function fins() {</code>	Header for fins
<code>  ctx.beginPath();</code>	Begin path
<code>  ctx.moveTo(finlx,finly);</code>	Move to left fin
<code>  ctx.lineTo(kx,ky);</code>	Draw line to center
<code>  ctx.lineTo(wx,wy);</code>	Draw line left and down
<code>  ctx.lineTo(finlx,finly);</code>	Draw to left fin
<code>  ctx.moveTo(finrx,finry);</code>	Move to right fin
<code>  ctx.lineTo(kx,ky);</code>	Draw to center
<code>  ctx.lineTo(zx,zy);</code>	Draw right and down
<code>  ctx.lineTo(finrx,finry);</code>	Draw back to right fin
<code>  ctx.moveTo(mx,my);</code>	Move to m (left and down)
<code>  ctx.lineTo(kx,ky);</code>	Draw to center
<code>  ctx.lineTo(xxx,xy);</code>	Draw to xx
<code>  ctx.lineTo(qx,qy);</code>	Draw down to q
<code>  ctx.lineTo(px,py);</code>	Draw over to p
<code>  ctx.lineTo(mx,my);</code>	Draw left to m
<code>  ctx.moveTo(xxx,xy);</code>	Move to xx
<code>  ctx.lineTo(nx,ny);</code>	Draw right to n
<code>  ctx.lineTo(rx,ry);</code>	Draw down to r
<code>  ctx.lineTo(qx,qy);</code>	Draw up and left to center
<code>  ctx.lineTo(xxx,xy);</code>	Draw to xx

(continued)

**Table 7-2.** (continued)

Code Line	Description
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in shape
<code>ctx.stroke();</code>	Draw outline
<code>skinnyline(kx,ky,qx,qy);</code>	Draw skinny line indicated center fold
<code>}</code>	Close fins
<code>function bothflapsup () {</code>	Header for bothflapsup
<code>ctx.fillStyle="teal";</code>	Set color
<code>ctx.beginPath();</code>	Begin path
<code>ctx.moveTo(slx,sly);</code>	Move to corner
<code>ctx.lineTo(tlx,tly);</code>	Draw line up to tip
<code>ctx.lineTo(kx,ky);</code>	Draw line to center
<code>ctx.lineTo(xxlx,xxly);</code>	Draw line left and down
<code>ctx.lineTo(slx,sly);</code>	Draw back to tip
<code>ctx.moveTo(mx,my);</code>	Move down (on the left)
<code>ctx.lineTo(kx,ky);</code>	Draw line to center
<code>ctx.lineTo(sx,sy);</code>	Draw to right side
<code>ctx.lineTo(qx,qy);</code>	Draw down, left
<code>ctx.lineTo(px,py);</code>	Draw to bottom, left tip
<code>ctx.lineTo(mx,my);</code>	Draw up
<code>ctx.moveTo(tx,ty);</code>	Draw up
<code>ctx.lineTo(sx,sy);</code>	Draw to right
<code>ctx.lineTo(kx,ky);</code>	Draw to center
<code>ctx.lineTo(tx,ty);</code>	Draw up
<code>ctx.moveTo(xxx,xy);</code>	Draw to right
<code>ctx.lineTo(nx,ny);</code>	Draw to right

(continued)



**Table 7-2.** (continued)

Code Line	Description
<code>ctx.lineTo(rx,ry);</code>	Draw down to tip
<code>ctx.lineTo(qx,qy);</code>	Draw to center
<code>ctx.lineTo(xxx,xxy);</code>	Draw back to right
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in shape
<code>ctx.stroke();</code>	Outline shape
<code>skinnyline(kx,ky,qx,qy);</code>	Add line indicating fold
<code>}</code>	Close bothflapsup
<code>function oneflapup() {</code>	Header for oneflapup
<code>ctx.fillStyle="teal";</code>	Set color
<code>ctx.beginPath();</code>	Begin path
<code>ctx.moveTo(ax,ay);</code>	Move to left corner
<code>ctx.lineTo(kx,ky);</code>	Draw to middle
<code>ctx.lineTo(mx,my);</code>	Draw down and left
<code>ctx.lineTo(ax,ay);</code>	Draw back to left corner
<code>ctx.moveTo(kx,ky);</code>	Move to middle
<code>ctx.lineTo(sx,sy);</code>	Draw to right
<code>ctx.lineTo(qx,qy);</code>	Draw down, middle
<code>ctx.lineTo(px,py);</code>	Draw left, down
<code>ctx.lineTo(mx,my);</code>	Draw up
<code>ctx.lineTo(kx,ky);</code>	Draw (back to) middle top
<code>ctx.moveTo(xxx,xxy);</code>	Draw right, down
<code>ctx.lineTo(nx,ny);</code>	Draw down
<code>ctx.lineTo(rx,ry);</code>	Draw down to right tip
<code>ctx.lineTo(qx,qy);</code>	Draw to center

(continued)

**Table 7-2.** (continued)

Code Line	Description
ctx.lineTo(xxx,xy);	Draw right, up
ctx.moveTo(kx,ky);	Move to middle
ctx.lineTo(tx,ty);	Draw to top
ctx.lineTo(sx,sy);	Draw down, right
ctx.lineTo(kx,ky);	Draw (back to) top
ctx.closePath();	Close path
ctx.fill();	Fill in shape
ctx.stroke();	Outline shape
skinnyline(qx,qy,kx,ky);	Draw fold line
}	Close one flap up
function littleguy() {	Header for littleguy
ctx.fillStyle="teal";	Set color
ctx.beginPath();	Begin path
ctx.moveTo(ax,ay);	Move to left corner
ctx.lineTo(kx,ky);	Draw to center
ctx.lineTo(mx,my);	Draw left, down
ctx.lineTo(ax,ay);	Draw back to corner
ctx.moveTo(kx,ky);	Move to center
ctx.lineTo(lx,ly);	Draw to right corner
ctx.lineTo(px,py);	Draw down and left
ctx.lineTo(mx,my);	Draw up
ctx.lineTo(kx,ky);	Draw back to center
ctx.moveTo(nx,ny);	Move right and down
ctx.lineTo(rx,ry);	Draw down
ctx.lineTo(qx,qy);	Draw to lower center

(continued)

**Table 7-2.** (continued)

Code Line	Description
<code>ctx.lineTo(nx,ny);</code>	Draw back, right
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in shape
<code>ctx.stroke();</code>	Outline shape
<code>skinnyline(qx,qy,kx,ky);</code>	Draw fold line
<code>ctx.beginPath();</code>	Begin path
<code>ctx.arc(qx,qy,30,-.5*Math.PI, -.25*Math.PI,false);</code>	Draw arc to represent angle
<code>ctx.stroke();</code>	Draw as stroke
<code>mountain(qx,qy,sx,sy,"orange")</code>	Indicate mountain fold
<code>}</code>	Close littleguy
<code>function unfolded() {</code>	Header for unfolded
<code>  diamond();</code>	Draw diamond shape
<code>  valley(ax,ay,cx,cy);</code>	Indicate valley across paper
<code>  valley(ex,ey,gx,gy);</code>	Indicate valley, midway, and down on left
<code>  valley(fx,fy,hx,hy);</code>	Indicate valley, midway, and down on right
<code>  mountain(ex,ey,gx,gry);</code>	Indicate mountain, midway, and up on left
<code>  mountain(fx,fy,hx,gry);</code>	Indicate mountain, midway, and up, right
<code>  valley(jx,jy,dx,dy);</code>	Valley from inner diamond to bottom
<code>  mountain(jx,jy,bx,by);</code>	Mountain from inner diamond to top
<code>  valley(ex,ey,jx,jy+diag6);</code>	Valley left, upper side of inner diamond
<code>  valley(jx,jy-diag6,fx,fy);</code>	Valley right, lower side of inner diamond
<code>  mountain(ex,ey,jx,jy-diag6);</code>	Mountain, left, lower side of inner diamond
<code>  mountain(jx,jy+diag6,fx,fy);</code>	Mountain, right, top side of inner diamond
<code>}</code>	Close unfolded

(continued)

**Table 7-2.** (continued)

Code Line	Description
function precollapse() {	Header for precollapse
diamondc();	Colored diamond
mountain(ax,ay,cx,cy);	Mountain across paper
valley(ex,ey,gx,gy);	Valley center, down on left
valley(fx,fy,hx,hy);	Valley center, down on right
valley(ex,ey,gx,gry);	Valley center, up on left
valley(fx,fy,hx,gry);	Valley center, up on right
valley(jx,jy-diag6,jx,jy+diag6);	Valley in middle of paper, vertical
mountain(jx,jy-diag6,bx,by);	Mountain from inner diamond up
mountain(jx,jy+diag6,dx,dy);	Mountain from inner diamond down
mountain(ex,ey,jx,jy+diag6);	Mountain, bottom, left side of inner diamond
mountain(jx,jy-diag6,fx,fy);	Mountain, top, right side of inner diamond
mountain(ex,ey,jx,jy-diag6);	Mountain, top, left side of inner diamond
mountain(jx,jy+diag6,fx,fy);	Mountain, bottom, right side of inner diamond
}	Close precollapse
function changedfolds() {	Header for changedfolds; note that this is the same as unfolded, except for sense (mountain versus valley) of some folds
diamond();	Draw diamond
valley(ax,ay,cx,cy);	Valley across paper
mountain(ex,ey,gx,gy);	Mountain, middle of paper, down on left
mountain(fx,fy,hx,hy);	Mountain, middle, down on right
mountain(ex,ey,gx,gry);	Mountain, middle, up on left
mountain(fx,fy,hx,gry);	Mountain, middle, up on right
mountain(jx,jy-diag6,jx,jy+diag6);	Mountain, middle, vertical
valley(jx,jy-diag6,bx,by);	Valley, inner diamond up

*(continued)*

**Table 7-2.** (continued)

Code Line	Description
valley(jx,jy+diag6,dx,dy);	Valley, inner diamond down
valley(ex,ey,jx,jy+diag6);	Valley, bottom, left side of inner diamond
valley(jx,jy-dia6,fx,fy);	Valley, top, right side of inner diamond
valley(ex,ey,jx,jy-dia6);	Valley, top, left side of inner diamond
valley(jx,jy+diag6,fx,fy);	Valley, bottom, right side of inner diamond
}	Close changefolds
function triangleM() {	Header for triangleM
triangle();	Draw triangle
shortdownarrow(ex,ey);	Indicate with arrow, one-third point
shortdownarrow(fx,fy);	Indicate with arrow, two-thirds point
valley(ex,ey,gx,gy,"orange");	Next valley fold
valley(fx,fy,hx,hy,"orange");	Next valley fold
}	Close triangleM
function thirds() {	Header for thirds
triangle();	Draw triangle
skinnyline(ex,ey,gx,gy);	Indicate folded line
skinnyline(fx,fy,hx,hy);	Indicate folded line
curvedarrow(cx,cy,ax,ay,0,-20);	Draw curve right to left, offset vertically
valley(jx,jy,dx,dy,"orange");	Draw (next) valley line
}	Close thirds
function cornerdown() {	Header for cornerdown
rttriangle();	Draw right triangle
ctx.clearRect(ex,ey,diag6+5,diag6);	Erase rectangle covering corner
ctx.beginPath();	Begin path
ctx.moveTo(ex,ey);	Move to start

(continued)

**Table 7-2.** *(continued)*

Code Line	Description
<code>ctx.lineTo(ex+diag6,ey+diag6);</code>	Draw right and down
<code>ctx.lineTo(ex,ey+diag6);</code>	Draw straight down
<code>ctx.lineTo(ex,ey);</code>	Draw back to start
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in triangle shape
<code>ctx.stroke();</code>	Outline triangle shape
<code>}</code>	Close cornerdown
<code>function showkami() {</code>	Header for showkami
<code>  ctx.strokeRect(kamix,kamiy,</code> <code>  kamiw*i2p,kamih*i2p);</code>	Draw a rectangle
<code>}</code>	Close showkami
<code>function diamond1() {</code>	Header for diamond1
<code>  diamond();</code>	Draw diamond
<code>  valley(ax,ay,cx,cy,"orange");</code>	Add orange valley
<code>  curvedarrow(bx,by,dx,dy,10,0);</code>	Add vertical curved arrow
<code>}</code>	Close diamond1
<code>function diamondc() {</code>	Header for diamondc
<code>  ctx.beginPath();</code>	Begin path
<code>  ctx.moveTo(ax,ay);</code>	Move to left corner
<code>  ctx.lineTo(bx,by);</code>	Line up and right
<code>  ctx.lineTo(cx,cy);</code>	Line down and right
<code>  ctx.lineTo(dx,dy);</code>	Line down and to middle
<code>  ctx.lineTo(ax,ay)</code>	Line to start
<code>  ctx.closePath();</code>	Close path

*(continued)*

**Table 7-2.** (continued)

<b>Code Line</b>	<b>Description</b>
<code>ctx.fillStyle="teal";</code>	Set color
<code>ctx.fill();</code>	Fill in diamond
<code>ctx.stroke();</code>	Draw outline
<code>}</code>	Close diamondc
<code>function diamond() {</code>	Header for diamond
<code>ctx.beginPath();</code>	Begin path
<code>ctx.moveTo(ax,ay);</code>	Move to left corner
<code>ctx.lineTo(bx,by);</code>	Draw line up and over
<code>ctx.lineTo(cx,cy);</code>	Draw line down and over
<code>ctx.lineTo(dx,dy);</code>	Draw line down to center
<code>ctx.lineTo(ax,ay)</code>	Draw back to start
<code>ctx.closePath();</code>	Close path
<code>ctx.stroke();</code>	Draw outline
<code>}</code>	Close diamond
<code>function triangle() {</code>	Header for triangle function
<code>ctx.fillStyle="teal";</code>	Set to color
<code>ctx.beginPath();</code>	Begin path
<code>ctx.moveTo(ax,ay);</code>	Move to left corner
<code>ctx.lineTo(cx,cy);</code>	Draw line across
<code>ctx.lineTo(dx,dy);</code>	Draw line down
<code>ctx.lineTo(ax,ay);</code>	Draw line back up
<code>ctx.closePath();</code>	Close path
<code>ctx.fill();</code>	Fill in shape
<code>ctx.stroke();</code>	Draw outline
<code>}</code>	Close triangle

(continued)

**Table 7-2.** (continued)

Code Line	Description
function rttriangle() {	Header for rttriangle
ctx.fillStyle="teal";	Set color
ctx.beginPath();	Begin path
ctx.moveTo(ax,ay);	Move to left corner
ctx.lineTo(jx,jy);	Draw line across to middle
ctx.lineTo(dx,dy);	Draw line down
ctx.lineTo(ax,ay);	Draw line back up
ctx.closePath();	Close path
ctx.fill();	Fill in right triangle
valley(ex,ey,ex+diag6,ey+diag6,"orange");	Draw diagonal valley
skinnyline(ex,ey,gx,gy);	Draw a narrower line between ex, ey and gx, gy
}	Close rttriangle
</script>	Closing script tag
</head>	Closing head tag
<body onLoad="init();">	body, with call to init
<video id="sink" loop="loop" preload="auto" controls="controls" width="400">	video tag
<source src="sink.mp4video.mp4" type='video/mp4; codecs="avc1.42E01E, mp4a.40.2"'>	MP4
<source src="sink.theora.ogv" type='video/ogg; codecs="theora, vorbis"'>	OGG type; note file extension is what I have
<source src="sink.webmvp8.webm" type='video/webm; codec="vp8, vorbis"'>	WEBM; note file extension is what I have

*(continued)*



**Table 7-2.** (continued)

Code Line	Description
Your browser does not accept the video tag.	Message for old browsers
</video>	Closing video tag
<video id="talk" loop="loop" preload="auto" controls="controls">	video tag
<source src="talk.mp4video.mp4" type='video/mp4; codecs="avc1.42E01E, mp4a.40.2"'>	MP4 type
<source src="talk.theora.ogv" type='video/ogg; codecs="theora, vorbis"'>	OGG type; note the file extension is what I have
<source src="talk.webmvp8.webm" type='video/webm; codec="vp8, vorbis"'>	WEBM type; note the file extension is what I have
Your browser does not accept the video tag.	Message for old browsers
</video>	Closing video tag
<canvas id="canvas" width="900" height="480">	Set up canvas
Your browser does not recognize the canvas element	Message for old browsers
</canvas>	Closing canvas tag
 	Break
<div id="directions"> Press buttons to advance or go back </div>	Place to put directions, with closing div tag
<hr/>	Horizontal rule
<button onClick="goback();" style="color: #F00">Go back </button>	Set up Go Back button

(continued)

**Table 7-2.** (continued)

Code Line	Description
<code>&lt;button onClick="donext();" style="color: #03F"&gt;Next step &lt;/button&gt;</code>	Set up Next Step button
<code>&lt;/body&gt;</code>	Closing body tag
<code>&lt;/html&gt;</code>	Closing html tag

You can apply this methodology directly to preparing directions for other origami models or similar construction projects. However, do think more broadly about other topics in which line drawings would benefit from mathematical calculations and for which line drawings and images and videos could be used together. You don't have to know everything at the start. Be prepared to work through the project a step at a time.

## Testing and Uploading the Application

The `origamifish.html` application can be fully tested on your own computer, assuming you download the photographs and the video clips. If and when you upload it or your own application to a server, you'll need to upload the HTML file, all the image files, and all the video files. Remember, to have an application work on all browsers, you may need multiple formats for each video.

## Summary

In this chapter, you learned how to build a substantial application for presenting directions involving line drawings, photographs, and video clips. The programming techniques included the following:

- The use of mathematics (algebra, geometry, and trigonometry) to make precise drawings
- The use of an array holding text and function names corresponding to each step
- The integration of photographs and video clips through the use of functions

In the next chapter, we tackle another project integrating photographs and video clips: the construction of a jigsaw puzzle that turns into a video when the player puts the puzzle together.

## CHAPTER 8

# Jigsaw Video

In this chapter, you will learn the following:

- Ways to break up an image into pieces to produce pieces for a jigsaw puzzle
- How to respond to player moves to move pieces around to solve the puzzle
- How to calculate horizontal and vertical coordinates and manipulate left and top style attributes to reposition elements on the screen
- About the concept of tolerance or margin so your player does not have to be perfect to solve the puzzle
- How to make the completed jigsaw appear to turn into a running video

## Introduction

The project for this chapter is a jigsaw puzzle that becomes a video when complete. It has been tested on Chrome, Firefox, Opera, and Safari on computers equipped with a mouse. The jigsaw pieces are positioned randomly on the screen each time the program is loaded or the button is clicked to restart the program. Figure 8-1 shows an opening screen when the program is run on a desktop computer running the Firefox browser.

**Monkey bars**



**Figure 8-1.** *Opening screen on computer*

On a computer, the player uses the mouse to move and reposition pieces. Randomly positioned pieces may end up on top of each other. Figure 8-2 shows the jigsaw pieces spread out. I did this using the mouse. My example has six rectangular-shaped pieces.

**Monkey bars**



Do jigsaw again. Feedback: Keep working.

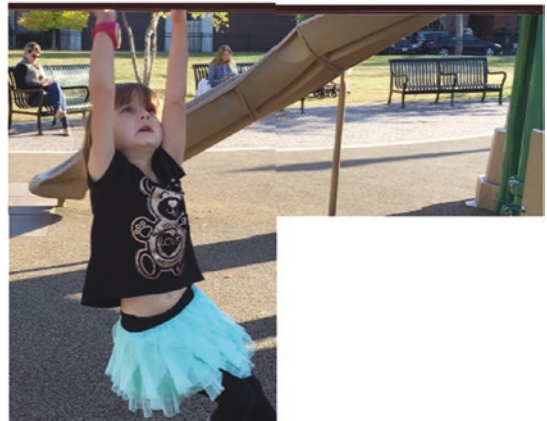
**Figure 8-2.** *Pieces spread out*

Figure 8-3 shows how I made progress in putting the puzzle together. I can position the puzzle anywhere on the screen. Three pieces of the puzzle have been put together.

**Monkey bars**



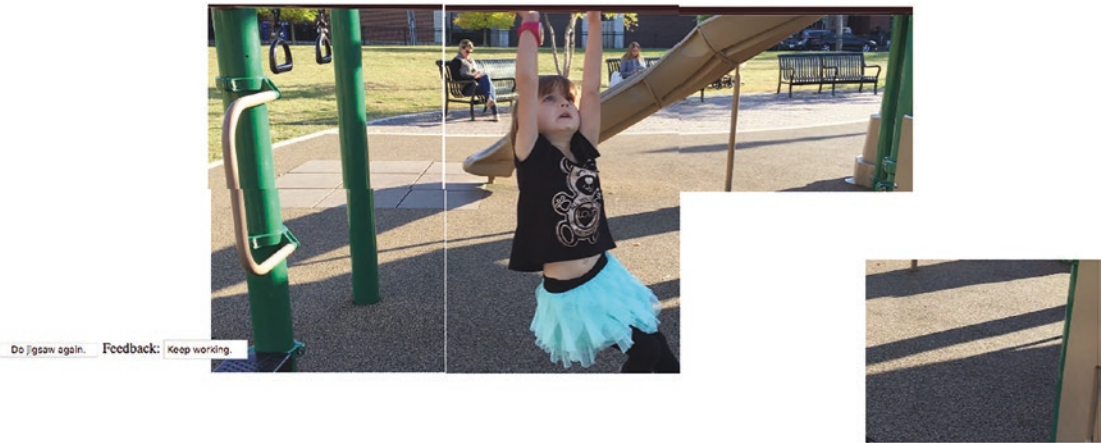
Do jigsaw again. Feedback: Keep working.



**Figure 8-3.** *Progress made on the puzzle*

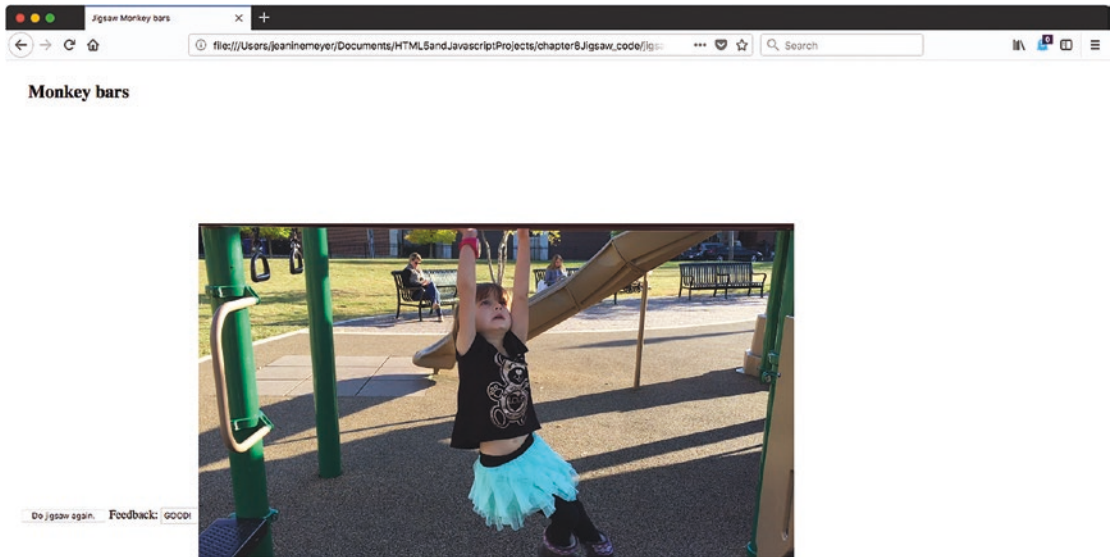
Notice that the box with the label Feedback says to *keep working*. Figure 8-4 shows the puzzle nearly complete.

**Monkey bars**



**Figure 8-4.** *Just one piece left to fit into the jigsaw puzzle*

The program allows for a margin of error, which I term the *tolerance*, when putting the pieces together. You can see by noticing the white gaps that the puzzle is not perfectly put together. When I move in the last piece, Figure 8-5 shows a screen capture shortly after my last move.

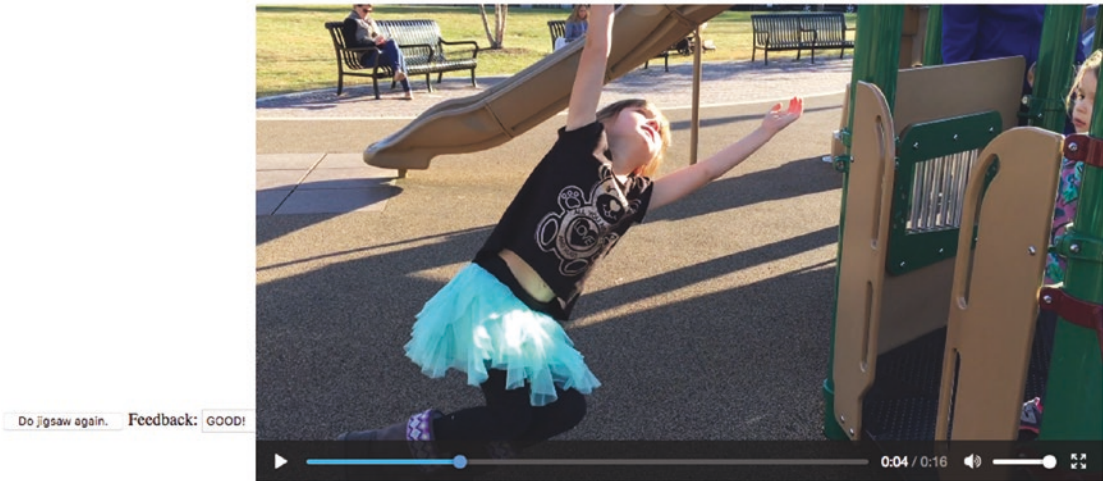


**Figure 8-5.** Pieces replaced by a video

Notice that the feedback now reads “GOOD!” A video has begun to play and I stopped it and reset to the start to obtain this screenshot. The picture appears perfect. In fact, the six jigsaw pieces have been replaced by the video. Figure 8-6 shows the video with controls showing. The controls do not show automatically, but can be seen if the player puts the mouse on top of the lower part of the video. The video controls vary across the different browsers.



