HTML5 – Canvas
JavaScript
Pixels

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Lecture Objectives

- Provide Examples
  - Basic HTML5 canvas
  - Pixel Manipulation
  - “Loading” Images

What this is Not

- To complete your projects
  - You must learn more about HTML5 and JavaScript than what is about to be shown
    - This is an “on-your-own” activity
      - Instructor can help, but you must try on your own
    - A prereq to this course is CS 244
      - So you have programmed before
      - This stuff is “easy” compared to that =)
      - Likewise on the math topics
- In Sum: The following is just a place to start
  - More examples will follow throughout the course

Background

- A Digital Image
  - Is a picture or image converted to numeric form
  - In grey-scale the image can be thought of as
    - 2D function f(x, y) or a matrix
    - x, y, and f(x, y) are discrete and finite
    - Image size = (x_{max}) by (y_{max}), e.g. 1024 x 768
    - Pixel Intensity Value = f(x,y) $\in$ [0, 255]

HTML5/JS: Direct Pixel Manipulation

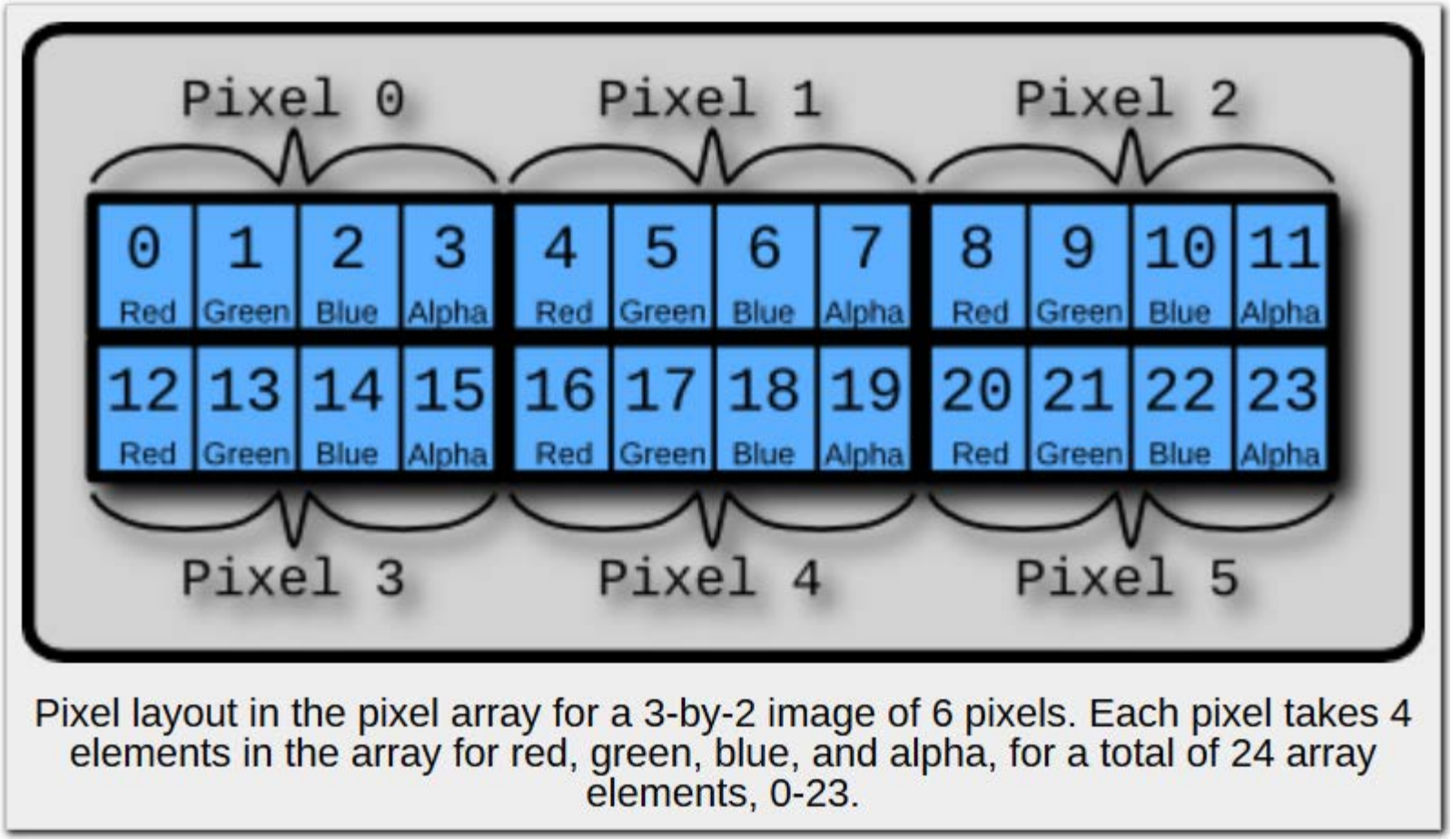
- Three basic things you can do
  - Create an array of empty pixels
  - Get an array of pixels from an existing canvas
  - Set the pixels of a canvas using a pixel array