**Monkey bars**



**Figure 8-6.** Video clip with controls

I decided to take the challenge of making the project work for an iPhone, iPad, and Android phone. This meant constructing a user interface that allows the player to use finger touches. To be more precise and demonstrate my ambitions, I wanted to produce one program as a website that would work for both mouse and touch. I will postpone the explanation on how to respond to touch until Chapter 10, “Responsive Design and Accessibility”. In this chapter, I address the issue of modifying the program to work with windows of different dimensions. This can be checked out on a desktop by changing the width and/or height of the window.

Note that the Apple operating systems on mobile devices may require users to click the Play button to start all videos. This is considered a feature, not a bug, by Apple. Requiring a click does give the owners of the devices a chance to prevent downloading of a video, which takes time and battery power and may incur fees. For the jigsaw-to-video project, I would prefer it to be seamless and that is what it is on a desktop or laptop computer. The program does exhibit seamless behavior using Chrome on my Mac desktop, so the autoplay policy discussed in Chapter 2 appears to be satisfied.

With this introduction to what can be called the jigsaw-puzzle-with-video-reward project, we can go on to discuss the requirements for the project and the implementation.

## Background and Critical Requirements

Three distinct circumstances inspired me to want to build this particular project. I had built jigsaw puzzles turning into videos in Adobe Flash for a Programming Games course that I taught, and many students were happy to use them as models for their own projects. When I was working on a US states educational game, which is the subject of Chapter 9, I decided a jigsaw activity to put the states together was a good addition to other questions such as asking the player to identify a state by clicking on the state in a map of the whole USA. Lastly, I frequently receive videos of family members and so shameless incorporated them into my teaching examples. These circumstances were the motivation to create the jigsaw turning into video project.

The requirements for this project start with the challenge of creating the jigsaw pieces. One approach is to create—cut up—the base picture outside of this program. If you do this, you must record the relative locations of each jigsaw piece. You can make the pieces more irregular than in this example. See the “How to Build the Application and Make It Your Own” section for ideas. I describe a different approach here. My program cuts up the base picture. The pieces are the same rectangular shape.

After making the adjustments to fit the window, the main technical requirement is to build the user interface. The user interface consists of the mouse or finger touch actions to move individual pieces, along with a button to do the jigsaw again and feedback provided in a text field.

The program presents the pieces randomly positioned on the screen. The player then moves pieces to construct the image. After each release of a piece, the program performs a calculation to see if the puzzle has been solved. This calculation must satisfy two requirements. The puzzle can be put together anywhere on the screen so the calculations must be done in terms of relative positions. Secondly, there needs to be a tolerance in the positioning of the pieces, since we can't require the positioning to be perfect (i.e., to the pixel).

When the puzzle is deemed complete, it turns into a video. More accurately, a video appears where the pieces were located on the screen.

## HTML5, CSS, JavaScript, and Programming Features

The features used for the jigsaw video project are a mixture of HTML5 constructs and general programming techniques.

## Creating the Base Picture

The first step is to create an image file from the first frame of the video. How you do this depends on the tools you have and what you feel comfortable using. I used the Grab tool on my Mac. Other possibilities are pressing the PC Print Screen key twice to capture the screen, or pressing Command+Shift+4 to get crosshairs on the Mac. There also is SnagIt. If you have a video editing tool, you can access the first frame using the tool. An alternative is to have the jigsaw picture be independent of the video. This would never have occurred to me, but someone did suggest it.

## Dynamically Created Elements

In Chapter 2, you read about the Family Collage project, in which images were repositioned on a canvas. I take a somewhat different approach here. Each piece will be its own canvas element, with the markup created dynamically and sections of the base image drawn on each canvas. The pieces are created in a function called `makePieces` invoked by the `init` function. The game is set up using a function called `setupGame`, also invoked from `init`. The fact that I have three functions—`init`, `makePieces` and `setupGame`—is partially an artifact of the history of this project. I reused code created for the US states game, in which the jigsaw puzzle was just a part. However, breaking up a function into smaller pieces generally is a good thing to do. The `init` function does some work, calls `makePieces`, does some more work, and then calls `setupGame`. The `setupGame` function is also invoked from `endjigsaw` so the player can play the game again. Often, I am too lazy to allow a player to play again because this can be challenging. What needs to be reset and what doesn't? However, I decided to make the effort in this case. The pieces are not re-created but are positioned randomly once again in the window. The way I created this application is not the only way it could be done. In some situations, here and in other chapters, I chose to write a function that is more general than needed, and in others I did not.

The base image (`img`) and the video elements are each specified in the HTML body. Directives in the `style` element make each of these invisible. The base `img` is never made visible, but its contents are used to build the pieces. The `init` function is invoked by the action of an `onload` attribute in the `body` tag. This means that game play will not start until the base image file and the video files are loaded. The `init` function does some housekeeping tasks of obtaining references to elements and invokes the `makePieces` and the `setupGame` functions.

The `makePieces` does the task of determining the adjustments required to fit the window dimensions. It then virtually cuts up the jigsaw pieces. To adjust the pieces and the video to different windows *and* preserve the proportions, I need to determine the relationship of the base image and the window. I decided I wanted the base width to be no more than 80% of the `window.innerWidth` and the base height to be no more than 80% of the `window.innerHeight`. I also did not want the base to be grow in size if the width and height was less than those amounts. The following statements produce in the variable `ratio`, the critical factor:

```
origW = base.width;
origH = base.height;
var ratio =Math.min(1.0,.80*window.innerWidth/origW,.80*window.
innerHeight/origH);
```

You can think it out this way: if the `origW` value is bigger than `.80*window.innerWidth`, it means that my code needs to shrink the picture. In this case, the second parameter to the `Math.min` function will be less than 1. The same can be said regarding height. Whichever factor is the least gets assigned to the `ratio` variable. If both of these factors are greater than 1, then `ratio` is set to 1 and the pieces and the video are not increased in size. If one of these factors is less than one, then `ratio` will be set to less than 1. The following statements use `ratio` to set the critical variables. The invocation of the `drawImage` function will use `opieceW`, `opieceH`, `pieceW`, and `pieceH` to create the jigsaw pieces from the original base. The jigsaw pieces and the video may be changed from the original dimensions.

```
baseImgW = origW*ratio;           //possibly modified
baseImgH = origH*ratio;           //possibly modified
v.width = baseImgW;               //possibly modified video width
v.height =baseImgH;              //possibly modified video height
opieceW = origW/numOfCols;        //width of the source for a jigsaw piece
opieceH = origH/numOfRows;        //height of the source for a jigsaw piece
pieceW = ratio*opieceW;           //jigsaw piece width
pieceH = ratio*opieceH;           //jigsaw piece height
```

The `makePieces` function invokes `drawImage` to extract and scale pieces of the base image to be drawn, each into its own newly created canvas element. This operation takes place within nested for loops. The base image is divided into `numOfRows` and `numOfCols`. The pieces, that is, references to the canvas elements and the `x` value and the `y` values are

each stored in the arrays `pieces`, `piecesx` and `piecesy`. Think of the `drawImage` method as performing the jigsaw operation, although it is more complicated because scaling takes place:

```
for(i=0.0; i<numOfRows; i++) {
  for (j=0.0; j<numOfCols; j++) {
    //Some other tasks
    sCTX.drawImage(base, j*opieceW, i*opieceH, opieceW, opieceH, 0, 0, pieceW,
    pieceH);
    //Some other tasks
  }
}
```

The base image has not been changed. The `sCTX` is the context for the canvas created for each piece. The `drawImage` function extracts—clips—a section of the base image starting at `j*opieceW` and `i*opieceH` and `opieceW` wide and `opieceH` high. It draws this piece of the image into the `sCTX` canvas element, scaling it to be `pieceW` and `pieceH`. This takes up the whole canvas.

You can examine the complete code in Table 8-2. The canvas pieces are made visible by appending them to the body element and also setting the style attribute `visibility` to `visible`. The `addEventListener` method for each canvas element sets up the response to `mousedown` for each canvas. The code arranges the pieces so that they resemble the original picture, the first frame of the video clip. However, the `setUpGame` function is invoked soon afterward so the player will not see the puzzle solution. After the nested for loops, another initialization is performed. The `firstpkel` variable points to the newly created element holding the first piece, the piece in the top-left corner. This is the reference point the code uses to position the video clip. The calculation that positions the pieces correctly in relation to each other is independent of the location of the first piece.

## Setting Up the Game

The work of setting up the jigsaw puzzle starts with stopping the video and making it not display. This isn't necessary the very first time, but it is easier to have the code always perform these operations. The next task is to place the pieces randomly on the screen. The code does this using `Math.random` and `Math.floor`. The `display` attribute is set to `inline` to make the pieces visible, but not with a line break, which would be the case

if the code used `block`. When the circumstances occur to play the video, all the pieces are made invisible by setting the `display` to `none`, so this code is necessary. Note that the variable `v` has been set in the `init` function to point to the video element.

```
function setupGame() {
  var i;
  var x;
  var y;
  var thingelem;
  v.pause();
  v.style.display = "none";
  doingjigsaw = true;
  for (i=0;i<nums;i++) {
    x = 10+Math.floor(Math.random()*baseImgW*.9);
    y = 50+Math.floor(Math.random()*baseImgH*.9);
    thingelem = pieces[i];
    thingelem.style.top = String(y)+"px";
    thingelem.style.left = String(x)+"px";
    thingelem.style.visibility='visible';
    thingelem.style.display="inline";
  }
  questionfel.feedback.value = " ";
}
```

---

**Note** If you notice that a certain amount of complexity occurs in the coding to handle the issue of replaying the jigsaw game, this is typical. Restarting, reinitializing, and so on are more of a challenge than programming something to happen just once.

---

## Handling Player Actions

My approach was to implement the mouse events first and get those working. Then, when my ambitions rose to build an application for certain family members who use iPhones and iPads, I implemented the finger touch by making a touch event simulate a mouse event. I explain the mouse events in this chapter and the coding for touch in Chapter 10.

## Using Mouse Events

The tasks for moving the jigsaw pieces are to

- Recognize that the mouse button is down and the mouse is on top of a piece
- Move the piece when the mouse moves, adjusting the location to make sure that the piece doesn't jump, but remains as if the cursor were attached to its original position, perhaps in the middle of the element.
- Release or drop the element when the player has released the mouse button.

You may recall similar operations in Chapter 2. This reasoning suggests that my code will set up at least three events, and this is what happens. In the `makePieces` function, the following statement is executed in the nested `for` loops that create a canvas element for each piece. The variable `s` holds the reference to the canvas element.

```
s.addEventListener('mousedown',startdragging);
```

This sets up event handling for `mousedown` for each piece. The `startdragging` function sets a variable named `movingobj` to be the event target, which is the specific jigsaw piece. The function also sets the global variables `oldx` and `oldy` to the position of the mouse. The function sets up event handling for `mousemove` and `mouseup`.

```
movingobj.addEventListener("mousemove",moving);
movingobj.addEventListener("mouseup",release);
```

Notice that nothing happens if the mouse is not over a piece when the player presses down on the mouse button because the only events “listened to” are events over the canvas elements. The `moving` function is:

```
function moving(ev)
{
  if((movingobj!=null) &&(mouseDown)){
    newx = parseInt(ev.pageX);
    newy = parseInt(ev.pageY);
    delx = newx-oldx;
    dely = newy-oldy;
```

```

    oldx = newX;
    oldy = newY;
    curx = parseInt(movingobj.style.left);
    cury = parseInt(movingobj.style.top);
    movingobj.style.left = String(curx+delx)+"px";
    movingobj.style.top = String(cury+dely)+"px";
  }
};

```

Checking that `movingobj` is not null and `mouseDown` is true is redundant, but I decided to keep it just in case I want to add something in the future. The moving function performs a relative move of `movingobj`. The moving jigsaw piece is moved by the same amount horizontally and vertically as the mouse is moved. It does not matter where on the piece canvas the mouse is positioned. Whatever the changes from the last time that the mousemove event has occurred, the piece canvas is adjusted using the same changes.

The release function is invoked when the player releases the mouse button. I handled a failure of release to be invoked when one piece is on top of another by setting up another event:

```
document.body.onmouseup = release;
```

There is no problem with invoking release multiple times.

```

function release(e){
  mouseDown = false;
  movingobj = e.target;
  movingobj.removeEventListener("mousemove",moving);
  movingobj.removeEventListener("mouseup",release);
  movingobj=null;
  checkpositions();
}

```

Changing the variable `mouseDown` to false means that nothing will happen if and when the player moves the mouse until the player presses down on the mouse button again, invoking the `startdragging` function. This completes the mouse event handling. The `checkpositions` function is explained in the next section.



## Calculating If the Puzzle Is Complete

Recall that I set the requirements for calculating if the puzzle is complete to be that the puzzle can be located anywhere on the screen and that the player does not have to be precise. Another more-or-less implicit requirement is that the checking be done automatically. After the player releases the mouse or lifts his or her finger, the release function invokes `checkpositions`. The `checkpositions` function is called after each move. Don't worry, JavaScript is doing the work, not you.

The `checkpositions` function computes the difference between the `piecesx` value and the `style.left` value of each piece element, and the difference between the `piecesy` value and the `style.top` value of each piece element. The `style.left` and `style.top` values are character strings, not numbers, and include "px". The code needs to remove the "px", which stands for "pixels," and calculate the numeric value. The differences are stored in the arrays `deltax` and `deltay`.

The function calculates the average of these differences (one for x and one for y). If the puzzle were put together exactly according to the values in the `piecesx` and `piecesy` arrays, the differences would each be zero, and consequently, the averages for x and for y would each be 0. If the puzzle were put together such that the actual locations were each 100 pixels closer to the left side—that is, more left and 50 pixels further down the page, that is higher value y, then the averages would be 100 and 50. The puzzle would be put together perfectly, but at a location to the left and below the original location. The differences for x for all pieces would be 100 and the differences for y for all pieces would be 50. Each of the differences would have the same value as the corresponding (x or y) average.

The goal is to *not* require perfection. The tasks of the `checkpositions` function are to compute the differences in x and y, compute the two averages, and check if each of the differences is close enough to the average.

After computing the difference values, the function performs these tasks by iterating over each piece to compare it with the corresponding average. The check is done using absolute values, because our code doesn't care if a piece is a few pixels left or right or up or down. The criteria for being close enough is the value held in the variable `tolerance`. If the gap is bigger than `tolerance` for any piece, the puzzle is not considered complete. The critical `if` test is

```
if ((Math.abs(averagex - deltax[i])>tolerance) || (Math.abs(averagey-
deltay[i])>tolerance)) {
    break;
}
```

The `doaverage` function computes and returns the average value of numbers in an array. This is accomplished in the usual way. The variable `sum` is called an *accumulator*. It is initialized to 0. A `for` loop iterates over the elements in the array, adding each one to the variable `sum`.

```
function doaverage(arr) {
    var sum;
    var i;
    var n = arr.length;
    sum = 0;
    for(i=0;i<n;i++) {
        sum += arr[i];
    }
    return (sum/n);
}
```

To summarize the action a different way, the `checkpositions` function uses the first `for` loop to determine the differences in current horizontal and vertical position of each piece. It then computes two averages: for `x` and for `y`. Then the function uses a second `for` loop to see if the horizontal or vertical difference for any piece is significantly different in absolute value from the relevant average. As soon as this happens, control leaves the `for` loop and the puzzle is deemed not complete. If the loop has completed, the puzzle is complete and the video is positioned and played. The `checkpositions` function is shown in Table 8-2. I chose to display a message to the player giving feedback on the puzzle. The form element `questionfel` holds a reference to the form, and `feedback` is an input field.

I will describe what happens when the puzzle is deemed complete in the next section.

## Preparing, Positioning, and Playing the Video and Making It Hidden or Visible

Preparing the video clip is the same as what you have seen for the other projects involving video. You need to create multiple encodings of the video. Also, as with the other projects, when we do not want the video to appear until a certain situation occurs, the style section contains the directive to make the video initially not visible, set it up

to be positioned absolutely, and (when it is displayed) put it in the window at the same location as `firstpkel`, the upper-left corner piece. The relevant code is

```
v.style.left = firstpkel.style.left;
v.style.top = firstpkel.style.top;
v.style.display="block";
v.currentTime = 0;
v.play();
```

The video may demonstrate different behavior in different circumstances. Specifically, on an iPad or iPhone, the player may need to click an arrow to play the video. On my desktop (and I am using an iMac) using Chrome or Firefox and on an Android phone, the video starts automatically, which is what I prefer. In Chapter 2, I discussed the issue of the autoplay policy. I have not muted the monkey bars video. It may be that the calculation performed in Chrome for media engagement index (see <https://developers.google.com/web/updates/2017/09/autoplay-policy-changes>) produces these results.

You have seen several HTML5 features to use, as well as programming tricks you can use in other applications. The next section shows you the bulk of the code for the project. The entire program is stored with the source code. I include the program for the same application, but using touch, with the source code for Chapter 10.

## Building the Application and Making It Your Own

You can make these projects your own by using your own video clip. You also can make a jigsaw puzzle by itself, though you probably should wait to read the next chapter, which describes a more elaborate jigsaw puzzle and contains pointers on how to cut up more intricate shapes. If the pieces have transparent areas, you still would set up the mousedown event for the whole canvas element. But, you would then code a check if the pixel “under” the mouse is or is not transparent.

Another approach to jigsaw puzzles is to check if a piece is close enough to another piece, using some tolerance or margin calculation, and snap them together. Your code must then move the snapped together pieces together.

You may decide to omit or change the feedback of Keep working or Good. My implementation has the Do Jigsaw Again button and the feedback box on top of pieces but under the video clip. This means that if the player chooses to create the puzzle so that the do over button is hidden, there is no way except re-loading to start again.

Here is an informal summary/outline of the jigsaw-to-video project:

- `init`: For initialization, including invoking calls to `setupGame` and `setupjigsaw`.
- `makePieces`: For creating the pieces.
- `setupGame`: For randomly positioning the pieces and setting up event handling.
- `endjigsaw`: For stopping the video and making it not display and then invoking `setupGame` for a new game.
- `startdragging`, `moving`, `release`: For handling events.
- `checkpositions`: For determining if the puzzle is complete.
- `doaverage`: For calculating the average of values in an array.

Table 8-1 lists all the functions and indicates how they are invoked and what functions they invoke.

**Table 8-1.** *Functions in the Jigsaw-to-Video Project*

Function	Invoked/Called By	Calls
<code>init</code>	Invoked by action of the <code>onLoad</code> attribute in the <code>&lt;body&gt;</code> tag	<code>makePieces</code> , <code>setupGame</code>
<code>makePieces</code>	Invoked by <code>init</code>	
<code>setupGame</code>	Invoked by <code>init</code> and <code>endjigsaw</code>	
<code>endjigsaw</code>	Invoked by the <code>onSubmit</code> setting in the form in the body	<code>setupGame</code>
<code>checkpositions</code>	Invoked by <code>release</code>	<code>doaverage</code>
<code>doaverage</code>	Invoked by <code>checkpositions</code>	
<code>startdragging</code>	Invoked by event setting in <code>makePieces</code>	
<code>moving</code>	Invoked by event setting in <code>startdragging</code>	
<code>release</code>	Invoked by event setting in <code>startdragging</code>	<code>checkpositions</code>
	for individual pieces and <code>makePieces</code> for the body	

Table 8-2 shows the code for the basic application, with comments for each line. Much of this code you have seen in the previous chapters.

**Table 8-2.** Complete Code for the Jigsaw-to-Video Project

---

<code>&lt;!DOCTYPE html&gt;</code>	Header
<code>&lt;html&gt;</code>	html tag
<code>&lt;meta charset="UTF-8"&gt;</code>	Specific character set
<code>&lt;head&gt;</code>	head tag
<code>&lt;title&gt;Jigsaw Monkey bars</code>	title for tab
<code>&lt;/title&gt;</code>	Closing title tag
<code>&lt;style&gt;</code>	Style tag
<code>#base {position:absolute;</code> <code>border:none; visibility: hidden;}</code>	Make base image start out hidden, absolute positioning
<code>form {position: absolute;</code> <code>z-index: 10;}</code>	Put form on top of pieces
<code>body { height:100%; margin: 30px;}</code>	Format for body
<code>video {display:none; position:</code> <code>absolute; z-index: 100;}</code>	Make video start out not displayed; places on top of pieces
<code>&lt;/style&gt;</code>	Close style
<code>&lt;script type="text/javascript"&gt;</code>	script tag
<code>var pieces = [];</code>	Will hold pieces
<code>var nums;</code>	Will hold number of pieces
<code>var baseImgW;</code>	Will hold adjusted width of base image
<code>var baseImgH;</code>	Will hold adjusted height of base image
<code>var origW;</code>	Original width of base
<code>var origH;</code>	Original height of base
<code>var opieceW;</code>	Calculated width of a piece in terms of base image
<code>var opieceH;</code>	Calculated height of a piece in terms of base image

---

*(continued)*

**Table 8-2.** *(continued)*


---

<code>var pieceW;</code>	Width of a piece; result of scaling operation
<code>var pieceH;</code>	Height of a piece; result of scaling operation
<code>var numOfRows = 2.0;</code>	Number of rows
<code>var numOfCols = 3.0;</code>	Number of columns
<code>var piecesx = [ ];</code>	Will hold original x coordinate for all pieces
<code>var piecesy = [ ];</code>	Will hold original y coordinate for all pieces
<code>var v;</code>	Will hold reference to video element
<code>var base;</code>	Will hold reference to base <code>img</code>
<code>var doingjigsaw = false;</code>	Flag for when jigsaw is in play
<code>var firstpkel;</code>	First piece, located in upper-left corner
<code>var oldx;</code>	Will hold previous x coordinate of moving item
<code>var oldy;</code>	Will hold previous y coordinate of moving item
<code>var questionfel;</code>	Reference to question (status) element
<code>var mouseDown = false;</code>	Flag indicating a piece is being dragged
<code>var movingobj;</code>	Will hold reference to current moving piece
<code>function init(){</code>	Header for <code>init</code>
<code>v = document.getElementById("bars");</code>	Get reference to video
<code>base = document.</code> <code>getElementById("base");</code>	Get reference to base image
<code>makePieces();</code>	Invoke <code>makePieces</code>
<code>nums = pieces.length;</code>	The <code>pieces</code> array is now set and populated and so can store the length
<code>questionfel = document.getElement</code> <code>ById("questionform");</code>	Reference to place to display form holding <code>do over</code> button and feedback
<code>questionfel.style.left = "20px";</code>	Location of form
<code>questionfel.style.top = "600px";</code>	Location of form
<code>questionfel.submitbut.value =</code> <code>"Do jigsaw again.";</code>	Label on the form submit button

---

*(continued)*

**Table 8-2.** *(continued)*

---

<pre> setupGame(); </pre>	Invoke function to set up puzzle, mainly randomly placing pieces
<pre> } </pre>	Close init
<pre> function makePieces() { </pre>	Header for makePieces function
<pre>     var i; </pre>	Indexing variable
<pre>     var x; </pre>	Will hold horizontal coordinate
<pre>     var y; </pre>	Will hold vertical coordinate
<pre>     var s; </pre>	Will hold reference to each dynamically created canvas element for holding a piece
<pre>     var sCTX; </pre>	Context for canvas elements
<pre>     origW = base.width; </pre>	Width of base image
<pre>     origH = base.height; </pre>	Height of base image
<pre>     var ratio =Math.min(1.0,.80* window.innerWidth/origW,.80*window. innerHeight/origH); </pre>	Computes the required scaling factor
<pre>     baseImgW = origW*ratio; </pre>	Scaled width
<pre>     baseImgH = origH*ratio; </pre>	Scaled height
<pre>     v.width = baseImgW; </pre>	Set width of video after scaling
<pre>     v.height =baseImgH; </pre>	Set height of video after scaling
<pre>     opieceW = origW/numOfCols; </pre>	Compute the width of the portion of the base image to be scaled and drawn on each canvas element
<pre>     opieceH = origH/numOfRows; </pre>	Compute the height
<pre>     pieceW = ratio*opieceW; </pre>	Compute the actual width of each canvas piece
<pre>     pieceH = ratio*opieceH; </pre>	Compute the actual height
<pre>     for(i=0.0;i&lt;numOfRows;i++) { </pre>	for loop going through the rows
<pre>         for (j=0.0;j&lt;numOfCols;j++) { </pre>	for loop, within a row, going through the columns

---

*(continued)*

**Table 8-2.** *(continued)*


---

<code>s = document. createElement('canvas');</code>	Create a canvas
<code>s.width = pieceW;</code>	Set its width
<code>s.height = pieceH;</code>	Set its height
<code>s.style.position = 'absolute';</code>	Set position style
<code>sCTX = s.getContext('2d');</code>	Set context
<code>sCTX.drawImage(base,j*opieceW, i*opieceH,opieceW,opieceH,0,0,piec eW,pieceH);</code>	Cut out of the base image the section to be scaled and drawn to the canvas
<code>document.body.appendChild(s);</code>	Make visible by appending to the body
<code>pieces.push(s);</code>	Add to the pieces array
<code>x = j*pieceW +100;</code>	Set a temporary x value; think of this as the nominal correct x
<code>y = i*pieceH +100;</code>	Set a temporary y value; think of this as the nominal correct y
<code>s.style.top = String(y)+"px";</code>	Set the top of this canvas element
<code>s.style.left = String(x)+"px";</code>	Set the left of this canvas element
<code>piecesx.push(x);</code>	Add value to piecesx for later use in checkposition
<code>piecesy.push(y);</code>	Add value to piecesy for later use in checkpositions
<code>    s.addEventListener     ('mousedown',startdragging);</code>	Set up event handling for a mousedown on this element; Note this is never removed
<code>s.style.visibility='visible';</code>	Make visible
<code>    }</code>	Close inner for
<code>  }</code>	Close outer for
<code>firstpkel = pieces[0];</code>	Set reference to the very first piece

---

*(continued)*



**Table 8-2.** *(continued)*

---

<pre>document.body.onmouseup = release;</pre>	Makes sure release is invoked for situation when pieces are on top of each other
<pre>}</pre>	Close makePieces
<pre>function endjigsaw() {</pre>	Header for endjigsaw; this is end and then re-start
<pre>  if (doingjigsaw) {</pre>	If jigsaw is being done
<pre>    doingjigsaw = false;</pre>	Set doingjigsaw to false
<pre>    v.pause();</pre>	Pause video
<pre>    v.style.display = "none";</pre>	Make video not display
<pre>  }</pre>	Close if true clause
<pre>    setupGame();</pre>	Re-start game
<pre>  return false;</pre>	Prevents page refresh
<pre>}</pre>	Close endjigsaw
<pre>function checkpositions() {</pre>	Header checkpositions
<pre>  var i;</pre>	Indexing variables, used in for loop
<pre>  var x;</pre>	Will hold horizontal value
<pre>  var y;</pre>	Will hold vertical value
<pre>  var tolerance = 10;</pre>	Set margin for checking
<pre>  var deltax = [];</pre>	Will hold differences from nominal x position
<pre>  var deltay = [];</pre>	Will hold differences from nominal y position
<pre>  var delx;</pre>	Used in calculation for x values
<pre>  var dely;</pre>	Used in calculation for y values
<pre>  for (i=0;i&lt;nums;i++) {</pre>	for loop, to determine horizontal and vertical differences
<pre>    x = pieces[i].style.left;</pre>	Get the left style
<pre>    y = pieces[i].style.top;</pre>	Get the top style
<pre>    x = x.substr(0,x.length-2);</pre>	Remove px

---

*(continued)*

**Table 8-2.** *(continued)*


---

<code>y = y.substr(0,y.length-2);</code>	Remove px
<code>x = Number(x);</code>	Convert to number
<code>y = Number(y);</code>	Convert to number
<code>delx = x - piecesx[i];</code>	Calculate difference
<code>dely = y - piecesy[i];</code>	Calculate difference
<code>deltax.push(delx);</code>	Add to array
<code>deltay.push(dely);</code>	Add to array
<code>}</code>	End for loop
<code>var averagex = doaverage(deltax);</code>	Calculate average horizontal difference
<code>var averagey = doaverage(deltay);</code>	Calculate average vertical difference
<code>for (i=0;i&lt;nums;i++) {</code>	for loop to check if any delta (x or y) is more than tolerance from average
<code>if ((Math.abs(averagex - deltax[i])&gt;tolerance)    (Math.abs(averagey - deltay[i])&gt;tolerance)) {</code>	Do comparisons (taking absolute values)
<code>break;</code>	If true, leave loop
<code>}</code>	Close if true clause
<code>}</code>	Close for loop
<code>if (i&lt;nums) {</code>	Look at last i; if this is less than nums, then there was a deltax or deltay that was bigger than tolerance
<code>questionfel.feedback.value = "Keep working.";</code>	Display message
<code>}</code>	Close if true
<code>else {</code>	Else
<code>questionfel.feedback.value = "GOOD!";</code>	Display message

---

*(continued)*

**Table 8-2.** *(continued)*

---

<pre> for (i=0;i&lt;nums;i++) {     pieces[i].style.display =         "none"; } v.style.left = firstpkel.style. left; v.style.top = firstpkel.style. top; v.style.display="block"; v.currentTime = 0; v.play(); } } function doaverage(arr) {     var sum;     var i;     var n = arr.length;     sum = 0;     for(i=0;i&lt;n;i++) {         sum += arr[i];     }     return (sum/n); } function setupGame() {     v.pause();      v.style.display = "none";     doingjigsaw = true; </pre>	<pre> for loop to make all pieces not be displayed Make display none  Close for loop Position video horizontally ... and vertically Make video display Set video at start Play video Close else Close function Header for doaverage Will hold sum Indexing variable Store length Initialize sum for loop going through items in arr Add to sum Close for Return calculated average Close doaverage Header for setupGame Pause the video; no action or error if video not being played Make video not display Set flag to true </pre>
---	--

---

*(continued)*

**Table 8-2.** *(continued)*


---

<code>var i;</code>	Indexing variable
<code>var x;</code>	Will hold horizontal value
<code>var y;</code>	Will hold vertical value
<code>var thingelem;</code>	Will hold reference to pieces (canvases for pieces)
<code>for (i=0;i&lt;nums;i++) {</code>	Loop through all the pieces
<code>x = 10+Math.floor(Math.random()*baseImgW*.9);</code>	Set random value for horizontal position
<code>y = 50+Math.floor(Math.random()*baseImgH*.9);</code>	Set random value for vertical position
<code>thingelem = pieces[i];</code>	Get the ith piece
<code>thingelem.style.top = String(y)+"px";</code>	Set the top
<code>thingelem.style.left = String(x)+"px";</code>	Set the left
<code>thingelem.style.visibility='visible';</code>	Make visible
<code>thingelem.style.display="inline";</code>	Set display
<code>}</code>	Close for loop
<code>questionfel.feedback.value = " ";</code>	Erase any previous feedback
<code>}</code>	Close <code>setupGame</code> function
<code>function release(e){</code>	Header for <code>release</code>
<code>movingobj = e.target;</code>	Set to piece released
<code>mouseDown = false;</code>	Set flag to false
<code>movingobj.removeEventListener("mousemove",moving);</code>	Stop listening for mouse move

---

*(continued)*

**Table 8-2.** *(continued)*


---

<code>movingobj.removeEventListener</code> <code>("mouseup",release);</code>	Stop listening for mouse up.
<code>movingobj=null;</code>	Set this variable to null
<code>checkpositions();</code>	Invoke checkpositions
<code>}</code>	Close release function
<code>function startdragging(e) {</code>	Header for startdragging
<code>movingobj = e.target;</code>	Store the event target; this is the piece being dragged
<code>mouseDown = true;</code>	Set flag to true
<code>oldx = parseInt(e.pageX);</code>	Store current horizontal value of mouse
<code>oldy = parseInt(e.pageY);</code>	Store current vertical value of mouse
<code>movingobj.addEventListener</code> <code>("mousemove",moving);</code>	Set up listening for mousemove
<code>movingobj.addEventListener</code> <code>("mouseup",release);</code>	Set up listening for mouseup
<code>}</code>	Close startdragging
<code>function moving(ev) {</code>	Header for moving
<code>if((movingobj!=null)</code> <code>&amp;&amp;(mouseDown)){</code>	Only do anything if movingobj is defined and mouseDown is true; this is redundant, but may ease later enhancements
<code>newx = parseInt(ev.pageX);</code>	Extract horizontal mouse position
<code>newy = parseInt(ev.pageY);</code>	Extract vertical mouse position
<code>delx = newx-oldx;</code>	Calculate change (delta) from last value stored in oldx
<code>dely = newy-oldy;</code>	Calculate change (delta) from last value stored in oldy
<code>oldx = newx;</code>	Now, store newx in oldx

---

*(continued)*

**Table 8-2.** *(continued)*


---

<code>oldy = newy;</code>	... store newy in oldy
<code>curx = parseInt(movingobj.style.left);</code>	Extract the number from the <code>style.left</code> for this element
<code>cury = parseInt(movingobj.style.top);</code>	Extract the number from the <code>style.top</code> for this element
<code>movingobj.style.left = String(curx+delx)+"px";</code>	Reset the <code>style.left</code> using the calculated values and concatenate "px"
<code>movingobj.style.top = String(cury+dely)+"px";</code>	Reset the <code>style.top</code> using the calculated values and concatenate "px"
<code>}</code>	Close if
<code>}</code>	Close moving function
<code>&lt;/script&gt;</code>	Ending script tag
<code>&lt;/head&gt;</code>	Ending head tag
<code>&lt;body id="body" onLoad="init();"&gt;</code>	Body tag; note <code>onLoad</code> attribute
<code>&lt;h2&gt; Monkey bars&lt;/h2&gt;</code>	Title displayed
<code>&lt;form id="questionform" name="questionform" onSubmit="return endjigsaw();" &gt;</code>	Form for submit button to end and re-start and for feedback
<code>&lt;input name="submitbut" type="submit" value=" " size="30"/&gt;</code>	Submit button
Feedback: <code>&lt;input name="feedback" value=" " size="11" /&gt;</code>	Feedback field
<code>&lt;/form&gt;</code>	Close form
<code>&lt;video id="bars" controls="controls" preload="auto" width="800"&gt;</code>	Video element; put in body so it will be loaded before any action taken
<code>  &lt;source src="monkeybars.mp4" &gt;</code>	Type of video
<code>  &lt;source src="monkeybars.webm" &gt;</code>	Type of video
<code>  &lt;source src="monkeybars.ogv" &gt;</code>	Type of video

---

*(continued)*

**Table 8-2.** *(continued)*


---

Your browser does not accept the video tag.	Note for old browsers
<code>&lt;/video&gt;</code>	Close video element
<code>&lt;img src="barsbase.png" id="base" width="800px" height="420px"/&gt;</code>	The <code>img</code> for the base image; it is never shown
<code>&lt;/body&gt;</code>	Close body
<code>&lt;/html&gt;</code>	Close html

---

## Testing and Uploading the Application

Testing the application requires the video files and the image file for the base image to be in the same folder as the HTML document. You can test the adaptability to different window dimensions by changing the window and reloading.

## Summary

In this chapter, you learned how to build a jigsaw puzzle that turns into a video clip. The techniques included the following:

- Adapting to different screen dimensions while keeping the jigsaw pieces and the video in proportion.
- Forming the jigsaw pieces by dynamically creating HTML elements and setting the HTML markup.
- Defining event handling for mouse events.
- Placing the jigsaw pieces randomly on the screen at the start of a game and then moving the elements in the response to movement of the mouse.

- Producing the code to check if the jigsaw puzzle is complete, within a tolerance.
- When appropriate, making the video appear and play.

In the next chapter, we tackle another project that includes a jigsaw puzzle, along with other possible moves by the player. Because a jigsaw puzzle such as my set of the 50 states is challenging, I explain a way to store the puzzle as a work-in-progress using the `localStorage` feature of HTML5.



## CHAPTER 9

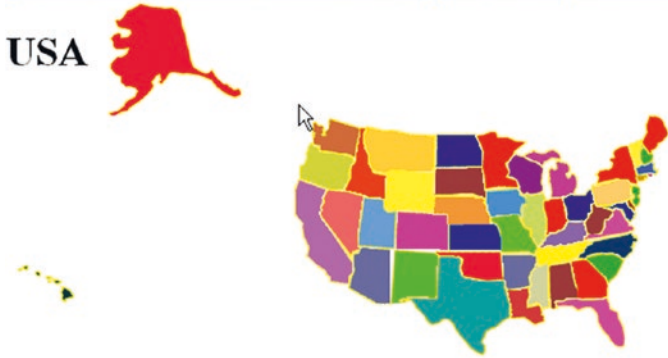
# US States Game: Building a Multiactivity Game

In this chapter, you will learn the following:

- How to build a user interface for a game involving different types of player moves, including putting together a jigsaw puzzle
- How to use the mouse to reposition pieces
- How to acquire an image, break it up into pieces, and determine the coordinates for those pieces to produce a jigsaw puzzle
- How to encode and retrieve the current state of the jigsaw game
- How to use `localStorage` to store and retrieve the information, including using `try` and `catch` for situations when `localStorage` is not allowed

## Introduction

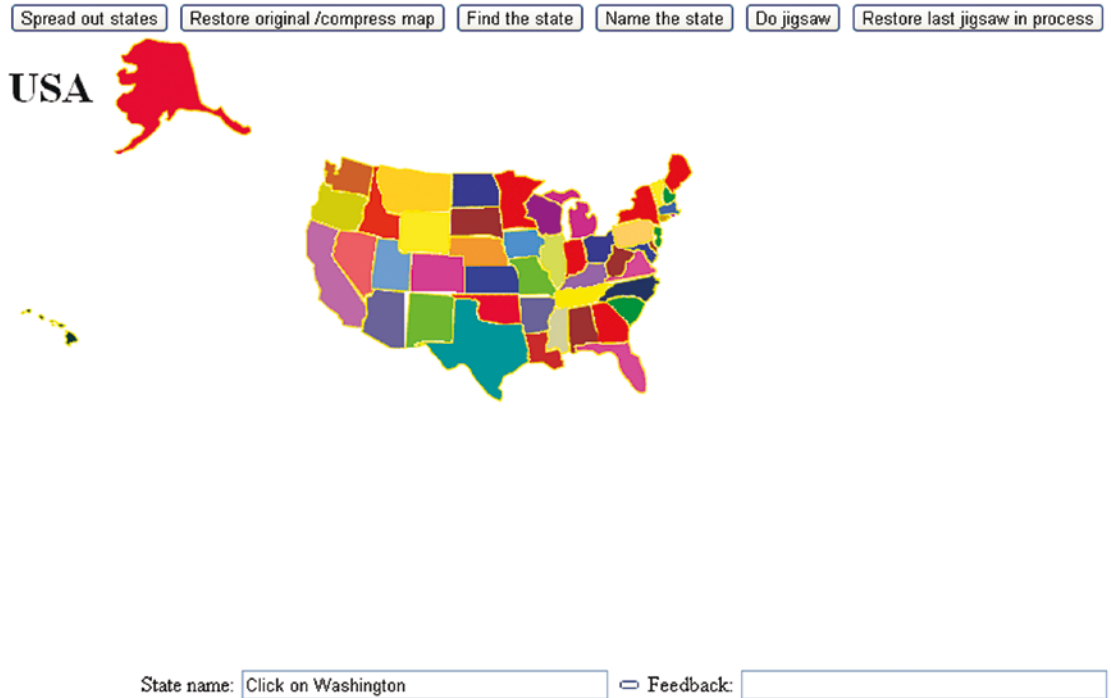
The project for this chapter is an educational game in which the player/student clicks a state on a map of the United States in response to a text prompt, names a state that is indicated by a border by typing in the name, or puts the states that have been randomly positioned on the screen all together again. Figure 9-1 shows the opening screen.



State name:

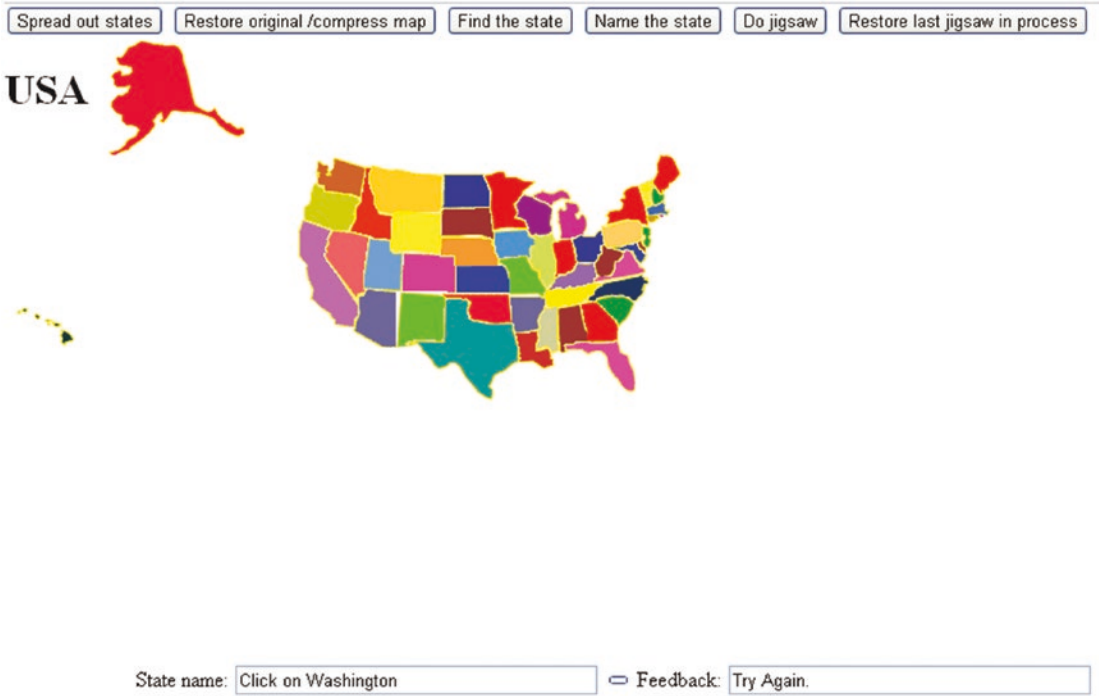
**Figure 9-1.** *Opening screen of the US states game*

I follow the common practice and present a map with Alaska and Hawaii not in correct position nor proportionally sized. Note also that Rhode Island is bigger than it really is so there's enough room to click it. The game presents the player with different possibilities. Figure 9-2 shows the result of clicking the Find the State button.



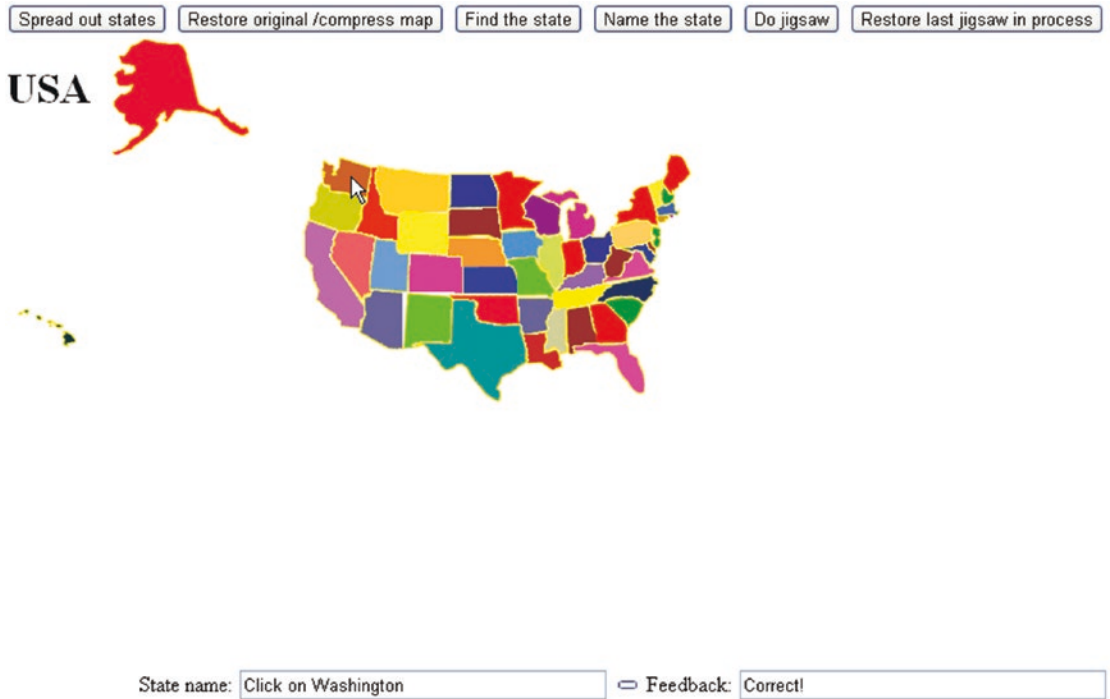
**Figure 9-2.** *The prompt is to find Washington*

When I clicked Oregon, I saw what is shown in Figure 9-3.



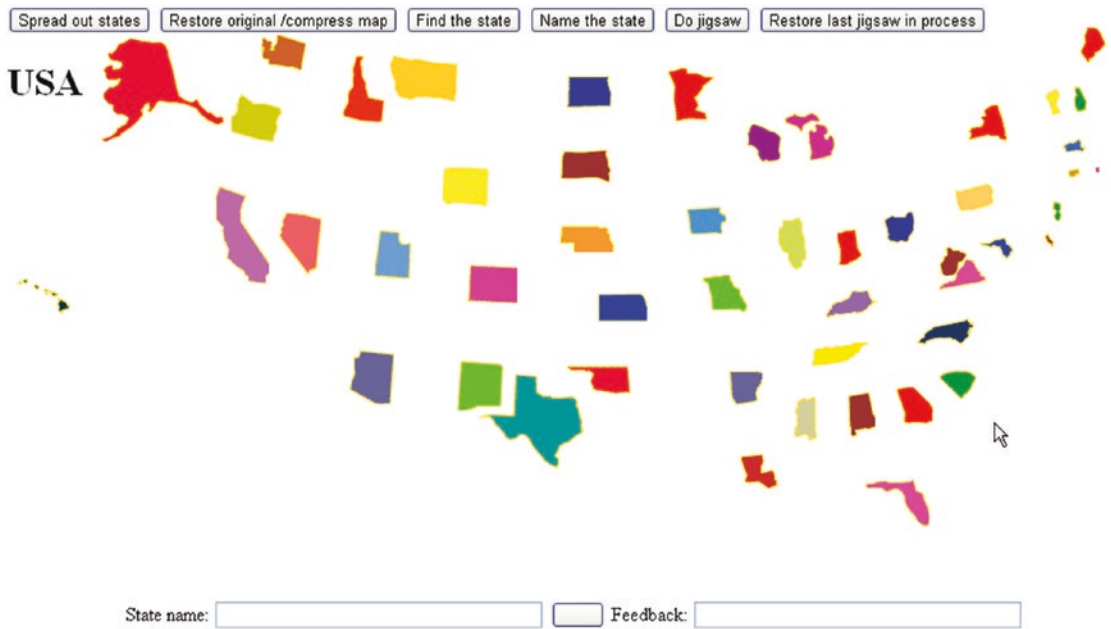
**Figure 9-3.** *Response to an incorrect choice*

When I clicked the correct choice, the application responded appropriately, as shown in Figure 9-4.



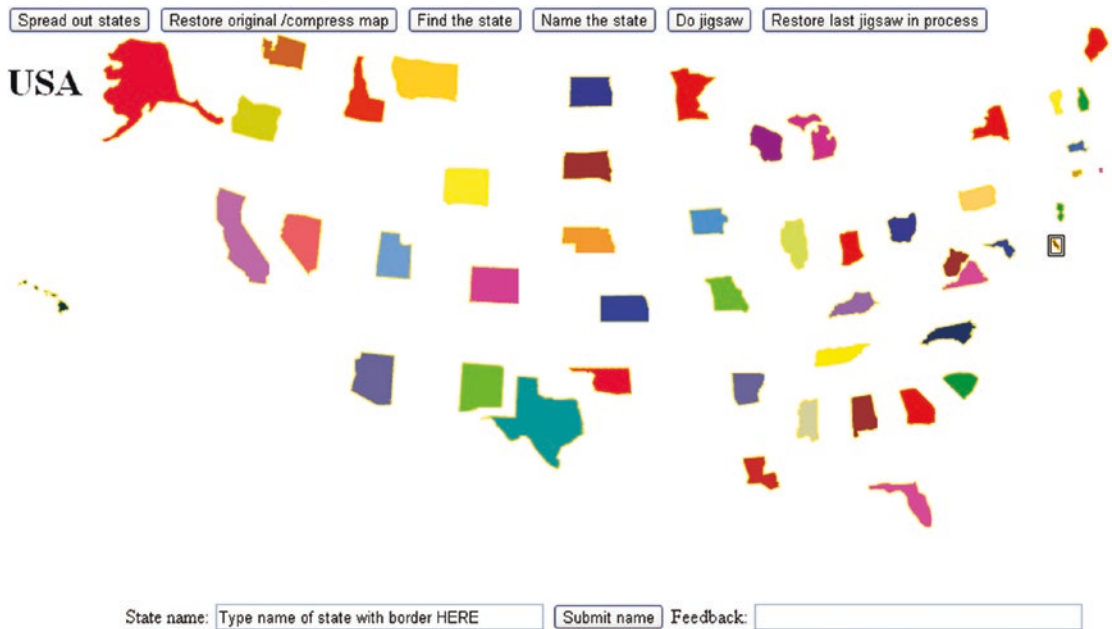
**Figure 9-4.** Response to a correct answer

I decided that it would be helpful to offer the player the option to spread out all the states. After clicking the button labeled Spread Out States, you see what is shown in Figure 9-5.



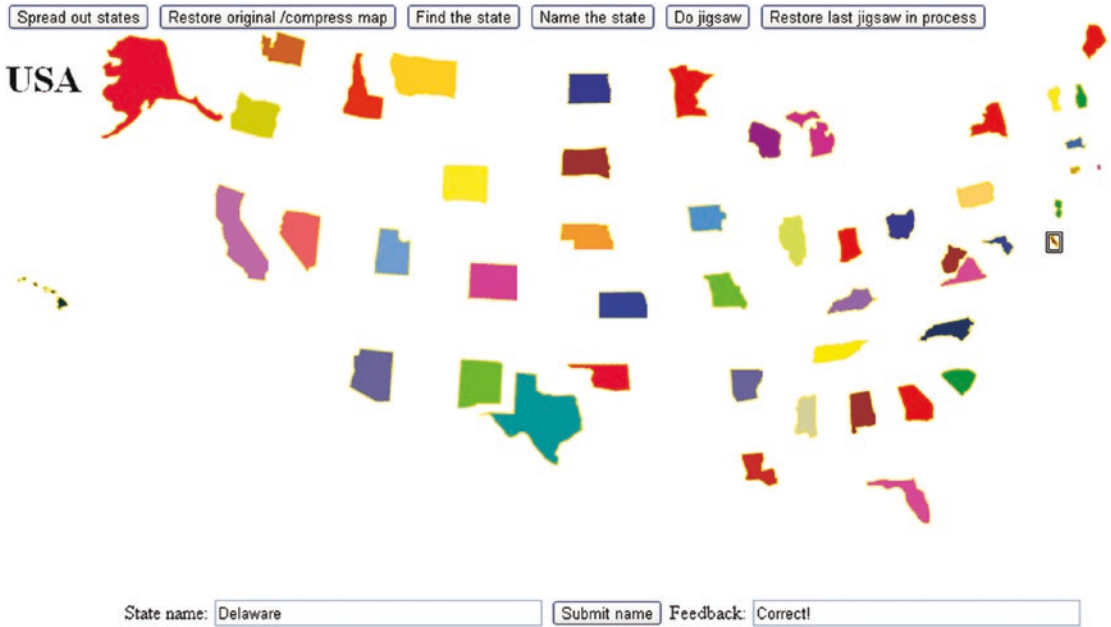
**Figure 9-5.** *The states spread out*

The player can use the Restore Original/Compress Map button or keep playing with the states spread out. Clicking the Name the State button produces a prompt consisting of one randomly selected state surrounded by a border, as shown in Figure 9-6.



**Figure 9-6.** Border around the state to be named

Notice the double-line border around Delaware, the very small state on the right side (Atlantic coast) in the middle. This demonstrates a case in which the states being spread out would make a real difference for the player. Figure 9-7 shows the response to my typing the correct answer.



**Figure 9-7.** Response after the correct answer is submitted



The application also provides activity for the player in the form of a jigsaw puzzle. After clicking the Do Jigsaw button, you will see something like Figure 9-8. I say “something like” because the states are arranged using pseudorandom processing, so they’ll appear in different arrangements each time.



**Figure 9-8.** States jumbled for the jigsaw puzzle

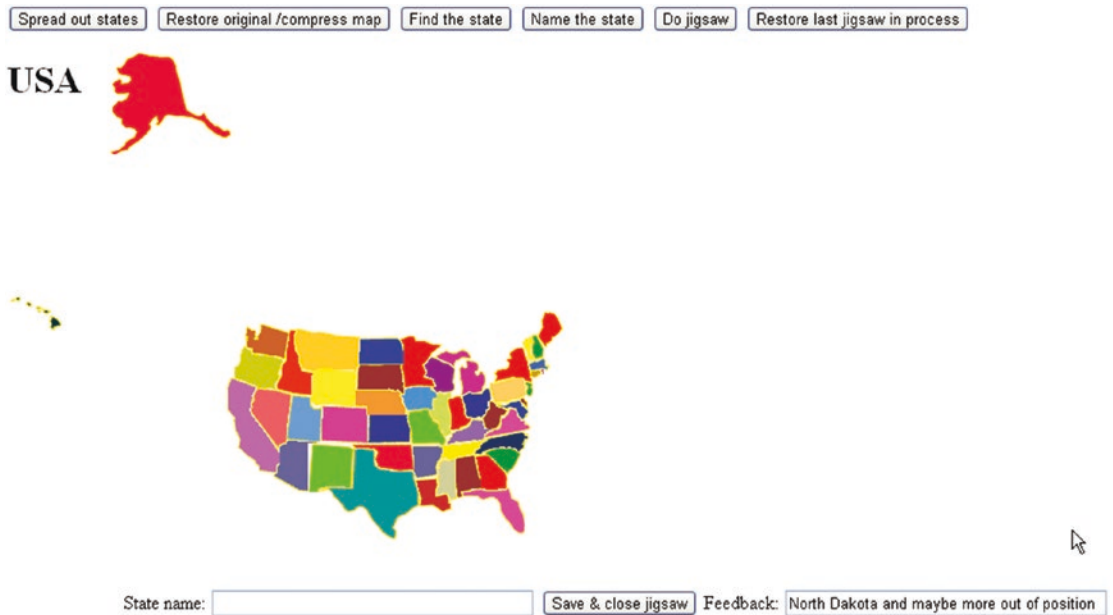
The player can now use the mouse to drag and drop pieces in the same manner (and implemented the same way) as the jigsaw-to-video puzzle described in Chapter 8. Figure 9-9 shows my work in progress.



**Figure 9-9.** *Jigsaw puzzle in progress*

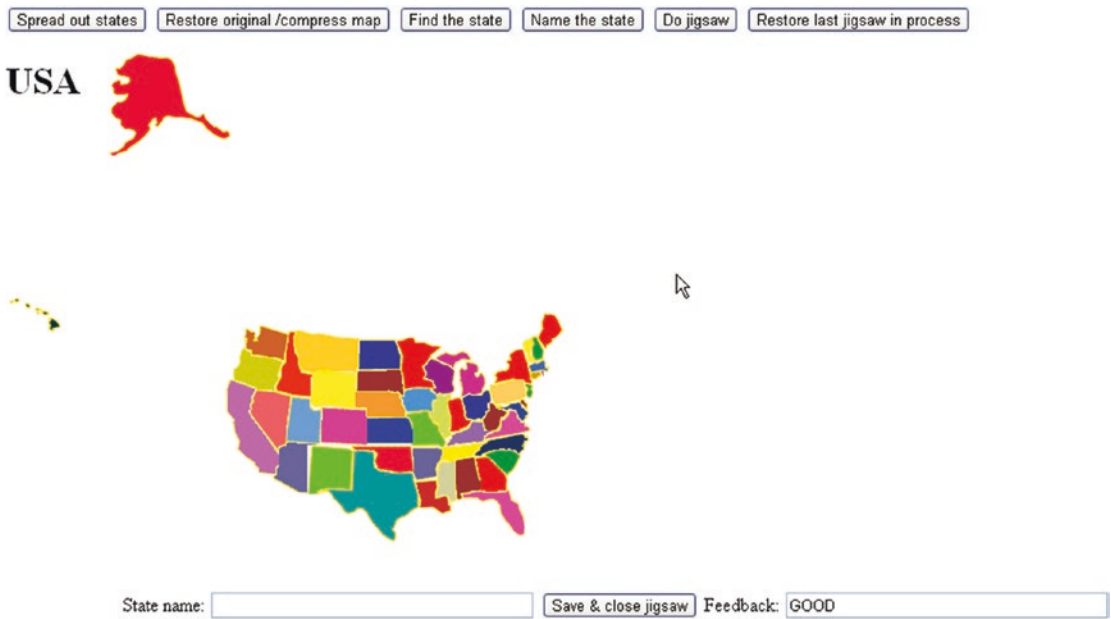
Observe that I have sorted out Alaska and Hawaii, five states in the West, seven states in the South, all of New England, and New York and New Jersey. The feedback says that Illinois and maybe more are out of position. The feedback could be improved, but it is not strictly programming that is the issue.

This was a challenging puzzle for me. In the interests of full disclosure, and also because it demonstrates a feature of the game, I clicked the Save & Close Jigsaw button, which allowed me to see the states all back in position. I then clicked Restore Last Jigsaw in Process to get back to where I was. With this facility available to me, I was able to get to what is shown in Figure 9-10.



**Figure 9-10.** *Not quite correct*

The feedback indicates that something is wrong with North Dakota. After cheating—that is, clicking Save & Close Jigsaw and looking at the completed map—I realized that North Dakota and Kansas, two similar rectangular shapes, needed to be swapped. Figure 9-11 shows the correct arrangement.



**Figure 9-11.** *Jigsaw puzzle put together correctly*

Notice that the positions of Alaska and Hawaii are not closely examined. The puzzle is deemed complete.

After this introduction showing the features of this educational game, I will describe the critical requirements for implementation.

## Critical Requirements

The critical requirements for the educational game involve presenting the player with different types of activities. For the jigsaw puzzle activity, the application provides a save-and-restore feature. This feature can be used to take a look at the completed puzzle or to put the puzzle aside for a period of time and do something else. The task for the builder of the game is to provide the features of the user interface and ways for play to go from one type of activity to another.

The application requires the presentation of a complete map of the United States, with the individual states clickable. The first type of activity I described in the “Introduction” section was for the game to display the name of a state and prompt the player to click it. The application must be able to determine if the response was right or wrong and provide feedback.

The next type of activity I demonstrated is the opposite. A state on the map is marked in some way, and the player is prompted to type in the name. There are different ways to single out an individual state. I chose to put a border around the state to be named. The program must read in the player input and determine if the name was correct.

After implementing these two types of activities, it occurred to me that we have some very small states. I then decided to provide the spread-out feature and the capability of undoing it. This could be useful for other maps as well. I also modified the image representing tiny Rhode Island to be bigger.

Lastly, I decided to provide a way to see if people could put the states together. The application presents a jigsaw puzzle in which the states are randomly positioned on the screen, and the player uses the mouse to reposition them. It was at this point that I realized that I needed something different from the drag-and-drop-in-bins feature of HTML5. If you haven't done so already, you can now read Chapter 8 for how to implement a jigsaw puzzle. The US States game has two additional requirements: I need to build a way to enter jigsaw mode and exit it so that the buttons all work and so the player can click a state. I also need a way to save an incomplete puzzle. This wasn't necessary for the monkey bar video featured in the jigsaw-to-video project in Chapter 8, but it is necessary for a jigsaw puzzle with 50 pieces. I also view this as an educational game, so it is appropriate to give players a chance to look at the completed map, and also to rest.

## HTML5, CSS, JavaScript Features, Programming Techniques, and Image Processing

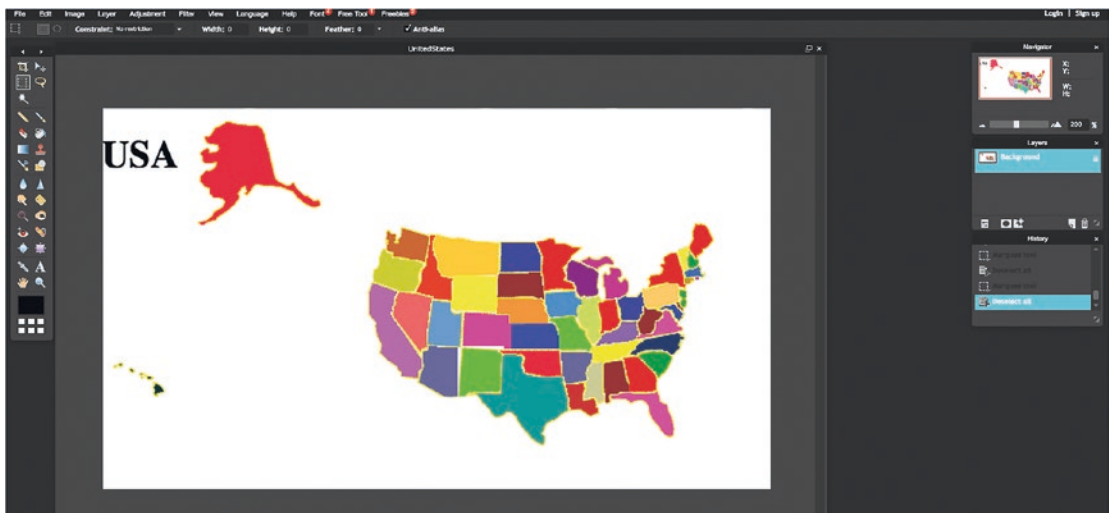
The features and techniques to implement the educational states game are, for the most part, things you have seen before. However, putting them together can be tricky, so there will be some redundancy between this chapter and the material in previous chapters.

### Acquiring the Image Files for the Pieces and Determining Offsets

Image files for each of the 50 states are part of the downloads for this chapter. However, since you may want to make your own map puzzle, I will describe the critical features of the puzzle pieces and the information necessary for checking positioning and for restoring the completed map which must be recorded.

You need to produce image files for each puzzle piece, that is, each individual state of the United States for my game. Since no state is strictly rectangular and image files need to be rectangles, the images will be a bounding box for each state with the areas outside the actual state transparent. There is no special treatment to accommodate the islands of Hawaii or upper and lower Michigan.

The first tasks for making the individual pieces representing the states is to acquire a map of the United States (or the country or region you pick) and to pick your favorite image processing program. I used Adobe Flash, which was popular when I made my first United States game example, but will illustrate the process using pixlr, an online image editing tool. The numbers in the source are from my original implementation and will not be the numbers mentioned here. Figure 9-12 shows the map of the United States. Alaska and Hawaii are not positioned accurately. I finesse this challenge by simply not checking positioning for these two states when my code checks on the job done by the player.



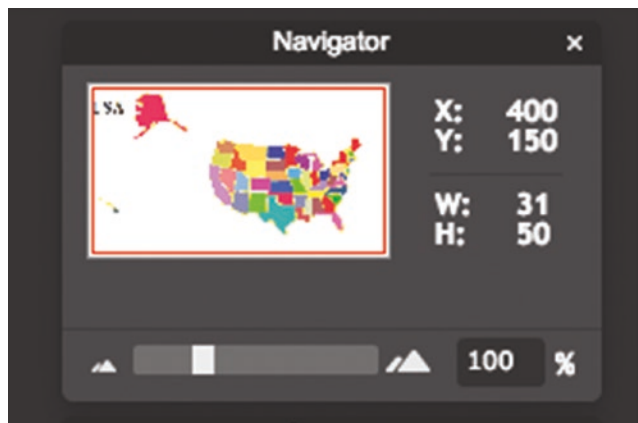
**Figure 9-12.** Original complete map image in pixlr

The next task is to determine the relative location information for each state. The information needed is the relative location of the upper-left corner for a bounding rectangle for each state. This point may not be on the state, but it will determine the correct position. In Figure 9-13, I have used the marquee tool to draw a box around the state of Illinois.



**Figure 9-13.** *Box around Illinois*

When doing this, I write down the x and y coordinates of the starting position, the upper-left corner of the box, from the Navigator panel, shown in Figure 9-14.



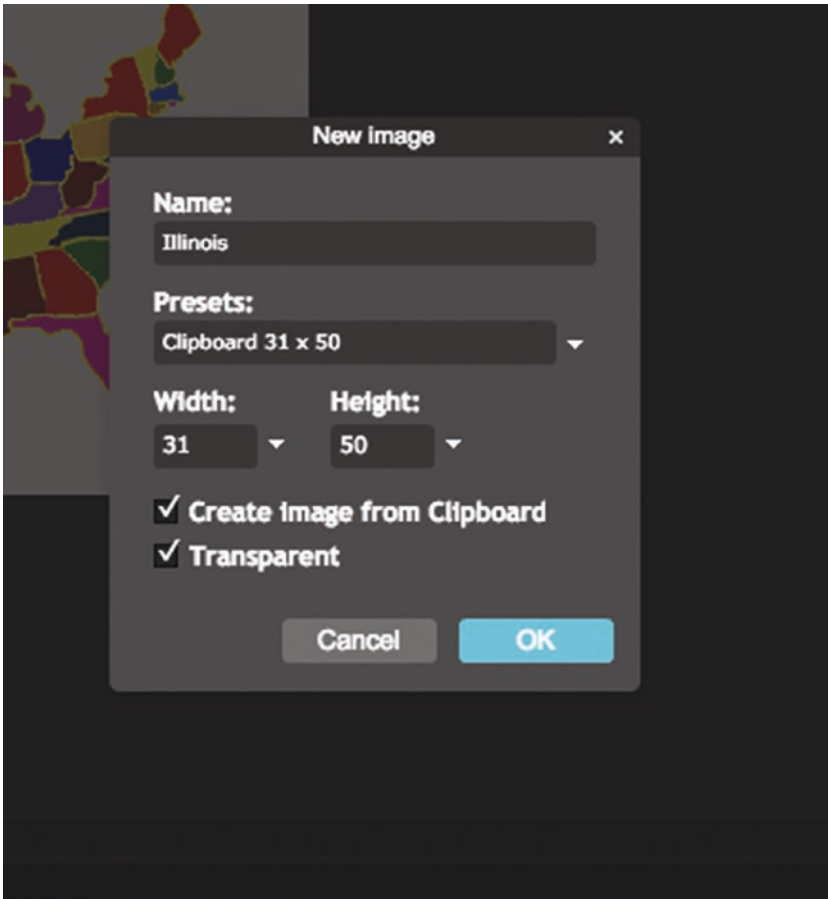
**Figure 9-14.** *Navigator panel*

---

**Note** These are not the coordinates for the upper corner for Illinois, but what was produced during my process for taking screenshots. The Navigator panel shows the position of the mouse.

---

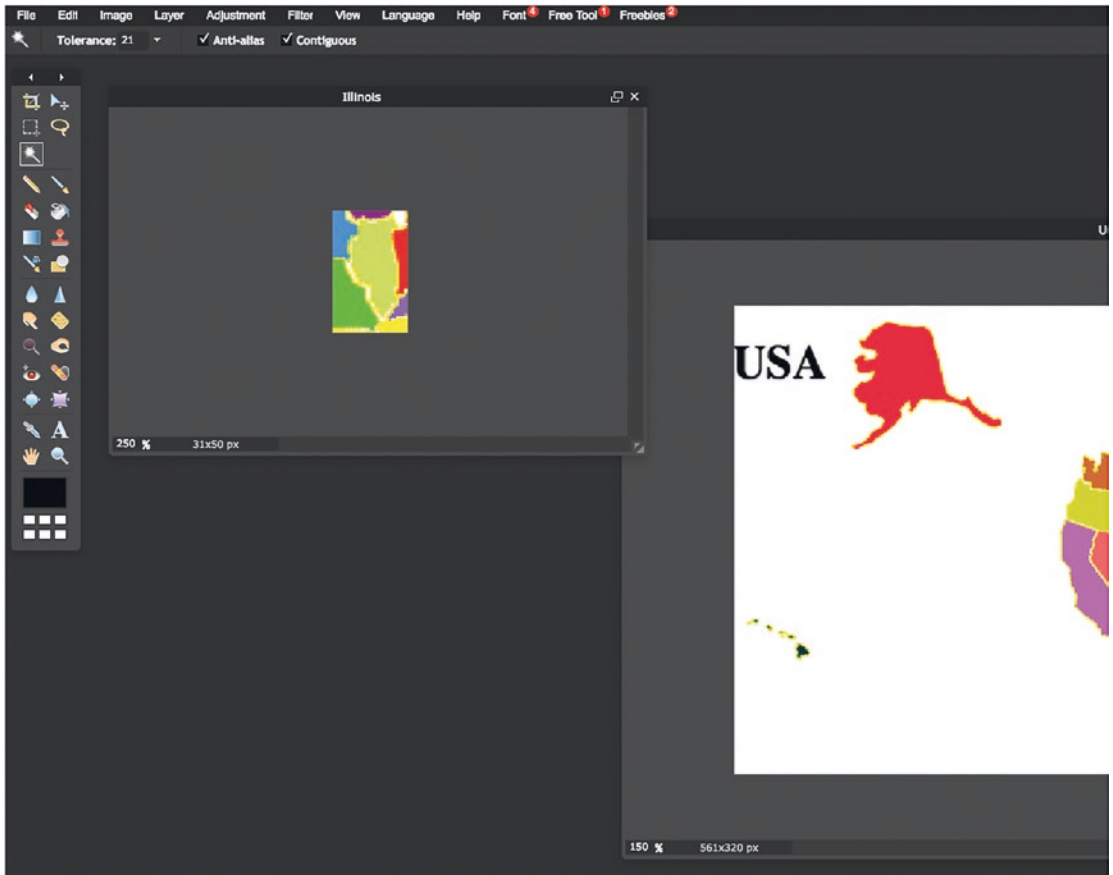
The next task is to copy the selection into a new image using first Copy on the drop-down menu under Edit on the pixlr toolbar and then New Image under File. Figure 9-15 shows the panel that appears. Notice that I have given the image a name, Illinois, and the instructions to take the image from the clipboard and maintain transparency. I will need to do something to create the transparent regions.



*Figure 9-15. Panel to create a new image, giving it a name and instructions*

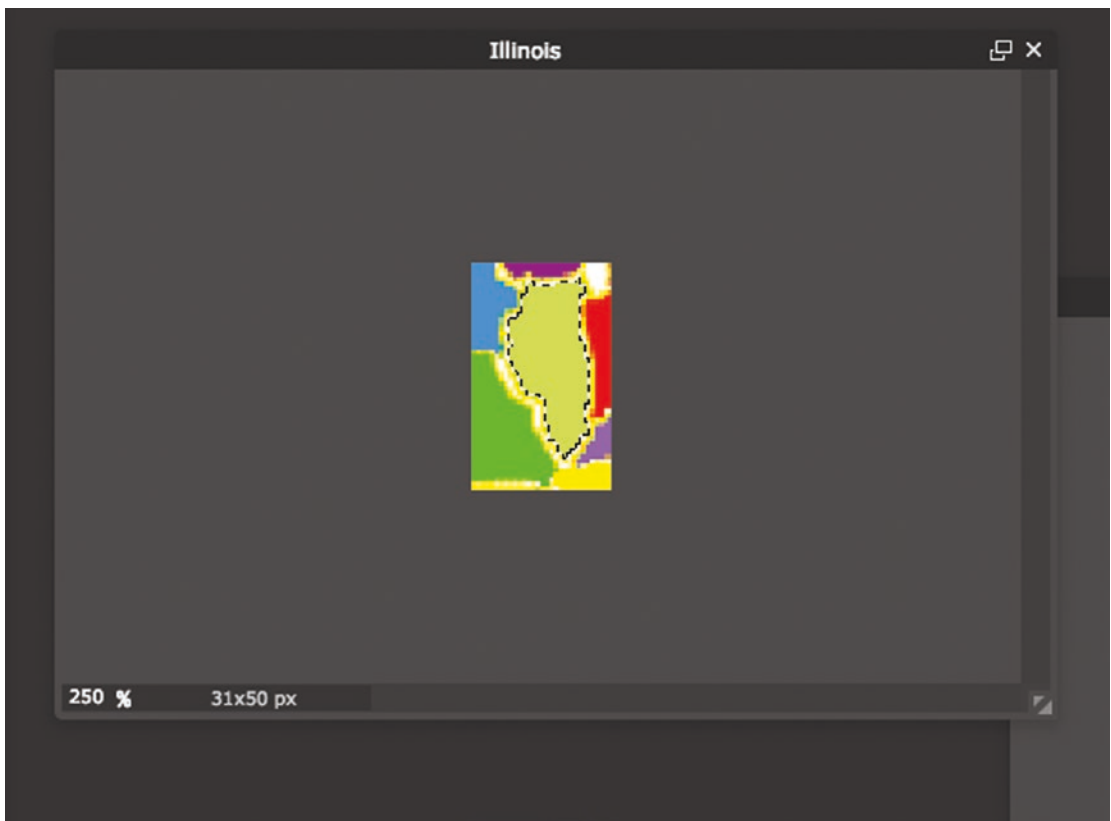


The pixlr program now has two images and I needed to move the big map one to get at the new image. I also used the zoom feature under View to make it bigger. It is shown in Figure 9-16.



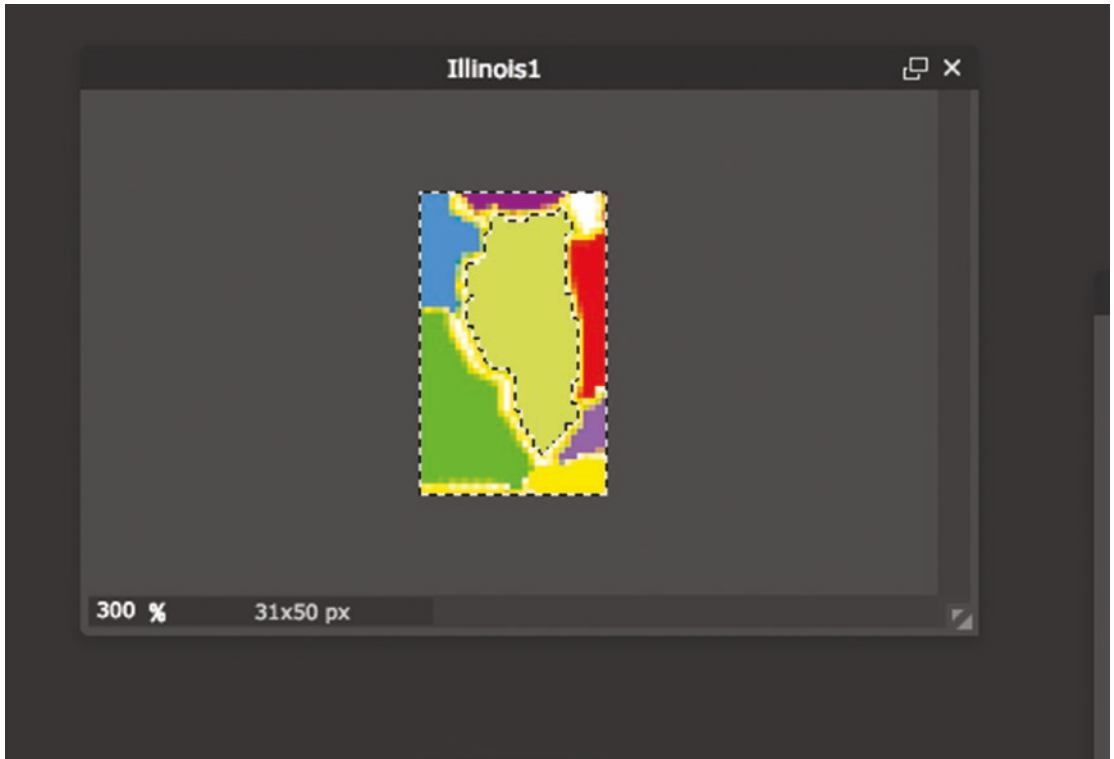
**Figure 9-16.** *New image holding Illinois*

I now use the wand (also sometimes called magic wand) tool and click on the light green Illinois. This selects just Illinois, as shown in Figure 9-17, using the color. It does not have to be the only light green region on the map but just be different from the adjacent regions.



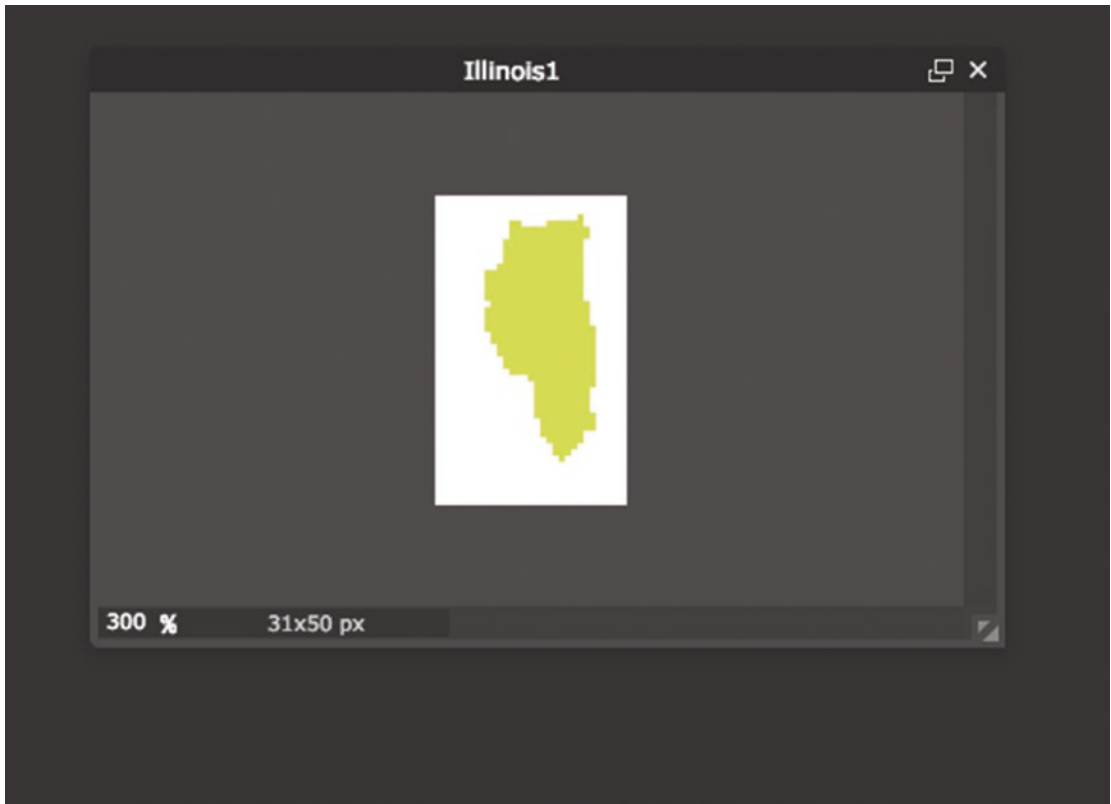
**Figure 9-17.** Selection of Illinois using the wand tool

What I want is to cut out everything except the Illinois shape. This is performed by Edit/Invert Selection. This is shown in Figure 9-18. By the way, I saved this file as a PNG with transparency and named it Illinois1, just to not confuse myself.



**Figure 9-18.** *Inverted selection: everything except the image of Illinois*

Then I Edit/Cut and produce the Illinois shape against a white background, which actually is transparent. Figure 9-19 shows the image that I save.



**Figure 9-19.** *The Illinois image against a transparent background*

These are the necessary steps for each state.

I created arrays holding the names of the image files and the horizontal (x) and vertical (y) offset data. I also created an array listing the full names of the states. These are four parallel arrays. An alternative approach could be to systematically save the files with an underscore for any internal breaks—for example, `North_Carolina.gif`. I could write code to replace the underscore with a blank both for the game to display and for checking player’s answers. However, I decided to produce the names directly. Having described the creation of the four parallel arrays holding everything the program needs for the states, it now is time to review how to create the elements.

## Creating Elements Dynamically

Chapter 6 and Chapter 8 each involved generating HTML markup dynamically—that is, during runtime. The states game and other map games you may create will also feature this technique. The work is done in the function `setupgame`.

The code determines how many elements—that is, puzzle pieces—from the `nums` variable have been set to be the length of the `states` array. If and when you build a puzzle with 10 countries, for example, `nums` will be set to 10. A `for` loop is used to construct an element for each state. Each element has a generated unique ID value. The attribute `innerHTML` of any element is set to be the markup. The code uses the information in the array variables `states`, `statesx`, and `statesy`. As was the case in the last chapter, the code converts numbers to character strings, and then concatenates the string "px" to make the values for setting the `style.top` and `style.left` attributes of the element. The code follows:

```
function setupgame() {
  var i;
  var x;
  var y;
  var uniqueid;
  var s;
  for(i=0;i<nums;i++) {
    uniqueid = "a"+String(i);
    s = document.createElement('state');
    s.innerHTML = (
      "<img src='"+states[i]+''' id='"+uniqueid+''/>");
    document.body.appendChild(s);
    thingelem = document.getElementById(uniqueid);
    x = statesx[i] +310;
    y = statesy[i] + 200;
    thingelem.style.top = String(y)+"px";
    thingelem.style.left = String(x)+"px";
    stateelements.push(thingelem);
  }
}
```

```

questionfel = document.getElementById("questionform");
questionfel.style.left = "100px";
questionfel.style.top = "500px";
questionfel.question.value = " ";
questionfel.feedback.value = " ";
}

```

The element is created of a custom defined type 'state'. Its innerHTML is set with the appropriate value. The positioning is done using the offset values in the statesx and statesy arrays (corresponding to the arrays I named piecesx and piecesy in Chapter 8). The second part of the setupgame function positions the form already present in the body element. The form will be used for the identifying and naming activities.

## User Interface Overall

It is time to reveal the body element for the application since that will show the buttons for the various operations:

```

<body id="body" onLoad="init();">
<button onClick="spread();">Spread out states </button>
<button onClick="restore();">Restore original /compress map </button>
<button onClick="setupfindstate();">Find the state </button>
<button onClick="setupidentifystate();">Name the state</button>
<button onClick="setupjigsaw();">Do jigsaw</button>
<button onClick="restorepreviousjigsaw();">Restore last jigsaw in process
</button>
<h1>USA</h1>
<form id="questionform" name="questionform" onSubmit="return checkname();">
State name: <input type="text" name="question" value=" " size="40"/>
<input name="submitbut" type="submit" value=" " size="30"/>
Feedback: <input type="text" name="feedback" value=" " size="40" />
</form>
</body>

```

The HTML markup produces the six buttons at the top of the screen (refer back to Figure 9-1). The buttons on top each invoke a function; more detail on each follows in the next few sections. The form at the bottom is used in distinct ways for each of the

three different types of activity. This is a design decision; I am trying to be efficient with screen real estate, avoiding the clutter of multiple forms at the possible cost of confusion to the player.

## User Interface for Asking the Player to Click a State

After the player clicks the Find the State button, the application generates a question. Before choosing the state, the program removes any border that may exist around the last chosen state. This situation could arise if the player had just performed the name a state activity. If this is the very first activity by the player, the code would not produce an error, but would merely set the border of the 0th state to empty, which is what it already was. It is a good habit to make the start of any activity do this type of housekeeping. It makes the application easier to change or upgrade in the future. Similarly, if the previous question also was an identifying question, the code would not produce an error. This transition from activity to activity must be attended to for the game to work smoothly. We do not want any state to have a border when the player has moved on to the next activity.

The `setupfindstate` function makes a random choice among the states. The global variable `choice` holds a value made for the random choice. The function then sets up event handling for each of the elements corresponding to a state. The prompt for the player is placed in the question field of the form.

```
function setupfindstate(){
    var i;
    var thingelem;
    stateelements[choice].style.border="";
    choice = Math.floor(Math.random()*nums);
    for (i=0;i<nums;i++) {
        thingelem = stateelements[i];
        thingelem.addEventListener('click',pickstate,false);
    }
    var nameofstate = names[choice];
    questionfel.question.value = "Click on "+nameofstate;
    questionfel.feedback.value = " ";
    questionfel.submitbut.value = "";
}
```

The appropriate player response for this activity is to click a state on the map. When the player clicks any state, JavaScript event handling is set up to invoke the `pickstate` function. The task of this function is to determine if the player's pick was the correct one. To do this, my code uses information in the event information passed to the function and the value in the global variable `choice` set by `setupfindstate`. The code for `pickstate` is

```
function pickstate(ev) {
    var picked = Number(ev.target.id.substr(1));
    if (picked == choice) {
        questionfel.feedback.value = "Correct!";
    }
    else {
        questionfel.feedback.value = "Try Again.";
    }
}
```

Now I need to remind you of how I set the ID fields for each of the state elements. I used the index values 0 to 49 and added an *a* at the beginning. This addition of an *a* was not strictly necessary. I did it when I thought I may be creating other sets of elements. The `ev` parameter to `pickstate` has a `target` attribute referencing the target that received the click event. The ID of that target would be `a0`, or `a1`, or `a2`, and so forth. The `String` method `substr` extracts the substring of a string starting at the parameter, so `substr(1)` returns 0, 1, 2, and so on. My code turns the string into a number. It now can be compared to the value in the global variable `choice`.

You may decide to limit the number of tries a player can make and/or provide hints.

## User Interface for Asking the Player to Name a State

After the player chooses to do the activity of naming a state, the `setupidentifystate` function is invoked. The task is to place a border around a state on the map and prompt the player to type in the name. For this operation, unlike the last one, my code puts in a value for the submit button. The function also removes the event handling for clicking a state.

```
function setupidentifystate(){
    stateelements[choice].style.border="";
    stateelements[choice].style.zIndex = "";
    choice = Math.floor(Math.random()*nums);
}
```



```

stateelements[choice].style.border="double";
stateelements[choice].style.zIndex = "20";
questionfel.question.value = "Type name of state with border HERE";
questionfel.submitbut.value = "Submit name";
questionfel.feedback.value = " ";
var thingelem;
for (i=0;i<nums;i++) {
  thingelem = stateelements[i];
  thingelem.removeEventListener('click',pickstate,false);
}
}

```

The player's action is examined by the `checkname` function. This is already set up as the `onsubmit` attribute for the form. The function `checkname` actually does double-duty: if the current activity is doing the jigsaw, `checkname` ends that activity by restoring the states to their original locations, that is, the original map of the whole United States. If the player is not doing the jigsaw puzzle, `checkname` checks whether or not the player has typed in the correct name for the chosen state. The code in `checkname` follows:

```

function checkname() {
  if (doingjigsaw) {
    restore();
  }
  else {
    var correctname = names[choice];
    var guessedname = document.questionform.question.value;

    if (guessedname==correctname) {
      questionfel.feedback.value = "Correct!";
    }
    else {
      questionfel.feedback.value = "Try again.";
    }
  }
  return false;
}
}

```

Notice that again I do not limit the number of tries, nor do I give any hint or any tolerance for misspellings.

## Spreading Out the Pieces

The task of spreading out the states while maintaining their positional relationships is straightforward, although I did some experimentation with the constants to get the effect I wanted. The idea is to use the offset values in a systematic way. The offsets represent distances from a point roughly in the center of the map. My code stretches those offset values for all the states except Alaska and Hawaii. I have positioned Alaska and Hawaii to be the last two states. The code follows:

```
function spread() {
  var i;
  var x;
  var y;
  var thingelem;
  for (i=0;i<nums-2;i++) { // don't move alaska or hawaii

    x = 2.70*statesx[i] +410;
    y = 2.70*statesy[i] + 250;
    thingelem = stateelements[i];
    thingelem.style.top = String(y)+"px";
    thingelem.style.left = String(x)+"px";
  }
}
```

Restoring the states is simply a matter of repositioning them at the values indicated in the `statesx` and `statesy` arrays. The `restore` function will be explained following, in the “Saving and Recreating the State of the Jigsaw Game and Restoring the Original Map” section.

## Setting Up the Jigsaw Puzzle

Setting up the jigsaw activity involves randomly positioning the states on the screen and setting up the event handling for the mouse operations. It also means turning off the default drag-and-drop event handling and also turning off the buttons at the top of the screen. The submit button on the question form at the bottom of the screen will be left operational, and this button will perform the operation of saving the state of the jigsaw puzzle, as described in the next section. The only way to stop the jigsaw activity, restore the map, and return to the other activities is to click the button.

The newly created div with ID `fullpage`, created to prevent the drag-and-drop default action, is set up in the style section to not cover the bottom of the screen containing the form. The CSS is

```
#fullpage
{
  display:block;
  position:absolute;
  top:0;
  left:0;
  width:100%;
  height:90%;
  overflow: hidden;
  z-index: 1;
}
```

Recall that in CSS, the layering is done with the attribute `z-index`. In JavaScript, the attribute is `zIndex`. The `setupjigsaw` function follows:

```
function setupjigsaw() {
  doingjigsaw = true;
  stateelements[choice].style.border="";
  var i;
  var x;
  var y;
  var thingelem;
  for (i=0;i<nums;i++) {
    x = 100+Math.floor(Math.random()*600);
```

```

    y = 100+Math.floor(Math.random()*320);
    thingelem = stateelements[i];
    thingelem.style.top = String(y)+"px";
    thingelem.style.left = String(x)+"px";
    thingelem.removeEventListener('click',pickstate,false);
  }
d.onmousedown = startdragging;
d.onmousemove = moving;
d.onmouseup = release;
var df = document.createElement('div');
df.id = "fullpage";
bodyel.appendChild(df);
questionfel.question.value = "";
questionfel.submitbut.value = "Save & close jigsaw";
questionfel.feedback.value = " ";
questionfel.style.zIndex = 100;
}

```

The player does the jigsaw puzzle by using the mouse to reposition the pieces. Go back to Chapter 8 for explanation of the use of the mouse events. The check for completeness is done each time the player lets up on the mouse button. The release function invokes the function I named `checkpositions`. The `checkpositions` puzzle computes the average difference in `x` and the average difference in `y` of the actual positions of the pieces to the offsets stored in the `statesx` and `statesy` arrays. The code then checks if any difference is more than the tolerance amount from the corresponding average. The function stops iterating over the pieces as soon as one is found to be out of place. For the very simple six-piece jigsaw puzzle in Chapter 8, my feedback to the player when this occurs is simply to display “Keep working.” For the US States game, I wanted to do something more. What I decided to do was to report the first state in which either the `x` or the `y` difference was greater than the average. When most of the pieces are not in place, this information is not especially helpful, so this is an opportunity for improvement.

## Saving and Recreating the State of the Jigsaw Game and Restoring the Original Map

As I noted previously, the only way to end the jigsaw activity is to click the submit button on the form. If the global variable `doingjigsaw` is true, then the `restore` function is invoked. The `restore` function will turn off the event handling for the mouse and remove the `fullpage` div. I realized that even I could not complete the jigsaw puzzle in a single session and without cheating—that is, looking at the completed puzzle. I am getting better at it, however. This is what motivated me to implement a save-and-restore feature.

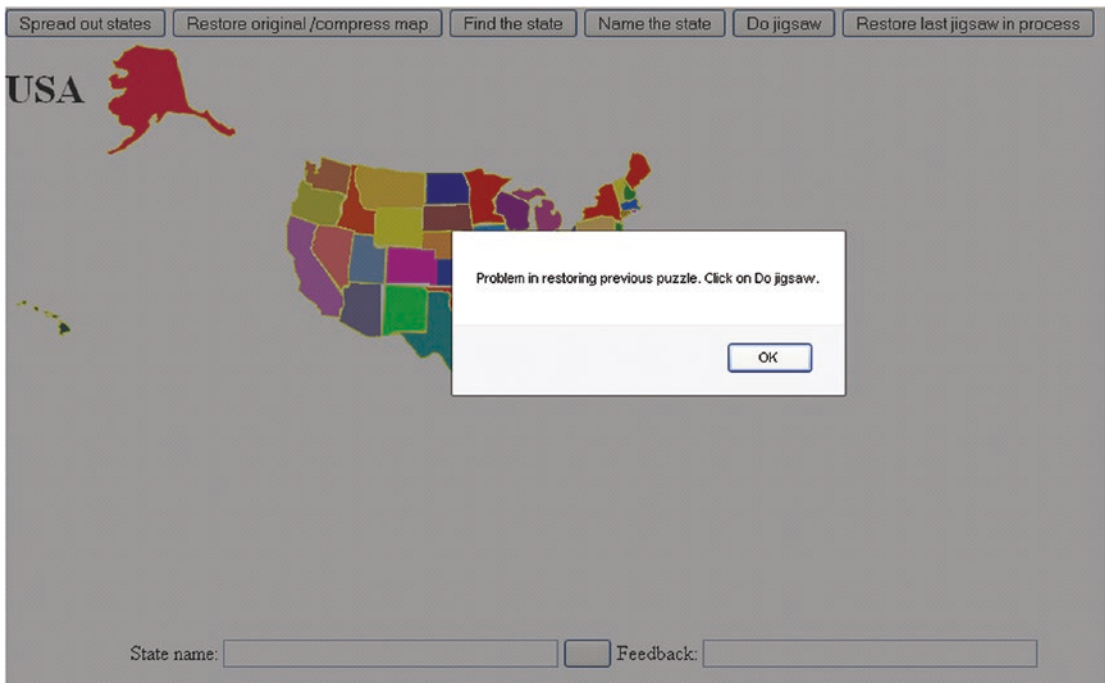
The issue of defining application states depends, naturally enough, on the application. Saving the state of a jigsaw game in process requires code to encode the position of each puzzle piece. For the jigsaw puzzle, what needs to be stored are the `style.top` and `style.left` attributes of each of the elements. I will be using the `localStorage` feature of HTML5, which is a version of cookies. I will describe `localStorage` next. The goal for this program is to have one character string hold all the information. What I do first is combine `style.top` and `style.left` into one string by using `&` to concatenate them. I then put each of these strings into an array using the following line:

```
xydata.push(thingelem.style.top+"&"+thingelem.style.left);
```

When all 50 strings have been placed in the array, my code uses the `join` method to combine everything in one big array, with the delimiter of my choice (`;`) separating them. This is the string that is stored using `localStorage`.

In HTML5, `localStorage` is a variation on cookies. Values are stored on the player's (client) computer as name/value pairs. A `localStorage` item is associated with the browser. The state of the jigsaw puzzle stored when using Firefox will not be available when using Chrome. For the name of the `localStorage` item, I use the name `jigsaw`, and for the value, the result of the `join` operation.

The `localStorage` facility may not work. For example, the player may have used the browser settings to prevent any use of cookies, `localStorage` or other, similar features. A `localStorage` item is associated with a specific web domain. Chrome allows setting and retrieving from a program on the local computer. When I originally built this application, Firefox threw an error for retrieving data. My code uses `try` and `catch` to present an alert statement if there are problems. Figure 9-20 shows the result of trying to restore a jigsaw puzzle saved using Firefox when using a file on the local computer. This could also happen if the player/user turned off the use of cookies.



**Figure 9-20.** Alert shown when trying to use `localStorage` locally with Firefox

Moving on, there are two distinct functions: `restore` and `restorepreviousjigsaw`. Remember that the `restore` function does double-duty: it restores the original map after the pieces are spread out *and* it restores the original map after the player has done the jigsaw activity.

```
function restore() {
    var i;
    var x;
    var y;
    var thingelem;
    var df;
    var lsname = "jigsaw";
    var xydata = [];
    var stringdata;
    if (doingjigsaw) {
        doingjigsaw = false;
        d.onmousedown = "";
    }
}
```

```

    d.onmousemove = "";
    d.onmouseup = "";
    df = document.getElementById("fullpage");
    bodyel.removeChild(df);
    for (i=0;i<nums;i++) {
        thingelem = stateelements[i];
        xydata.push(thingelem.style.top+"&" + thingelem.style.left);
    }
    stringdata = xydata.join(";");
    try {
        localStorage.setItem(lsname, stringdata);
    }
    catch(e) {
        alert("data not saved, error given: "+e);
    }
}
for (i=0;i<nums;i++) {
    x = statesx[i] + 310;
    y = statesy[i] + 200;
    thingelem = stateelements[i];
    thingelem.style.top = String(y) + "px";
    thingelem.style.left = String(x) + "px";
}
}

```

The `restorepreviousjigsaw` function attempts to read in the data stored as one long string in `localStorage` under the name `jigsaw`; decodes the string to be an array of 50 strings, each one holding the top and left information; and uses that information to position the pieces. The function then sets up event handling for the mouse events and sets up the `fullpage` div. Finally, the function sets the label of the submit button to indicate that this button saves and closes the puzzle. The code follows:

```

function restorepreviousjigsaw() {
    var i;
    var lsname = "jigsaw";
    var xydata;

```

```

var stringdata;
var ss; // will hold combined top and left for a state
var ssarray;
var thingelem;
try {
stringdata = localStorage.getItem(lname);
xydata = stringdata.split(";");
for (i=0;i<nums;i++) {
    ss = xydata[i];
    ssarray = ss.split("&");
    thingelem = stateelements[i];
    thingelem.style.top = ssarray[0];
    thingelem.style.left = ssarray[1];
}

doingjigsaw = true;
stateelements[choice].style.border="";
d.onmousedown = startdragging;
    d.onmousemove = moving;
    d.onmouseup = release;
    var df = document.createElement('div');
    df.id = "fullpage";
    bodyel.appendChild(df);
questionfel.question.value = "";
questionfel.submitbut.value = "Save & close jigsaw";
questionfel.feedback.value = " ";
questionfel.style.zIndex = 100;
}
catch(e) {
    alert("Problem in restoring previous puzzle. Click on Do jigsaw.");}
}

```



## Building the Application and Making It Your Own

You can make the project your own by refining and building on the states application, perhaps giving hints or keeping score, or using the application as a model for a different part of the world. For a different map, do pay attention to the special handling I use for Alaska and Hawaii. You probably will want to remove the `nums - 2` where it occurs. You can add another parallel array with the names of the capitals and make naming the capital and identifying a state with an indicated capital additional activities. You also can use this as a model for identifying parts of any diagram or picture (e.g., parts of the body). Notice that each activity has a function for setting up and a function for checking the response.

You can use what is described in Chapter 8 to make this project work with finger touches. The US states seemed too much for a phone, but it may be feasible for a tablet. You can use the methods shown in Chapter 5 to extract the content to an external file. If you're feeling really brave, you may also want to experiment with using SVG (scalable vector graphics) to create a vector version of the map.

The application demonstrated individual features that you can use for other projects. An informal outline/summary of the functions in the states game follows:

- `init` is for initialization, including invoking `setupgame`.
- `setupgame` builds the state elements and positions the form.
- `setupfindstate` sets up the clicking state function and `pickstate` checks the player's response.
- `setupidentifystate` sets up the typing in the name, and `checkname` checks the response.
- `setupjigsaw` sets up the jigsaw puzzle. The functions `startdragging`, `moving`, and `release`, along with `offset` and `draw`, handle the player actions with regard to using the mouse to move pieces. The `checkpositions` function, along with `doaverage`, checks if the puzzle is complete.
- `spread` spreads out the pieces and `restore` restores the pieces to the original map locations. The `restore` function also saves the state of the jigsaw puzzle using `localStorage`.
- `restorepreviousjigsaw` extracts the information from `localStorage` to set up the puzzle as it was left.

More formally, Table 9-1 lists all the functions and indicates how they are invoked and what functions they invoke. Notice that several functions are invoked as a result of the function being specified as a method of an object type.

**Table 9-1.** *Functions in the US States Game Project*

Function	Invoked/Called By	Calls
init	Invoked by action of the onLoad attribute in the <body> tag	setupgame
setupgame	Invoked by init	
pickstate	Invoked by addEventListener call in setupfindstate	
spread	Invoked by button	
restore	Invoked by button and checkname	
restorepreviousjigsaw	Invoked by button	
setupfindstate	Invoked by button	
setupidentifystate	Invoked by button	
checkname	Invoked as an action of onSubmit in the form	restore
checkpositions	Invoked by release of mouse (mouseup event)	doaverage
doaverage	Invoked by checkpositions	
setupjigsaw	Invoked by button	
release	Invoked by setting up events in restorepreviousjigsaw and setupjigsaw	checkpositions
startdragging	Invoked by setting up events in restorepreviousjigsaw and setupjigsaw	offset
moving	Invoked by setting up events in restorepreviousjigsaw and setupjigsaw	draw
draw	Invoked by moving the mouse (mousemove event)	
offset	Invoked by startdragging	

Table 9-2 shows the code for the basic application, with comments for each line.

**Table 9-2.** Complete Code for the US States Game Project

Code Line	Description
<code>&lt;!DOCTYPE html&gt;</code>	Doctype header
<code>&lt;html&gt;</code>	html tag
<code>&lt;head&gt;</code>	head tag
<code>  &lt;title&gt;USA States game&lt;/title&gt;</code>	Complete title
<code>&lt;style&gt;</code>	style tag
<code>img {position:absolute;}</code>	All image elements positioned absolutely
<code>form {position: absolute; z-index: 10;}</code>	Form positioned absolutely
<code>body{ height:100%; margin: 0;}</code>	Body styled to take up whole height
<code>  #fullpage</code>	Style directive for the created div
<code>  { display:block; position:absolute;</code>	Take up whole width and nearly whole height;
<code>  top:0; left:0; width:100%;</code>	layer underneath
<code>  height:90%; overflow: hidden;</code>	
<code>  z-index: 1; }</code>	
<code>&lt;/style&gt;</code>	Closing style tag
<code>&lt;script type="text/javascript"&gt;</code>	script tag
<code>var names = [</code>	Names of the states; one of many parallel arrays with information on states; order and grouping here not important but order must be the same and Alaska and Hawaii last
<code>  "Illinois","Iowa","Missouri",</code>	
<code>  "Oregon","Michigan",</code>	
<code>  "Indiana","Vermont",</code>	
<code>  "New Hampshire","Maine",</code>	
<code>  "South Dakota","North Dakota",</code>	
<code>  "Ohio","Wisconsin","Kentucky",</code>	
<code>  "Tennessee",</code>	

(continued)

**Table 9-2.** (continued)

Code Line	Description
<pre>"North Carolina", "South Carolina", "Georgia", "Alabama", "Mississippi", "Virginia", "West Virginia", "Maryland", "Delaware", "Pennsylvania", "New Jersey", "New York", "Rhode Island", "Connecticut", "Massachusetts", "Louisiana", "Arkansas", "Minnesota", "Florida", "Kansas", "Arizona", "California", "Colorado", " Idaho", "Montana", "Nebraska", "Nevada", "New Mexico", "Texas", "Oklahoma", "Utah", "Washington", "Wyoming", "Hawaii", "Alaska" ] var states = [ "illinois.gif", "iowa.gif", "missouri.gif", "oregon.gif", "michigan.gif", "indiana.gif", "vermont.gif", "newhampshire.gif", "maine.gif", "southdakota.gif", "northdakota.gif", "ohio.gif", "wisconsin.gif", "kentucky.gif", "tennessee.gif",</pre>	<p>End of names array</p> <p>Array for addresses of image files</p>

(continued)

**Table 9-2.** (continued)

Code Line	Description
"northcarolina.gif", "southcarolina.gif", "georgia.gif", "alabama.gif", "mississippi.gif", "virginia.gif", "westvirginia.gif", "maryland.gif", "delaware.gif", "pennsylvania.gif", "newjersey.gif", "newyork.gif", "rhodeislandbig.gif", "connecticut.gif", "massachusetts.gif", "louisiana.gif", "arkansas.gif", "minnesota.gif", "florida.gif", "kansas.gif", "arizona.gif", "california.gif", "colorado.gif", "idaho.gif", "montana.gif", "nebraska.gif", "nevada.gif", "newmexico.gif", "texas.gif", "oklahoma.gif", "utah.gif", "washington.gif", "wyoming.gif", "hawaii.gif", "alaska.gif"	
];	End of address-of-image-files array
var statesx = [ 88.65,60.15,65.40, -81.70,90.40, 107.40,171.95,181.00,183.00,21.10, 22.60,	Array of horizontal (x) offsets

(continued)

**Table 9-2.** *(continued)*

Code Line	Description
121.70,78.90,103.65,99.40, 132.20,138.95,125.45,110.45,93.90, 138.95,138.95,151.65,171.95,144.20, 174.20,147.95, 187.75,179.35,177.60,77.40,73.65, 54.15, 115.70,32.35, -44.95,-86.85,-8.15,-47.20, -32.15,21.10, -66.70,-11.15,-4.40,22.60, -36.70, -72.50,-15.65,-300.95,-230.30 ];	End of statesx array
var statesy = [ -26.10,-29.85,-8.45, -64.75,-59.05, -22.70,-66.00,-67.30,-85.65, -47.15,-70.30, -27.90,-55.30,-3.60,12.90, 5.20,21.45,26.40,27.90,29.65, -13.20,-17.10,-19.85,-20.85, -36.40,-31.35,-61.30, -41.85,-41.85,-50.85,47.10,21.15, -72.70, 55.45,-2.85, 15.15,-35.75,-11.85,-76.70,-76.30, -23.85,	Array of vertical (y) offsets

*(continued)*

**Table 9-2.** (continued)

Code Line	Description
-27.60,18.15,22.65,19.65,-22.35, -83.45,-41.75,31.55,-171.30	
];	End of statesy array
var doingjigsaw = false;	Flag indicating if doing jigsaw
var bodyel;	Used to hold reference to body
var nums = states.length;	Number of states
var stateelements = [];	Will hold the dynamically created elements
var questionfel;	Used to hold reference to form
function init(){	Header for init function
setupgame();	Invoke setupgame
bodyel = document. getElementById("body");	Set reference to use to add fullpage div
}	Close init function
function setupgame() {	Header for setupgame function
var i;	For indexing
var x;	For x value
var y;	For y value
var uniqueid;	For the unique ID created for each element
var s;	Hold each newly created element
for(i=0;i<nums;i++) {	Iterate over the states
uniqueid = "a"+String(i);	Define an ID
s = document.createElement('state');	Create element
s.innerHTML = ( "<img src='"+states[i]+ "' id='"+uniqueid+"'>");	Set the HTML markup contents of the newly created element to be an image with the attributes as indicated

(continued)

**Table 9-2.** *(continued)*

Code Line	Description
<code>document.body.appendChild(s);</code>	Append to body
<code>thingelem = document. getElementById(uniqueid);</code>	Get the reference
<code>    x = statesx[i] + 310;</code>	Calculate horizontal coordinate
<code>    y = statesy[i] + 200;</code>	Calculate vertical coordinate
<code>thingelem.style.top = String(y)+"px";</code>	Set style.top to be x
<code>thingelem.style.left= String(x)+"px";</code>	Set style.left to be y
<code>stateelements.push(thingelem);</code>	Add to stateelements array
<code>    }</code>	Close for loop
<code>questionfel = document.getElement ById("questionform");</code>	Set reference to form
<code>questionfel.style.left = "100px";</code>	Position form horizontally
<code>questionfel.style.top = "500px";</code>	Position form vertically
<code>questionfel.question.value = " ";</code>	Clear out question field
<code>questionfel.feedback.value = " ";</code>	Clear out feedback field
<code>    }</code>	Close setupgame function
<code>function pickstate(ev) {</code>	Header for pickstate function
<code>var picked = Number(ev.target. id.substr(1));</code>	Extract and calculate index for the state the player picked
<code>    if (picked == choice) {</code>	Compare to choice
<code>questionfel.feedback.value = "Correct!";</code>	Display feedback as correct
<code>    }</code>	Close clause

*(continued)*



**Table 9-2.** (continued)

Code Line	Description
else {	Else
questionfel.feedback.value = "Try Again.";	Display feedback to try again
}	Close clause
}	Close pickstate function
function spread() {	Header for spread function
var i;	For indexing
var x;	For x value
var y;	For y value
var thingelem;	For element
for (i=0;i<nums-2;i++) {	Iterate over 48 states
x = 2.70*statesx[i] +410;	Stretch out x and add constant
y = 2.70*statesy[i] + 250;	Stretch out y and add constant
thingelem = stateelements[i];	Get <i>i</i> th element
thingelem.style.top = String(y)+"px";	Set style.top
thingelem.style.left= String(x)+"px";	Set style.left
}	Close for loop
}	Close spread function
function restore() {	Header for restore function
var i;	For indexing
var x;	For x
var y;	For y
var thingelem;	For element reference

(continued)

**Table 9-2.** (continued)

Code Line	Description
var df;	Used to remove fullpage
var lsname = "jigsaw";	Name for localStorage
var xydata = [];	Used for saving
var stringdata;	Used for saving
if (doingjigsaw) {	Check if doingjigsaw is true
doingjigsaw = false;	Set to false
d.onmousedown = "";	Remove event handling
d.onmousemove = "";	Remove event handling
d.onmouseup = "";	Remove event handling
df=	Get reference
document.getElementById("fullpage");	
bodyel.removeChild(df);	Remove df
for (i=0;i<nums;i++) {	Iterate over states
thingelem = stateelements[i];	Get reference to <i>i</i> th state element
xydata.push(thingelem.style.	Create a string that combines top and left
top+"&" + thingelem.style.left);	settings and add this to the xydata array
}	Close for loop
stringdata = xydata.join(";");	Generate a string from the array
try {	Try (since there may be problems with
	localStorage)
localStorage.	Set localStorage item
setItem(lsname,stringdata);	
}	End try clause
catch(e) {	catch clause
alert("data not saved, error given: "+e);	Error message
}	Close catch clause

*(continued)*

**Table 9-2.** (continued)

Code Line	Description
}	Close if doingjigsaw
for (i=0;i<nums;i++) {	Iterate over states
x = statesx[i] +310;	Set x to be original x-coordinate
y = statesy[i] + 200;	Set y to be original y-coordinate
thingelem = stateelements[i];	Get reference to <i>i</i> th state
thingelem.style.top = String(y)+"px";	Set style.top
thingelem.style.left= String(x)+"px";	Set style.left
}	Close for loop
}	Close restore function
function restorepreviousjigsaw() {	Header for restorepreviousjigsaw function
var i;	For indexing
var lsname = "jigsaw";	Name used for localStorage
var xydata;	Will be used in extracting the data
var stringdata;	Will be used in extracting the data
var ss;	Will hold combined top and left for a state
var ssarray;	Will be used in extracting the data
var thingelem;	Reference of <i>i</i> th state element
try {	Try
stringdata = localStorage. getItem(lsname);	Fetch the data saved in localStorage under the name "jigsaw"
xydata = stringdata.split(";");	Generate an array from stringdata
for (i=0;i<nums;i++) {	Iterate over states
ss = xydata[i];	Extract the <i>i</i> th element of xydata
ssarray = ss.split("&");	Split this string to get two values
thingelem = stateelements[i];	Get the <i>i</i> th element

(continued)

**Table 9-2.** *(continued)*

Code Line	Description
<code>thingelem.style.top = sarray[0];</code>	Set <code>style.top</code> to be the 0th item
<code>thingelem.style.left = sarray[1];</code>	Set <code>style.left</code> to be the first item
<code>}</code>	Close for loop
<code>doingjigsaw = true;</code>	Set for doing the jigsaw
<code>stateelements[choice].style.border="";</code>	Remove any border
<code>d.onmousedown = startdragging;</code>	Set up event handling
<code>d.onmousemove = moving;</code>	Set up event handling
<code>d.onmouseup = release;</code>	Set up event handling
<code>var df = document. createElement('div');</code>	Create a div
<code>df.id = "fullpage";</code>	Give it an ID of <code>fullpage</code>
<code>bodyel.appendChild(df);</code>	Append to body
<code>questionfel.question.value = "";</code>	Clear out question field
<code>questionfel.submitbut.value = "Save &amp; close jigsaw";</code>	Set label of the submit button
<code>questionfel.feedback.value = " ";</code>	Clear out feedback field
<code>questionfel.style.zIndex = 100;</code>	Set form to be on top
<code>}</code>	Close try clause
<code>catch(e) {</code>	Catch
<code>    alert("Problem in restoring     previous puzzle. Click on Do     jigsaw.");}</code>	Display alert box
<code>}</code>	Close <code>restorepreviousjigsaw</code> function
<code>var choice = 0;</code>	Global variable holding right answer
<code>function setupfindstate(){</code>	Header for <code>setupfindstate</code> function

*(continued)*

**Table 9-2.** (continued)

Code Line	Description
<code>var i;</code>	For indexing
<code>var thingelem;</code>	Reference to element
<code>stateelements[choice].style.border="";</code>	Remove border of last choice, if there was one
<code>choice = Math.floor(Math. random()*nums);</code>	Make a random choice for the question
<code>for (i=0;i&lt;nums;i++) {</code>	Iterate over the states
<code>  thingelem = stateelements[i];</code>	Set reference to <i>i</i> th element
<code>  thingelem.addEventListener   ('click',pickstate,false);</code>	Set up event handling for this element
<code>  }</code>	Close for loop
<code>var nameofstate = names[choice];</code>	Use choice as index to names array
<code>  questionfel.question.value =   "Click on "+nameofstate;</code>	Set the prompt
<code>  questionfel.feedback.value = "  ";</code>	Clear out feedback
<code>  questionfel.submitbut.value = "";</code>	Submit button not used for this task
<code>}</code>	Close setupfindstate function
<code>function setupidentifystate(){</code>	Header for setupidentifystate function
<code>  stateelements[choice].style.border="";</code>	Remove previous border
<code>  stateelements[choice].style.zIndex="";</code>	Put this state underneath what will be the next choice
<code>  choice = Math.floor(Math.   random()*nums);</code>	Make random choice
<code>  stateelements[choice].style.   border="double";</code>	Set border around the choice state
<code>  stateelements[choice].style.   zIndex="20";</code>	Make this element on top of others, so border will be on top

(continued)

**Table 9-2.** *(continued)*

Code Line	Description
questionfel.question.value = "Type name of state with border HERE";	Set up prompt indicating where to type in answer
questionfel.submitbut.value = "Submit name";	Set up label for button
questionfel.feedback.value = " ";	Clear feedback field
var thingelem;	Used for holding references to elements
for (i=0;i<nums;i++) {	Iterate over states
thingelem = stateelements[i];	Set to be <i>n</i> th element
thingelem.removeEventListener('click',pickstate,false);	Remove event handling
}	Close for loop
}	Close setupidentifystate function
function checkname() {	Header for checkname function
if (doingjigsaw) {	If player was doing jigsaw, then ...
restore();	... invoke restore
}	End clause
else {	Otherwise
var correctname = names[choice];	This is the correct name
var guessedname = document.questionform.question.value;	This was what the player typed in
if (guessedname==correctname) {	Was the player correct?
questionfel.feedback.value = "Correct!";	Display feedback
}	End clause
else {	Else

*(continued)*

**Table 9-2.** (continued)

Code Line	Description
questionfel.feedback.value = "Try again.";	Display feedback
}	End clause
return false;	Return false to prevent refresh (may not be necessary)
}	End if-not-jigsaw clause
}	Close checkname function
function checkpositions() {	Header for checkpositions function
var i;	Indexing
var x;	For x
var y;	For y
var tolerance = 20;	Margin allowed for positioning
var deltax = [];	Will hold the x differences
var deltax = [];	Will hold the y differences
var delx;	Used in computation
var dely;	Used in computation
for (i=0;i<nums-2;i++) {	Iterate over first 48 states; doesn't check Alaska or Hawaii
x = stateelements[i].style.left;	x is this state's left
y = stateelements[i].style.top;	y is this state's top
x = x.substr(0,x.length-2);	Remove px
y = y.substr(0,y.length-2);	Remove py
x = Number(x);	Convert to number
y = Number(y);	Convert to number
delx = x - statesx[i];	Calculate difference with the x offset

(continued)

**Table 9-2.** (continued)

Code Line	Description
dely = y - statesy[i];	Calculate difference with the y offset
deltax.push(delx);	Add to deltax array
deltay.push(dely);	Add to deltay array
}	Close for loop
var averagex = doaverage(deltax);	Calculate average of all x differences
var averagey = doaverage(deltay);	Calculate average of all y differences
for (i=0;i<nums;i++) {	Iterate
if ((Math.abs(averagex - deltax[i])>tolerance)    (Math.abs(averagey-deltay[i])>tolerance)) {	Check if x difference or y difference is bigger than tolerance from the respective average
break;	If so, leave loop
}	Close clause
}	Close for loop
if (i<nums) {	Did the loop break prematurely?
questionfel.feedback.value = names[i]+" and maybe more out of position";	Set feedback to display the state that was found to be out of position
}	Close clause
else {	Else loop did not end prematurely; could put in check on Hawaii and Alaska here
questionfel.feedback.value = "GOOD";	Display feedback
}	Close clause
}	Close checkpositions function
function doaverage(arr) {	Header for doaverage function; parameter is an array
var sum;	Used as accumulator in computation

(continued)



**Table 9-2.** (continued)

Code Line	Description
<code>var i;</code>	For indexing
<code>var n = arr.length;</code>	Length of array
<code>sum = 0;</code>	Initialize to zero
<code>for(i=0;i&lt;n;i++) {</code>	Iterate over elements
<code>sum += arr[i];</code>	Add the <i>i</i> th value
<code>}</code>	Close for loop
<code>return (sum/n);</code>	Return sum divided by number <i>n</i>
<code>}</code>	Close doaverage function
<code>function setupjigsaw() {</code>	Header for setupjigsaw function
<code>doingjigsaw = true;</code>	Set flag to true
<code>stateelements[choice].style.</code> <code>border="";</code>	Remove any previous border
<code>var i;</code>	For indexing
<code>var x;</code>	For x values
<code>var y;</code>	For y values
<code>var thingelem;</code>	Reference state element
<code>for (i=0;i&lt;nums;i++) {</code>	Iterate over states
<code>x = 100+Math.floor</code> <code>(Math.random()*600);</code>	Choose random value for x
<code>y = 100+Math.floor(Math.</code> <code>random()*320);</code>	Choose random value for y
<code>thingelem = stateelements[i];</code>	Set <i>i</i> th element
<code>thingelem.style.top = String(y)+"px";</code>	Position for top
<code>thingelem.style.left =String(x)+"px";</code>	Position for left
<code>thingelem.removeEventListener</code> <code>('click',pickstate,false);</code>	Remove event handling

(continued)

**Table 9-2.** (continued)

Code Line	Description
}	Close for loop
d.onmousedown = startdragging;	Set up event handling
d.onmousemove = moving;	Set up event handling
d.onmouseup = release;	Set up event handling
var df = document.createElement('div');	Create div
df.id = "fullpage";	Give it the ID
bodyel.appendChild(df);	Add to body
questionfel.question.value = "";	Clear out question field
questionfel.submitbut.value = "Save & close jigsaw";	Change the label on the submit button
questionfel.feedback.value = " ";	Clear out feedback field
questionfel.style.zIndex = 100;	Set form on top
}	Close setupjigsaw function
var d = document;	Holds document
var ie= d.all;	The Internet Explorer check; note that application has not been checked for latest Internet Explorer version
var mouseDown = false;	Initialize flag to false
var curX;	Current x
var curY;	Current y
var adjustX;	Used for dragging
var adjustY;	Used for dragging
var movingobj;	The object being dragged
function release(e){	Header for release function
mouseDown = false;	Set flag back to false
checkpositions();	Invoke check for puzzle being done

(continued)

**Table 9-2.** (continued)

Code Line	Description
};	Close release function
function startdragging(e) {	Header for startdragging function
var o;	Used to calculate offset
var j;	Used to hold reference to element
var i;	For indexing
curX = ie ? e.clientX+d.body. scrollLeft : e.pageX;	Compute location of cursor in x
curY = ie ? e.clientY+d.body. scrollTop : e.pageY;	Compute location of cursor in y
for (i=0; i<nums;i++) {	Iterate over states
j = stateelements[i];	Get the <i>i</i> th element
o = offset(j);	Determine offset
if (curX >= o.x && curX <= o.x + j.width && curY >= o.y && curY <= o.y + j.height)	Check if mouse over the <i>i</i> th element
{ break; }	If so, leave for loop
}	End of clause
if (i<nums) {	Was for loop exited prematurely?
movingobj = stateelements[i];	Set up the <i>i</i> th as the moving object
adjustX = curX- o.x;	Amount in x piece is offset from mouse cursor
adjustY = curY- o.y;	Amount in y piece is offset from mouse cursor
mouseDown = true;	Set flag to true: object in motion
}	Close clause for mouse over an object
}	Close startdragging function
function moving(e) {	Header for moving function
if (!mouseDown) return;	If no object is being moved, return

(continued)

**Table 9-2.** *(continued)*

Code Line	Description
if (ie)	Check if ie flag set
draw(e.clientX+d.body.scrollLeft, e.clientY+d.body.scrollTop);	Draw using these values
else	Else
draw(e.pageX, e.pageY);	Draw using these values
}	Close moving function
function draw(x, y) {	Header for draw function; this moves/drag the state
var js = movingobj.style;	Extract point to the style
js.left = (x - adjustX) + "px";	Change the style to new x (left) value
js.top = (y - adjustY) + "px";	Change the style to new y (top) value
}	Close draw function
function offset(obj) {	Header for offset function; adds in all offsets of obj from ancestors
var left = 0;	Initialize left
var top = 0;	Initialize top
if (obj.offsetParent)	Is there a parent?
do {	Then
left += obj.offsetLeft;	Increment left
top += obj.offsetTop;	Increment top
} while (obj = obj.offsetParent);	Keep going if there is a parent
return {x: left, y: top};	Return array with the left and top values
}	Close offset function
</script>	Closing script tag
</head>	Closing head tag

*(continued)*

**Table 9-2.** (continued)

Code Line	Description
<code>&lt;body id="body" onLoad="init();"&gt;</code>	Body tag, with onLoad set to init();
<code>&lt;button onClick="spread();"&gt;Spread out states &lt;/button&gt;</code>	Button to spread out states
<code>&lt;button onClick="restore();"&gt;Restore original /compress map &lt;/button&gt;</code>	Button to restore original map
<code>&lt;button onClick="setupfindstate();"&gt; Find the state &lt;/button&gt;</code>	Button to start Find the state task
<code>&lt;button onClick="setupidentifystate ();"&gt;Name the state&lt;/button&gt;</code>	Button to start Name the state task
<code>&lt;button onClick="setupjigsaw();"&gt; Do jigsaw&lt;/button&gt;</code>	Button to start jigsaw
<code>&lt;button onClick="restoreprevious jigsaw();"&gt;Restore last jigsaw in process &lt;/button&gt;</code>	Button to restore saved jigsaw
<code>&lt;h1&gt;USA&lt;/h1&gt;</code>	Heading onscreen for the USA puzzle
<code>&lt;form id="questionform" name="questionform" onSubmit="return checkname();"&gt;</code>	form tag, with onSubmit set to checkname call
State name: <code>&lt;input type="text" name="question" value=" " size="40"/&gt;</code>	Label and place for state name
<code>&lt;input name="submitbut" type="submit" value=" " size="30"/&gt;</code>	Submit button; value now empty
Feedback: <code>&lt;input type="text" name="feedback" value=" " size="40" /&gt;</code>	Label and place for feedback
<code>&lt;/form&gt;</code>	Closing form tag
<code>&lt;/body&gt;</code>	Closing body tag
<code>&lt;/html&gt;</code>	Closing html tag

## Testing and Uploading the Application

The project can be tested locally (on your home computer) using Chrome and also Firefox, although at one point, as I have mentioned, that was not true. This application requires the 50 files representing the states, so be sure and upload them as well (or whatever files correspond to the parts of the map for your application).

## Summary

In this chapter, you learned how to build an educational game that featured different types of questions for the player. The HTML5 features and programming techniques included the following:

- Building a user interface involving text or visual prompts. Player responses included clicking elements on the screen and typing text. After entering jigsaw mode, player actions were dragging and repositioning elements on the screen.
- Encoding and decoding information using split and join methods.
- Saving and restoring works-in-progress, including use of the `try...catch` construct.
- Reusing techniques explained in the last chapter:
  - Creating HTML markup dynamically to create the piece elements on the screen
  - Placing the jigsaw pieces randomly on the screen
  - Determining the coordinate values that indicated how the pieces fit together, and using those values, along with a defined tolerance, to check if the puzzle was put together properly
  - Manipulating the positioning of the piece elements to spread out the pieces and restore them to their original locations

In Chapter 10, the final chapter, we explore the requirements for preparing a web document that works on different devices, which is termed *responsive design*, and initial steps toward making applications more widely *accessible*.

## CHAPTER 10

# Responsive Design and Accessibility

In this chapter, you will:

- Learn techniques to make your interactive application usable on a variety of devices
- Learn how to make your application accessible to people using only a keyboard and a screen reader
- Make random multiple selections and, moreover, combine such tasks
- See additional examples of the dynamic creation of HTML markup

## Introduction

In the past, people used desktop or laptop computers, to use computer applications! Now, many people want to view and use computer applications, including web pages, on their tablets or smartphones. Moreover, many want to go to a website on all three classes of devices and have similar experiences. They also may choose to modify the dimensions of the window on a desktop or laptop or change the orientation of a mobile device. Preparing a project made using HTML, CSS, and JavaScript to adapt to the device (and the state of the device) is called *responsive design*. A different, but similar, objective is to prepare a project to be accessible to a variety of users. One critical challenge in this case is to make the application suitable for people with visual disabilities using a screen reader and/or people restricted to using only a keyboard. In this chapter, I describe certain techniques that will be helpful for these objectives, focusing on specific examples.

Figure 10-1 shows the screenshot of an HTML and JavaScript project that adjusts to the dimensions of the device. The program operates by cycling through a sequence of images by making a stroke with a mouse on a desktop or laptop computer or with touch on a tablet or a phone.

Mouse/touch down, slowly drag mouse/finger down or up the photo, then mouse/touch up.



**Figure 10-1.** *Opening screen of reveal program*



Pressing down on the mouse button and moving down or touching down with a finger and moving down will cause the next picture to be revealed gradually until close to the bottom. Figure 10-2 shows a picture in the process of being changed.

Mouse/touch down, slowly drag mouse/finger down or up the photo, then mouse/touch up.



**Figure 10-2.** *Change underway from one picture to the next*

When the mouse or finger is close enough, the whole next picture appears. Similarly, the user/player can move the mouse or finger up the screen and get the previous picture appearing. I encourage the reader to experiment with the source code.

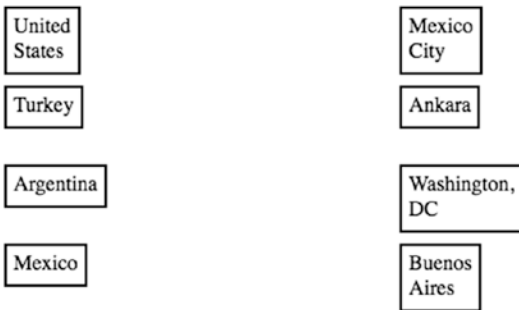
Figure 10-3 shows a screenshot of a quiz game that can be operated by mouse or touch or the keyboard alone. The set of four countries is selected randomly from the G20 countries and the corresponding capitals are mixed up, so you will see a different set of items each time. The quiz can be taken using just the keyboard and a screen reader program, with the tab key taking the player from item to item, making it suitable for someone with limited or no visual ability and/or someone unable to use a mouse or touch.

## G20 Countries and Capitals

This is a quiz for matching country and capital. There are 4 countries and 4 capitals. Click (or tab and then press enter) to pick a country or capital and then click (or tab and then press enter) on corresponding capital or country. There will be a video (with sound) if you match all 4. You can tab through everything repeated times. Reload for new game.

Action:

Score:



**Figure 10-3.** Opening screen for country/capital quiz

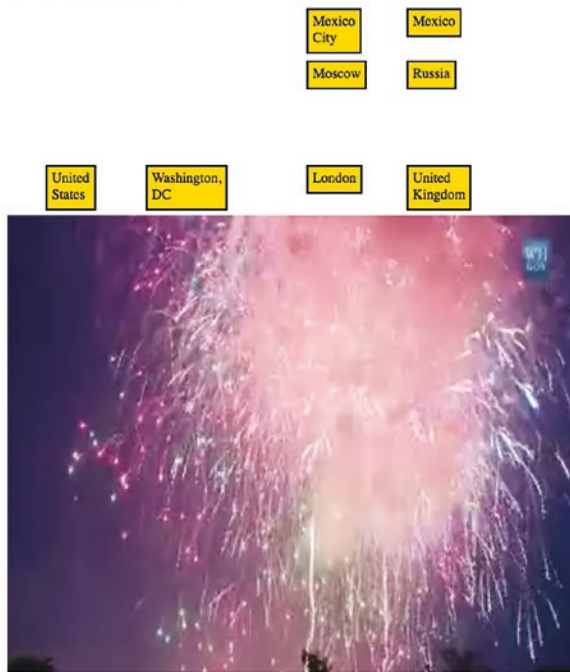
The Action and Score fields indicate the performance so far. The boxes do change color and move to next to the matched box to make it more interesting for the visually able. The yellow/gold color is used when a match is correct. As indicated in the instructions, a video is played when the player correctly makes four matches. Figure 10-4 shows a screenshot.

## G20 Countries and Capitals

This is a quiz for matching country and capital. There are 4 countries and 4 capitals. Click (or tab and then press enter) to pick a country or capital and then click (or tab and then press enter) on corresponding capital or country. There will be a video (with sound) if you match all 4. You can tab through everything repeated times. Reload for new game.

Action: RIGHT

Score: 4



**Figure 10-4.** Screenshot successful completion of quiz

The video has sound so the visually impaired gets the reward as well.

**Note** Screen readers are complex and provide options for customizing use. One screen reader I used “spoke” the names of the countries and capitals by themselves but another added the term “group,” which was tiresome. It is possible to use the Tab key with the Shift key to go back and forth hearing the country and capital names. However, screen readers do read the whole screen, including everything on my browser toolbar and this was repeated when clicking on the Tab key past the end of the document. My example shows how to include Tab information in dynamically generated HTML markup. I strongly recommend that when you continue your exploration of the use of screen readers and keyboard operation, study static HTML pages first and then move on to programs with dynamically generated HTML elements.

---

## Critical Requirements

Before going into specific technical features, it is important for developers to consider the most important target audience of a planned application and the feasibility of the application in different situations. There is a notion called *mobile first* that recommends that the best approach if something is to be available on a mobile device is to design and plan the mobile implementation first as opposed to designing and implementing for a desktop and then making adjustments. Starting with the problem specification, including the most common device and user, and formulating a solution is a good strategy. Teachers and book authors often do something quite different: start with concepts and features we want to explain and design what we believe are interesting programs that use the features.

When you’re designing a web application, it is important to consider that certain programs, such as ones featuring geolocation, are best for mobile. In contrast, a program requiring considerable text entry is best suited for desktops and laptops. A jigsaw puzzle is not for the visually impaired. However, the country/capital quiz, which I originally made for mouse or touch, can be adapted for keyboard operation. Thinking about different screens and different audiences can be a valuable way to determine what is critical for your application and the process of working toward responsive design and improving accessibility can benefit all audiences.

In this chapter, I focus on adapting to screen dimensions, ensuring that touch works in addition to or in place of a mouse, and supporting screen reader and keyboard-only operation for at least some applications. I also wanted to allow the user to resize and resize again the window to arbitrary width and height.

I will mention briefly features that can be useful for a variety of websites, generally having a static design.

## Screen Size and Dimension

You may expect to see code that checks for specific devices or device types by name, but that is not the recommended approach for many situations. Instead, if the critical properties to examine include screen width and screen height, then these measurements are checked directly. There are various ways to do that in HTML element properties, CSS rules and directives, and JavaScript code. You can learn, or at least be introduced to, many of the details in the HTML, CSS, and JavaScript features section.

## Touch

Mobile devices typically do not have a mouse but instead depend on touch. The interpretation of a touch as a mouse click comes “for free,” that is, no additional coding is required and will be demonstrated in the Quiz example. The Reveal application, which is based on a mouse down, mouse move, and mouse up sequence of operations requires JavaScript code to support touch. The technique is to set up the touch events to simulate the appropriate mouse events.

## Screen Reader and Tabs

A variety of screen reader tools exist. I used the built-in VoiceOver feature available on my iMac running MacOS High Sierra to test the quiz program. People with visual impairments and also people unable to operate a mouse need everything to be done through the keyboard. This includes providing the coding to support the use of the Tab key. The general advice for best support of screen reader and keyboard is good overall organization, dividing the text into smaller pieces, and providing labels for what the user cannot see.

## HTML, CSS, and JavaScript Features

HTML, together with CSS, provides ways to support responsive design and accessibility. In situations involving more interactive and dynamic behavior, it may be necessary to use JavaScript and I will focus on the JavaScript techniques for the examples.

### Meta Tags

The meta tag provides information about the document for the browser, for search engines, and other web programs. Nothing is displayed. The charset meta tag

```
<meta charset="UTF-8">
```

specifies what character set is to be used. The UTF-8 designation is the default and indicates the one- to four-byte Unicode standard. The intent in Unicode is to support all the world's languages, and though that may not quite be the case, most languages, including Japanese and Chinese, are supported. Even though Unicode is the default, a warning message may still be displayed on the web console in the absence of this meta tag, so including it will prevent seeing that message if you do go to the web console.

The following meta tag is recommended to set the width to the device width:

```
<meta name="viewport" content="width=device-width, initial-scale=1.0">
```

I use the following for the Reveal example to allow the user some ability to scale the window on mobile devices. This is applicable just to mobile devices.

```
<meta name="viewport"
content="width=device-width, user-scalable=yes, initial-scale=1.0, minimum-
scale=1.0, maximum-scale=2.0" />
```

If image or video elements are not given width or height attribute settings or given fixed amounts, making the window smaller will result in scrolling. Vertical scrolling is considered acceptable, but horizontal scrolling is not. The next section describes techniques to produce the desired effects.

## HTML and CSS Use of Percentages and Auto

It is a standard practice to specify the width and the height in pixels for elements such as `img`. If just one is specified using HTML for the element in the body element, the other is modified to maintain the aspect ratio. In the style section, using CSS, the term `auto` can be used. This is the default, but I like to mention it explicitly mainly as a reminder to me.

A variation on specifying width or height in pixels is to specify a dimension as a percentage of the containing element. The containing element could be the body element or a `div` or a semantic tag or something else. The default width dimension for an element with block display, such as a `div`, is 100% of the screen. It is possible to specify another percentage, say 50% or 80%. An example would be to include in the body

```

```

This would set the image to have a width taking up 50% of the screen with the height whatever preserves the aspect ratio. In the style section, either of these

```
#animal {width:50%; height: auto;}  
#animal {width:50%;}
```

would produce the same effect.

If the application window is manipulated (say, on a desktop) to be shorter than the calculated height, then the image would be cut off and a scroll bar would appear for vertical scrolling. If the desired effect is to put a bound on the width (or height), but not stretch the image beyond its original dimension, the `max-width` or `max-height` attribute can be used. Generally speaking, vertically scrolling is accepted more than horizontal scrolling so just specifying the width or the `max-width` is frequently offered as the way to achieve responsiveness. This is the approach I used for the reward video in the countries/capitals quiz.

The percentages can be used with `width` and/or `max-width` to set up a grid layout for elements. I encourage you to experiment with these features. The TRY-IT feature of many W3Cschool examples is helpful.

You will see how I use JavaScript to modify the width and the height.

## CSS @media

Web developers can set @media queries in the style element. These provide a way to check on attributes of devices and designate style directives for certain conditions. For example, on my Purchase website, I designate certain elements as being in a class I name col. If the screen is wide enough, I want these elements spaced across the window as columns. However, if the screen width is small, I do not want to require horizontal scrolling, but instead have the col elements be displayed vertically with the assumption that users will scroll vertically. The following @media directive produces this effect:

```
@media all and (max-width: 640px)
  {.col {display: block; width: 100%;}}
```

As was mentioned earlier, this is the technique suggested for testing for a narrow device such as a phone. The @media feature also can be used to specify distinct formatting for screen for computers and devices, the term print for printing out the web page and speech for screen readers.

A @media query can have the modifiers not and only. For example,

```
@media only screen and (max-width: 600px) {
  body {
    background-color: lightblue;
  }
}
```

produces a background color of lightblue (this is one of the known color names (see [https://www.w3schools.com/Colors/colors\\_names.asp](https://www.w3schools.com/Colors/colors_names.asp)) for everything in the body element for use on screens. I refer you to [https://www.w3schools.com/CSSref/css3\\_pr\\_mediaquery.asp](https://www.w3schools.com/CSSref/css3_pr_mediaquery.asp) for more examples and explanations.

## The HTML alt Attribute and Semantic Elements

The **alt** attribute for an **img** element provides information for a screen reader. The value of the **alt** attribute will be displayed if the file is missing or slow to download. Use of **alt** elements is recommended in normal cases and programs that check accessibility will indicate any **img** tags without **alt** elements. Thinking out what the **alt** attribute can be an important exercise in developing a web page. Please note that my code for this example does not display the **img** elements, which are only used as a way to ensure that the images are fully downloaded. Therefore, I did not think it appropriate to include the alt attribute.



Semantic elements can provide information that may be used by screen readers. The terms header, footer, main, section, article, and so on are meaningful when working with other people on large projects. They do not have specific formatting, which must be supplied.

## HTML tabIndex

People dependent on a screen reader or unable or uncomfortable using a mouse or touch depend on using the Tab key to go through a document. The tabIndex attribute can be set for any element. Pressing the Tab key takes the user to the next element in tab order (proceeding in numerical order, low to high). Pressing the Tab key and the Shift key reverses direction. The tabIndex for an element can be set when preparing the HTML document or produced by coding when creating HTML markup dynamically. In the quizTab application, I included the statement

```
d.innerHTML = (
"<div tabIndex='"+String(2+i)+"' class='thing'
id='"+uniqueid+"'>placeholder</div>");
```

This code produces successive values for the tabIndex for the country names.

The tabIndex can be changed during the operation of a web page, although I did not do this in my example. Playing (taking) the quiz does mean going through the items multiple times and this does mean hearing the directions again, and also going up to the address field of the browser again and, in some cases, hearing all the active sites represented by tabs in the browser.

## JavaScript Use of Width and Height Properties

The browser for any computer or device will adapt the line width of text to fit the window. However, I also wanted to adapt the font size in the instructions. The instructions are displayed using a font size that my code selects based on a calculation. The fontsz array is set using the statement:

```
var fontsz = ["14px", "16px", "18px", "20px", "24px"];
```

The size of the font is set in the `init` function using the `cwidth` variable that has been assigned the `window.innerWidth`. The code is

```
fs = Math.floor (cwidth/200);
fs = Math.min(fs,4);
bodyel.style.fontSize = fontsz[fs];
```

The challenge I set myself for the Reveal example was for the images to fit within the window without any scrolling, while retaining the proportions. The attributes I used include `window.innerWidth` and `window.innerHeight` for the window, and `width`, `naturalWidth`, `height`, and `naturalHeight` for the images. The “natural” attributes represent the original dimensions of an image. They cannot be changed. For the Reveal example, I had made sure all the images have the same dimension, so I only needed to do one set of calculations. The code checks that the width was less than the screen width and adjusted the height, and then made sure the height was less than the screen height and adjusted the width. You can go back to Chapter 8 for a variation on this involving calculating values for use in the `drawImage` method.

## Creating Elements Dynamically

The sequence of images for the Reveal example is implemented dynamically by drawing each into a canvas element. For any work involving images or other media on the web, it is critical to make sure the files are completely downloaded. I accomplish this by including `img` elements in the body but setting the visibility to be hidden in the style section. Then, my code invokes a function named `init` to do all the work of creating the canvas elements, drawing each image into its canvas element, and drawing the first image into the canvas set up in the body.

The countries/capitals quiz also creates elements dynamically. These are rectangular shapes holding the names of the countries and capitals. The HTML markup is created with attributes set for `id`, `class`, and `tabindex`. The `id` values hold the index into the `facts` array and is used to determine if the player has correctly matched a country and a capital.

## Choosing From List

The Quiz example makes random choices for two situations. It is straight-forward how to make one random choice. However, for this program, I need to make four random choices of country/capital pairs from the facts array on 20 countries, but without allowing repetition. Then, for each country and capital pair, since I do not want each capital name to be opposite its country name, I need code to make random choices for the positioning of each capital from among the four slots representing positions in the second column. This also needs to be done without repetition. Note: It may be the case that a capital does end up opposite its country, but it won't happen most of the time. See the placement of Mexico City, Ankara, Washington, D.C., and Buenos Aires in Figure 10-3.

My first step toward addressing this problem is to make the facts array hold something to tell me if a fact has been taken. The facts array is an array of arrays and the inner arrays have three elements: country, capital, and true/false. A false setting means the fact has not been selected and true means it has. The slots array will hold indices for the four capital names. I will use an initial setting of -100 to indicate a slot has not been taken. It actually could be any number less than zero. When a slot is chosen, the corresponding value in the slots array is set to the index value of the country/capital in the facts array. Do note that I could use any non-negative number here, because I (my code) does not use the value, but I was thinking about possible future applications.

The coding construct that I use for both situations is a do/while loop. The do/while construct can be used in many situations so try to keep it in mind. Describing it in general terms: the code between brackets is invoked at least one time. Then the condition in the parentheses following the term while is evaluated. If it is true, the code in the brackets is executed again. There can be multiple statements between the brackets. A pseudocode way to think of it is

```
do { one or more statements }
  while (repeat if this condition is true )
```

The check selecting facts is done by this code:

```
do {c = Math.floor(Math.random()*facts.length);}
  while (facts[c][2]==true)
```

The assignment to the variable `c` will be repeated if the fact represented by in the subarray `facts[c]` has already been chosen.

The analogous check on picking a slot is done by this code.

```
do {s = Math.floor(Math.random()*nq);}
    while (slots[s]>=0)
```

Values indicating that the position has been taken are indicate by `slots[s]` being greater than or equal to zero, so the random choice will be repeated if the slot has already been taken.

## Mouse Events, Touch Events, and Key Events

There are two main issues to address for responsive design. I have described checking and modifying the elements to fit the window sizes. The second consideration is providing for touch as opposed to mouse events. The handling of touch events is done by simulating mouse events. The mouse events have, presumably, been defined. As I already mentioned, certain touch events are handled without any extra programming. These are simple events such as clicking on an element. However, events such as `mousedown`, `mousemove`, and `mouseup` need to be translated. This is because the exact location of the mouse or touch is needed for calculations to draw from the source canvas to the displayed canvas.

In the `init` function, the `addEventListener` method is involved for five events. If this code is executed on a device without some of these events, there is no problem in referencing any event that cannot occur.

```
canvas.addEventListener("mousedown",startreveal,true);
canvas.addEventListener("touchstart", touchHandler, true);
canvas.addEventListener("touchmove", touchHandler, true);
canvas.addEventListener("touchend", touchHandler, true);
canvas.addEventListener("touchcancel", touchHandler, true);
```

The `touchHandler` function performs the task of determining which mouse event is to be simulated (using a switch statement), creating the event (with `new MouseEvent`), and then dispatching it. The `MouseEvent` function uses an associative array (also called a dictionary) in which certain attributes are set. There are other attributes that I let assume the default values for this example.

```

function touchHandler(event)
{
  var touches = event.changedTouches;
  if (touches.length>1) {
    return false;
  }
  var first = touches[0];
  var type = "";
  switch(event.type)
  {
    case "touchstart": type = "mousedown"; break;
    case "touchmove": type="mousemove"; break;
    case "touchend": type="mouseup"; break;
    default: return;
  }
  var simulatedEvent = new MouseEvent(type,{
    screenX: first.screenX,
    screenY: first.screenY,
    clientX: first.clientX,
    clientY: first.clientY
  });

  first.target.dispatchEvent(simulatedEvent);
  event.preventDefault();
}

```

---

**Note** The constructor `MouseEvent` is relatively new and replaces the use of `document.createEvent("MouseEvent")`, which is now marked as deprecated, meaning its use is discouraged and may not be recognized in the future. Changes in tools are something we need to accept. In fact, the new approach has a significant advantage over the old one: the use of an associative array for the arguments, instead of a long sequence of parameters indicated by position, with most of them taking the default values.

---

Notice that nothing happens if there is a multi-touch gesture and note also that any default action is prevented. I know of at least one commercial solitaire game—an iPad app—that does not do this and so the whole board may move when moving a card.

Independent of the issue of mouse versus touch: nothing happens if the user in the Reveal program presses down on with mouse or with a finger to the right of the image or below the image (further down the screen). This bad behavior is ignored by use of the following code in the `startreveal` function:

```
var startxy = getCoords(ev);
  if (startxy[0]>pwidth) return;
  if (startxy[1]>pheight) return;
```

Similarly, if the player clicks on two country names or two capital names in the Quiz application, the program supplies no special feedback, but does place the second item next to the first. It will not be considered a correct answer because the two `id` values will not match.

You must decide when building your own application, what feedback, if any, to supply in cases that we can describe as bad behavior.

For the Quiz example, the event handling of a touch (tap) event is interpreted as a mouse click by phone and tablet devices. However, I set myself the challenge of supporting keyboard operation. What I do is set up the `keyup` event to invoke my `pickelement` function, but in that function, do a return if the `keyCode` is 9, the `keyCode` for Tab. So, the player using the keyboard would tab to each of the countries and capital items, hear the screen reader say the names, and press Return to pick an item, or tab to the next.

## Building the Reveal Application and Making It Your Own

The Reveal program starts with the following sequence of events and actions.

1. When the document is fully loaded, including the images, the `init` function is invoked. The `init` function is invoked following a reload and a resize by the player. Note that the images are not visible because of a directive in the style element.

2. The `init` function determines the dimensions of the window and uses that information to choose the size of the font.
3. The `init` function invokes the `setupimages` function.
4. The `setupimages` function does calculations to make sure the images fit into the window, maintaining the aspect ratio. It creates a canvas element for each image.
5. Returning to the `init` function, the `mousedown` and all touch events are set up. The first image is drawn into the canvas element, drawing from a canvas to a canvas. The `next` and `prev` variables are set.

The action of revealing the next picture is handled by the functions `startreveal`, `revealing`, and `stopreveal`, with the called and calling relationships indicated in Table 10-1. I made the decision to allow the user to swipe up or down and change direction. I also decided to complete the transition if the vertical level was within a fudge factor of the top or bottom. My intentions are realized by the nested `if/else` statements in the program.

**Table 10-1.** *Functional Relationships for Reveal*

Function	Invoked By	Invokes
<code>init</code>	The <code>onload</code> and <code>onresize</code> attributes in the body tag	<code>setupimages</code>
<code>setupimages</code>	<code>init</code>	
<code>touchHandler</code>	Call of <code>addEventListener</code> in <code>init</code>	
<code>getCoords</code>	<code>startreveal</code> , <code>revealing</code>	
<code>startreveal</code>	Call of <code>addEventListener</code> in <code>init</code> and in <code>stopreveal</code>	<code>getCoords</code>
<code>revealing</code>	Call of <code>addEventListener</code> in <code>startreveal</code>	<code>getCoords</code>
<code>stopreveal</code>	Call of <code>addEventListener</code> in <code>startreveal</code> and direct call in <code>revealing</code>	

Table 10-2 shows the code with comments for the reveal program.

**Table 10-2.** Code for Reveal Program

Code	Description
<!DOCTYPE HTML>	Header
<html>	html tag
<head>	head tag
<title>Reveal next</title>	The complete title element
<meta name="viewport"	Start of viewport
content="width=device-width, user-scalable=yes, initial-scale=1.0, minimum-scale=1.0, maximum-scale=2.0" />	Indicates treatment of user changes
<meta charset="UTF-8">	Specifies the charset to be Unicode
<style>	Style tag
body {	Directive for body
font-family: Garamond, serif;	Font is Garamond, if available, otherwise serif
font-size: 24px;	Note size may be changed
overflow: hidden;	No overflow and no scrolling if too big
}	Close body directive
div#images {display:none;}	Do not display any images; images used to draw into canvas elements
</style>	Close style element
<script>	Start of script element
var ctx;	Will hold context for canvas elements
var fudge = 40;	Do not require user to go all the way up or all the way down for the next image to appear; this is a "fudge factor," meaning it is to give the user a small amount of room

*(continued)*



**Table 10-2.** (continued)

<b>Code</b>	<b>Description</b>
<code>var canvas;</code>	Will hold canvas
<code>var pwidth;</code>	Width of the pictures
<code>var pheight;</code>	Height of the pictures
<code>var cwidth;</code>	Window width
<code>var cheight;</code>	Window height
<code>var current = 0;</code>	Start with 0 <sup>th</sup> picture
<code>var prev = 3;</code>	Start with the previous being the picture at index 3
<code>var next = 1;</code>	The next picture is at index 1
<code>var rect;</code>	Used for getting mouse coordinates
<code>var revealflag = false;</code>	Flag
<code>var lastdrawn;</code>	Keeps track of last picture
<code>var lasty;</code>	The last y value
<code>var moving = false;</code>	Set to indicate moving mouse
<code>var canvases = [];</code>	Will hold canvases for all the pictures
<code>var fontsz = ["14px", "16px", "18px", "20px", "24px"];</code>	The possible font sizes
<code>function init() {</code>	Header for init function
<code>var fs;</code>	Used to determine font size
<code>canvas=document.</code> <code>getElementById("canvas");</code>	Pointer to the canvas element
<code>bodyel = document.</code> <code>getElementById("body");</code>	Pointer to the body element
<code>ctx = canvas.getContext("2d");</code>	Context for the canvas
<code>ctx.font = "24px serif";</code>	Default font and size
<code>cwidth = window.innerWidth;</code>	Width of window

(continued)

**Table 10-2.** *(continued)*

<b>Code</b>	<b>Description</b>
<code>cheight = window.innerHeight;</code>	Height of window
<code>fs = Math.floor (cwidth/200);</code>	Calculate for font size
<code>fs = Math.min(fs,4);</code>	Minimum is 4
<code>bodyel.style.fontSize = fontsz[fs];</code>	Set font size of instructions in the body to be fs element of fontsz array
<code>canvas.width = cwidth;</code>	Set canvas width
<code>canvas.height= cheight;</code>	Set canvas height
<code>rect = canvas. getBoundingClientRect();</code>	Used for determining mouse coordinates
<code>var noOfImgs = document. getElementsByTagName('img').length;</code>	Determines the number of img elements in document
<code>setupimages("noodles", noOfImgs);</code>	Invoke function that will set up the image (picture) canvases after performing any scaling
<code>canvas.addEventListener("mousedown", startreveal,true);</code>	Set mousedown event
<code>canvas.addEventListener("touchstart", touchHandler, true);</code>	All touch events invoke touchHandler
<code>canvas.addEventListener("touchmove", touchHandler, true);</code>	
<code>canvas.addEventListener("touchend", touchHandler, true);</code>	
<code>canvas.addEventListener ("touchcancel", touchHandler, true);</code>	
<code>ctx.drawImage(canvases[0],0,0);</code>	Draw the first (0 <sup>th</sup> index) picture into the canvas
<code>current = 0;</code>	Set current; this and the next two statements are necessary for init being called by onresize

*(continued)*

**Table 10-2.** (continued)

Code	Description
<code>prev = 3;</code>	Set prev
<code>next = 1;</code>	Set next
<code>}</code>	Close init
<code>function setupimages (base, lim){</code>	Header for setupimages function; the base holds the start of the names of the images and lim indicates the number of images
<code>var dref;</code>	Reference to first image; this one is used to calculate the scaling factor
<code>var can;</code>	Will point to each of the canvases
<code>var canctx;</code>	Will hold the context for each canvas
<code>canvases = [];</code>	Will hold the created canvases, with the images, all scaled to the appropriate size; you can think of these as buffers holding the images
<code>var img;</code>	Will hold each img in turn
<code>dref = document. getElementById("dummy");</code>	Get reference to the first image
<code>if (dref.naturalWidth) {</code>	This provides the original width of the image
<code>dref.width = dref.naturalWidth;</code>	Set width to this value
<code>pratio = dref.naturalHeight/     dref.naturalWidth;</code>	Calculate aspect ratio
<code>}</code>	Close if
<code>else {</code>	Less general when naturalWidth absent, which may be the case with some browsers
<code>pratio = dref.height/dref.width;</code>	Calculate ratio
<code>}</code>	Close else

(continued)

**Table 10-2.** *(continued)*

Code	Description
<code>dref.width = Math.min(dref. width,cwidth-fudge);</code>	Now possibly reset width
<code>dref.height = pratio * dref.width;</code>	Set the height to match the possibly modified width
<code>dref.height = Math.min(dref. height,cheight-fudge);</code>	Now possibly modify height
<code>dref.width = dref.height * (1/ pratio);</code>	Set the width to match the possibly modified height
<code>pwidth = dref.width;</code>	Set variable for later use
<code>pheight = dref.height;</code>	Set variable for later use
<code>for(var i=1;i&lt;=lim;i++){</code>	References the image files by name, by adding 1,2,3,4 to base; this loop scales the images (repeating the operation for the first one); note also the items in the canvases array are at index positions 0,1, 2, 3
<code>img = new Image();</code>	Create an Image object
<code>img.width = pwidth;</code>	Set the width
<code>img.height = pheight;</code>	Set the height
<code>img.src=base+String(i)+".jpg";</code>	Set the src using the base and a number
<code>can = document. createElement("canvas");</code>	Create a canvas
<code>can.width = cwidth;</code>	Set its width
<code>can.height = cheight;</code>	... and height
<code>canctx = can.getContext('2d');</code>	Set canctx to be the context
<code>canctx.drawImage(img,0,0,pwidth, pheight);</code>	Draw the image into this canvas
<code>canvases.push(can);</code>	Push into the canvases array
<code>}</code>	Close the for loop

*(continued)*

**Table 10-2.** (continued)

Code	Description
}	Close setupimages function
function touchHandler(event) {	Header for touchHandler
var touches = event.changedTouches;	Get array of touches
if (touches.length>1) {	If more than one
return false;	Return; don't do anything for multi-touch gestures
}	Close if
var first = touches[0];	Take the first (and only) touch
var type = "";	Initial setting
switch(event.type) {	Switch on type of event
case "touchstart": type = "mousedown"; break;	Set type variable to be the corresponding mouse event
case "touchmove": type="mousemove"; break;	
case "touchend": type="mouseup"; break;	
default: return;	Do nothing
}	Close switch
var simulatedEvent = new	Create the MouseEvent of the calculated type;
MouseEvent(type, {	set the locations from the locations of the touch event
screenX: first.screenX,	
screenY: first.screenY,	
clientX: first.clientX,	
clientY: first.clientY	
});	
first.target.dispatchEvent (simulatedEvent);	Dispatch event to be treated as actual event
event.preventDefault();	Stop any default response for the touch event

(continued)

**Table 10-2.** *(continued)*

Code	Description
}	Close touchHandler
function getCoords(ev){	Header for getCoords to pick up mouse position
var mx;	Will hold horizontal
var my;	Will hold vertical
mx = ev.clientX-rect.left;	The rect variable has been set; calculates mx
my = ev.clientY-rect.top;	Calculate my
return [mx,my];	Return an array
}	Close getCoords
function startreveal(ev){	Header for startreveal
var startxy = getCoords(ev);	Get the coordinates of the mouse
if (startxy[0]>pwidth) return;	No action if mouse or touch is to the right of the image
if (startxy[1]>pheight) return;	No action if mouse or touch is below the image
lasty = Math.max(startxy[1],fudge);	Start at least fudge distance from the top
canvas.addEventListener("mousemove", revealing,true);	Set up mousemove
canvas.addEventListener("mouseup", stopreveal,true);	Set up mouseup
canvas.removeEventListener ("mousedown", startreveal,true);	Stop listening for mousedown
revealflag = true;	Set flag
}	Close startreveal

*(continued)*

**Table 10-2.** (continued)

<b>Code</b>	<b>Description</b>
function revealing(ev){	Header for revealing
var slice;	Will indicate how much to be drawn from next picture (vertical amount)
var curxy;	Will hold mouse position
if (!revealflag) return;	If not in the reveal stage, return
curxy = getCoords(ev);	Get mouse coordinates
cury = curxy[1];	Set cury
if (moving){	Check moving flag
if (cury>=lasty){	If it is further down than last
if (cury<(pheight-fudge)){	If it isn't in the bottom part
slice = Math.max(1,cury-lasty)	Calculate the height
ctx.drawImage(canvases	Draw from the next canvas
[next],0,lasty,pwidth,	
slice,0,lasty,pwidth,slice);	
lastdrawn = next;	Set up for next move
lasty = cury;	
}	Close if
else {	Go immediately to set up for next
lastdrawn = next;	Set lastdrawn
stopreveal(ev);	ev passed to be consist with being eventhandler
}	Close else for cury<(pheight-fudge)
}	Close cury>=lasty
else {	Else cury< lasty, so moving up
if (cury>fudge){	If still outside of fudge area

(continued)

**Table 10-2.** *(continued)*

Code	Description
<pre>slice = Math.max(1, lasty-cury);</pre>	Calculate slice
<pre>ctx.drawImage(canvases [prev],0,cury,pwidth, slice,0,cury,pwidth,slice);</pre>	Draw from prev image
<pre>lastdrawn = prev;</pre>	Set lastdrawn to prev
<pre>lasty = cury;</pre>	Set lasty
<pre>}</pre>	Close if
<pre>else {</pre>	Else within fudge area, so complete transition
<pre>lastdrawn = prev;</pre>	Set lastdrawn
<pre>stopreveal(ev);</pre>	Invoke stopreveal
<pre>}</pre>	Closes else for cury>fudge
<pre>}</pre>	Close else for cury>=lasty
<pre>}</pre>	Close if moving
<pre>else {</pre>	First mov
<pre>moving = true;</pre>	Set moving
<pre>if (cury&gt;=lasty){</pre>	Check direction
<pre>prev = current;</pre>	Moving up, so set prev
<pre>if (cury&lt;(pheight-fudge)){</pre>	Check if above fudge
<pre>slice = Math.max(1,cury-lasty);</pre>	Set the slice
<pre>ctx.drawImage(canvases [next],0,lasty,pwidth, slice,0,lasty,pwidth,slice);</pre>	Draw from next
<pre>lastdrawn = next;</pre>	Set lastdrawn
<pre>lasty = cury;</pre>	Set lasty
<pre>}</pre>	Close if above fudge

*(continued)*



**Table 10-2.** *(continued)*

<b>Code</b>	<b>Description</b>
else {	Else
lastdrawn = next;	Set lastdrawn
stopreveal(ev);	Immediately go to stopreveal; the ev passed to be consist with being an eventhandler
}	Close else for cury<(pheight-fudge)
}	Close cury>=lasty for moving false
else {	Going up the image
next = current;	Set next
if (cury>fudge){	If greater than fudge
slice = Math.max(1,	Calculate slice
lasty-cury);	
ctx.drawImage(canvases	Draw slice
[prev],0,cury,pwidth,	
slice,0,cury,pwidth,slice);	
lastdrawn= prev;	Set lastdrawn
lasty = cury;	Set lasty
}	Close if above fudge
else {	Else (in fudge area)
lastdrawn = prev;	Set lastdrawn
stopreveal(ev);	Go immediately to stopreveal
}	Close else for if cury>fudge
}	Close else for cury>=lasty
}	Close else for if moving
}	Close function

*(continued)*

**Table 10-2.** *(continued)*

Code	Description
function stopreveal(ev) {	Header for stopreveal
revealflag = false;	Reset revealflag
moving = false;	Reset moving
ctx.drawImage(canvases [lastdrawn],0,0);	Draw the complete image
current = lastdrawn;	Set current
next = current+1;	Increment next
if (next==canvases.length) next = 0;	If at the end, set next to 0
prev = current-1;	Set prev
if (prev<0) prev=canvases.length-1;	If prev too low, set to the last index
canvas.removeEventListener ("mousemove", revealing,true);	Stop listening for mousemove
canvas.removeEventListener ("mouseup", stopreveal,true);	Stop listening for mouseup
canvas.addEventListener ("mousedown", startreveal,true);	Set up event for startreveal
}	Close stopreveal
</script>	End script element
<body id="body" onload="init();" onresize="init();">	Body tag, with setting for onload and onresize

*(continued)*

**Table 10-2.** (continued)

Code	Description
Mouse/touch down, slowly drag mouse/finger down or up the photo, then mouse/touch up.	Instructions
<pre>&lt;canvas id="canvas" width="100%" height="50%" &gt;</pre>	Canvas; may be scaled
<pre>    Your browser doesn't support canvas</pre>	Standard message
<pre>&lt;/canvas&gt;</pre>	Canvas end tag
<pre>&lt;div id="images"&gt;</pre>	The div holding the images
<pre>&lt;img src="noodles1.jpg" id="dummy"/&gt;</pre>	The first one is used for the scaling calculations
<pre>&lt;img src="noodles2.jpg"&gt;</pre>	
<pre>&lt;img src="noodles3.jpg"&gt;</pre>	
<pre>&lt;img src="noodles4.jpg"&gt;</pre>	
<pre>&lt;/div&gt;</pre>	Close div
<pre>&lt;/body&gt;</pre>	Close body
<pre>&lt;/html&gt;</pre>	Close html

## Testing and Uploading the Reveal Application

The Reveal (I also call it uncover) application requires a set of images of the same dimension, though that dimension does not need to be what I have for the girl-eating-noodles. You can have a different number of images than the four that I have. This is supported by the use of the `document.getElementsByTagName` invocation in the `setupimages` function. Of course, if you choose to include other images, you will need to do the call for the `div` holding the `img` elements in place of `document`.

## Building the Countries/Capitals Quiz and Making It Your Own

The quiz show is set up by selecting four country capital pairs from the facts table using `Math.random` and checking to be sure not to repeat any pair. Elements are created dynamically for countries and capitals and the order of how the capitals appear in the window is make random. These elements are created with `tabIndex` set. As each element is created, `addEventListener` is invoked for the click event *and* the keyup event. The functions with their relationships are shown in Table 10-3. Notice that there is no touchhandler event because the click using touch events are properly interpreted by browsers on devices. More generally, setting the `tabIndex` attribute provides the tab functionality without any additional JavaScript coding.

**Table 10-3.** *Functional Relations for Quiz*

Function	Invoked By	Invokes
<code>init</code>	Action by the <code>onload</code> attribute in the body tag	<code>setupgame</code>
<code>setupgame</code>	<code>init</code>	
<code>pickelement</code>	Action by <code>addEventListener</code> multiple times in <code>setupgame</code>	

The code with comments is shown in Table 10-4.

**Table 10-4.** Code for the Country/Capital Quiz

Code	Description
<code>&lt;!DOCTYPE html&gt;</code>	Standard header
<code>&lt;html&gt;</code>	The html tag
<code>&lt;head&gt;</code>	The head tag
<code>  &lt;title&gt;Quiz with Reward!&lt;/title&gt;</code>	Complete title
<code>&lt;style&gt;</code>	The style tag
<code>  country {position:absolute;left: 0px; top: 0px; border: 2px; border-style: double; background-color: white; margin: 5px; padding: 3px; visibility:hidden;}</code>	Format country blocks
<code>  capital {position:absolute;left: 0px; top: 0px; border: 2px; border-style: double; background-color: white; margin: 5px; padding: 3px; visibility:hidden;}</code>	Format capital blocks
<code>  #vid {position:absolute; visibility:hidden; z-index: 0; max-width: 50%; height: auto;}</code>	Make video hidden until time to play; set limit on width
<code>  main {display:block;}</code>	Force line breaks before and after main
<code>&lt;/style&gt;</code>	Closing style tag
<code>&lt;script type="text/javascript"&gt;</code>	Script tag
<code>  var facts = [</code>	Variable holding the information for the quiz; the third place in the inner arrays is used to indicate if the fact has been chosen for this game
<code>    ["China","Beijing",false],</code>	
<code>    ["India","New Delhi",false],</code>	
<code>    ["European Union","Brussels",false],</code>	
<code>    ["United States","Washington, DC",false],</code>	

(continued)

**Table 10-4.** *(continued)*

Code	Description
<pre>["Indonesia","Jakarta",false], ["Brazil","Brasilia",false], ["Russia","Moscow",false], ["Japan","Tokyo",false], ["Mexico","Mexico City",false], ["Germany","Berlin",false], ["Turkey","Ankara",false], ["France","Paris",false], ["United Kingdom","London",false], ["Italy","Rome",false], ["South Africa","Pretoria",false],</pre>	<p>Note: South Africa has three capitals; I chose to go with Pretoria; it is a matching game, so players will never see the other two city names</p>
<pre>["South Korea","Seoul",false], ["Argentina","Buenos Aires",false], ["Canada","Ottawa",false], ["Saudi Arabia","Riyadh",false], ["Australia","Canberra",false]</pre>	
<pre>];</pre>	<p>Close outer array of facts</p>
<pre>var thingelem;</pre>	<p>Used for each block item</p>
<pre>var nq = 4;</pre>	<p>Number of questions asked in a game</p>
<pre>var elementinmotion;</pre>	<p>Used to indicate selected element to be moved next to player's match</p>
<pre>var makingmove = false;</pre>	<p>Set to true while player choosing two blocks</p>

*(continued)*

**Table 10-4.** *(continued)*

<b>Code</b>	<b>Description</b>
<code>var inbetween = 150;</code>	Spacing between columns
<code>var col1 = 0;</code>	Start of first column
<code>var row1;</code>	Set in init; start of first row
<code>var rowsize = 60;</code>	Vertical space allocated for each item
<code>var slots = new Array(nq);</code>	Hold the index into facts array for the capital items
<code>function init(){</code>	Header for init function
<code>row1= .6* window.innerHeight;</code>	Set row1 as expression in total window height; if height is too small, vertical scrolling will be required
<code>setupgame();</code>	Invoke setupgame
<code>}</code>	Close init
<code>function setupgame() {</code>	Header for setupgame
<code>var i;</code>	Used in for loops
<code>var c;</code>	Used in calculation of random choice
<code>var s;</code>	Used in calculation of candidate slot for capitals
<code>var mx = col1;</code>	Starting x position
<code>var my = row1;</code>	Starting y position
<code>var d;</code>	Will hold reference to created element for country
<code>var uniqueid;</code>	Used to hold all the generated IDs
<code>for (i=0;i&lt;facts.length;i++) {</code>	Loop over all the facts
<code>facts[i][2] = false;</code>	Set as being unused

*(continued)*

**Table 10-4.** (continued)

Code	Description
}	Close for loop
for (i=0;i<nq;i++) {	Loop over all slots
slots[i] = -100;	Set slot value
}	Close for loop
for(i=0;i<nq;i++) {	Loop until nq distinct facts are chosen
do {c = Math.floor(Math.random()*facts.length);}	Do gets a random value
while (facts[c][2]==true)	If this fact is taken, repeat the do clause
facts[c][2]=true;	Now, having chosen a fact not taken, mark it as taken
uniqueid = "c"+String(c);	Generate an ID
d = document.createElement('country');	Create an element
d.innerHTML = (	Set the innerHTML
" <div tabIndex='"+String(2+i)+"' class='thing' id='"+uniqueid+"'>placeholder</div>");	... to be a div, class 'thing' to respond to the style directive
document.body.appendChild(d);	Append to body (so it will be displayed)
thingelem = document.getElementById(uniqueid);	Set thingelem to reference the newly created element
thingelem.textContent=facts[c][0];	Make its context the country
thingelem.style.top = String(my)+"px";	Position it at the my vertical and...
thingelem.style.left = String(mx)+"px";	... mx horizontal position
thingelem.addEventListener('click', pickelement);	Set up event handling for click
thingelem.addEventListener('keyup', pickelement);	Set up event handling for keyup

(continued)



**Table 10-4.** (continued)

Code	Description
<code>thingelem.style.visibility="visible";</code>	Set the visibility to visible
<code>    uniqueid = "p"+String(c);</code>	Now create a new unique ID
<code>    d = document.createElement('cap');</code>	Create an element
<code>d.innerHTML = (</code>	Set the innerHTML
<code>    "&lt;div tabIndex='0' class='thing'</code>	The div for the items; code will change
<code>    id='"+uniqueid+"'&gt;placeholder&lt;/div&gt;");</code>	<code>tabIndex</code>
<code>    document.body.appendChild(d);</code>	Append to the body so it will be visible
<code>thingelem = document.</code>	Set <code>thingelem</code> to reference this
<code>getElementById(uniqueid);</code>	element
<code>    thingelem.textContent=facts[c][1];</code>	Set its content
	Put this thing in random choice from empty slots
<code>    do {s = Math.floor(Math.random()*nq);} </code>	Do set <code>s</code> to be a random value
<code>    while (slots[s]&gt;=0)</code>	If the current value of <code>slots[s]</code> is greater than or equal to zero, it means this slot is taken and so repeat the <code>do</code> clause to get a new value <code>s</code>
<code>        slots[s]=c;</code>	This slot has not been taken, so set it to be the value <code>c</code>
<code>    thingelem.tabIndex = String(6+s);</code>	Set its <code>tabIndex</code>
<code>thingelem.style.top =</code>	Position it vertically, using the position indicated by <code>s</code>
<code>String(row1+s*rowsize)+"px";</code>	
<code>thingelem.style.left =</code>	All capitals have the same horizontal positioning to be the second column
<code>String(col1+inbetween)+"px";</code>	
<code>    thingelem.addEventListener</code>	Set event handling for click
<code>    ('click',pickelement);</code>	

(continued)

**Table 10-4.** *(continued)*

Code	Description
<pre>                 thingelem.addEventListener                 ('keyup',pickelement);             my +=rowsize;         }         document.f.score.value = "0";         return false;     }     function pickelement(ev) {         if (ev.keyCode ===9) {return;}         var thisx;          var thisxn;          var sc;         if (makingmove) {             if (this==elementinmotion) {                  elementinmotion.style.                 backgroundColor = "white";                 makingmove = false;                 return;             }         }     }                 </pre>	<p>Set event handling for keyup</p> <p>Increment my to go to the next row</p> <p>Close the for loop</p> <p>Set the score to 0</p> <p>Return, prevent any refresh of document (may not be needed)</p> <p>Close setupgame</p> <p>Header for pickelement</p> <p>Return immediately if keycode is tab</p> <p>Will hold character string indicating horizontal position</p> <p>Will hold the new horizontal position with the px removed</p> <p>Score</p> <p>If makingmove true</p> <p>If this is the first item selected—that is, same block clicked twice, treat as not a good move and go back to waiting for a first click</p> <p>Turn it white</p> <p>Reset makingmove</p> <p>return</p> <p>Close if</p>

*(continued)*

**Table 10-4.** (continued)

Code	Description
<code>thisx= this.style.left;</code>	The this block is a distinct second item selected; get horizontal position
<code>thisx = thisx.substring(0,thisx.length-2);</code>	Remove the px
<code>thisxn = Number(thisx) + 115;</code>	Convert to number and add some space
<code>elementinmotion.style.left = String(thisxn)+"px";</code>	Reset the elementinmotion to move element
<code>elementinmotion.style.top = this. style.top;</code>	Set vertical coordinate to save vertical level
<code>makingmove = false;</code>	Reset makingmove
<code>if (this.id.substring(1) ==elementinmotion.id.substring(1)) {</code>	Now check if this is a good match by comparing the part of the id string after "c" or "p"
<code>elementinmotion.style.backgroundColor = "gold";</code>	Set to gold
<code>this.style.backgroundColor = "gold";</code>	Set to gold
<code>document.f.out.value = "RIGHT";</code>	Output message
<code>sc = 1+Number(document.f.score.value);</code>	Increment score
<code>document.f.score.value = String(sc);</code>	Display score
<code>if (sc==nq) {</code>	Check if this means nq have been matched
<code>v = document.getElementById("vid");</code>	If so, get the video
<code>v.style.top = String(row1+4*rowsize+20) +"px";</code>	Locate just under the items; if height is small, video will be off-screen and require vertical scrolling to be visible; it will be heard.
<code>v.style.visibility = "visible";</code>	Make video visible

(continued)

**Table 10-4.** *(continued)*

Code	Description
<code>v.style.zIndex="10000";</code>	Put on top of items (this is for any changes putting the video on top; now it is below blocks)
<code>v.play();</code>	Play video
<code>}</code>	Close if <code>sc==nq</code>
<code>}</code>	Close if IDs match
<code>else {</code>	Else (bad move)
<code>document.f.out.value = "WRONG";</code>	Display wrong
<code>elementinmotion.style.backgroundColor = "white";</code>	Set to white
<code>}</code>	Close else
<code>}</code>	Close if second item
<code>else {</code>	Else (first item selected)
<code>makingmove = true;</code>	Set makingmove flag
<code>elementinmotion = this;</code>	Save this reference for later use
<code>elementinmotion.style.backgroundColor="tan";</code>	Set color
<code>}</code>	Close else
<code>}</code>	Close pickelement function
<code>&lt;/script&gt;</code>	Close script section
<code>&lt;/head&gt;</code>	Close head section
<code>&lt;body onLoad="init();"&gt;</code>	The body tag; notice call to init upon loading
<code>&lt;main tabIndex="1"&gt;</code>	The main element, tabIndex set
<code>&lt;h1&gt;G20 Countries and Capitals &lt;/h1&gt;</code>	Heading
<code>&lt;br/&gt;</code>	Force line break

*(continued)*

**Table 10-4.** (continued)

Code	Description
This is a quiz for matching country and capital. There are 4 countries and 4 capitals.	Instructions
Click (or tab and then press enter) to pick a country or capital and then click (or tab and then press enter) on corresponding capital or country. There will be a video (with sound) if you match all 4. You can tab through all the elements repeated times.	Instructions, continued
<p>	A paragraph tag
Reload for new game. </p>	More instructions
</main>	Close main element
<p>	A paragraph tag
<form name="f" >	A form element
Action: <input name="out" type="text" value="RIGHT OR WRONG"/> 	Will indicate results of player moves
Score: <input name="score" type="text" value="0"/>	Score, starting with 0
</form>	Close form
</p>	Close paragraph
<video id="vid" controls="controls" preload="auto" width="50%" alt="Fireworks video">	Video tag; note alt
<source src="sfire3.webmvp8.webm" type='video/webm; codec="vp8, vorbis"'>	Holds videos in different formats, starting with webm; note: I stayed with the long names for these files
<source src="sfire3.mp4">	The MP4 format

(continued)

**Table 10-4.** (continued)

Code	Description
<code>&lt;source src="sfire3.theora.ogv" type='video/ogg; codecs="theora, vorbis"'&gt;</code>	The OGV format
Your browser does not accept the video tag.	Standard message for older browsers
<code>&lt;/video&gt;</code>	Close video
<code>&lt;/body&gt;</code>	Close body
<code>&lt;/html&gt;</code>	Close html

## Testing and Uploading the Countries/Capitals Quiz Application

You can decide which countries to include in your list or, if you want to change the quiz to something different, you need to formulate and create the pairs of strings defining the content. You also can choose a different video to be the reward for successful completion of the quiz. If you want the quiz to serve the visually impaired as well as others, you will want to choose a video that includes loud, cheerful music.

## Testing and Uploading the Jigsaw Turning to Video Application

In Chapter 8, you learned how to create a simple jigsaw puzzle game that turns into a video clip when the jigsaw puzzle is complete. I have added to the jigsaw program the enhancements discussed in this chapter for responding to touch and included it with the source code for this chapter. You will not see anything different if you examine this code on a desktop or laptop. However, if you upload the code to your own website along with a base image and video files, you should see it work on mobile devices.

As I indicated in Chapter 8, be aware that the Apple operating systems on mobile devices may require users to click the Play button for all videos. This is considered a feature, not a bug, by Apple. Requiring a click does give the owners of the devices a chance to prevent downloading of a video, which takes time and battery power and may incur fees. I have discussed the issue of Chrome's autoplay policy in Chapters 2 and 3. For the jigsaw-to-video project, I would prefer transition from jigsaw to video to be automatic and that is what it is on a desktop or laptop computer. You need to be aware of this issue because there may be changes in the browsers in the future.

You make this game your own by using your own video, with the first frame extracted as an image file to serve as the base.

## Summary

In this chapter, you explored issues critical for expanding the audience for your work.

The concerns for responsive design include adapting to the size and shape of different screens as well as providing for touch as well as mouse actions. Certain HTML and CSS features were described that were not used in the examples.

The concerns for accessibility include providing support for keyboard operation when a mouse or touch is not feasible. This includes setting the tab index, which can be done even when elements are created dynamically. Playing a video as the reward for successful completion of a quiz works for the visually impaired if audio from the video is present and appropriate.

The applications described here and the enhanced jigsaw turning into video are built on everything you have learned in this book, including building elements dynamically, working with arrays and images, and setting up events and event handling. I hope you enjoyed the experience and have started building your own projects.

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