Pixel Array

- JavaScript arrays work like C/C++/Java
  - Use the standard accessors to index into the array
    - EX:
      - mya[0] is the first element in the array named *mya*
      - mya[k-1] is the k-th element in the array named *mya*
  - Pixels in the array are in row-major order
    - with values of 0 to 255
    - where each four-integer group represents the four color channels: Red-Green-Blue-Alpha or RGBA

- *illustration next slide*

Pixel Order

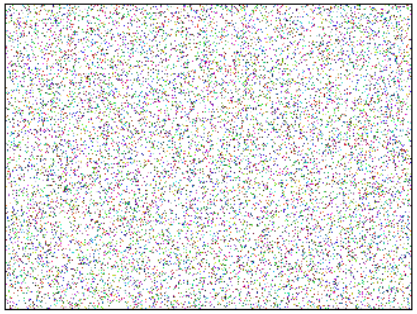


Pixel layout in the pixel array for a 3-by-2 image of 6 pixels. Each pixel takes 4 elements in the array for red, green, blue, and alpha, for a total of 24 array elements, 0-23.

image from: http://beej.us/blog/data/html5s-canvas-2-pixel/

Creating a Noise Image

- Use context's function: *createImageData()*
- Create a new function: *SetPixel()*
- Use context's function: *putImageData()*



createImage.html

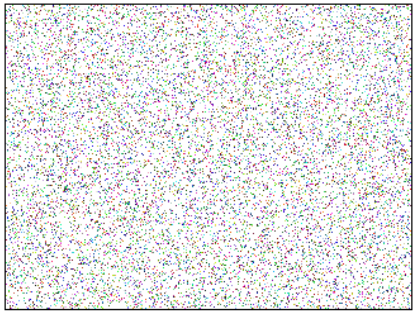
```
<!DOCTYPE html>
<html lang="en">
<head>
   <script src="createImage.js" type="text/javascript"></script>
</head>

<body>
   <div>
      <canvas id="myCanvas" width="320" height="240">
      Your browser does NOT support canvas!
      </canvas>
   </div>
</body>
</html>
```

Same basic HTML as previous examples

JavaScript filename changed to createImage.js

Creating a Noise Image



- Use context's function: *createImageData()*
- Create a new function: *SetPixel()*
- Use context's function: *putImageData()*

createImage.html

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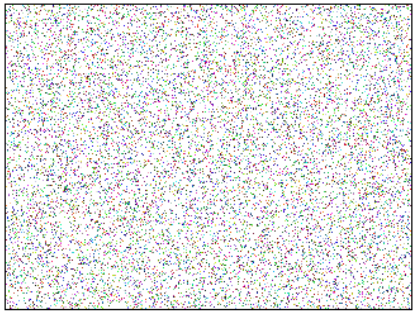
<html lang="en">
<head>
  <script src="createImage.js" type="text/javascript"></script>
</head>

<body>
   <div>
      <canvas id="myCanvas" width="320" height="240">
      Your browser does NOT support canvas!
      </canvas>
   </div>
</body>
</html>
```

Questions on the HTML file ?

Creating a Noise Image



- **Use context's function: *createImageData()***
- Create a new function: *SetPixel()*
- Use context's function: *putImageData()*

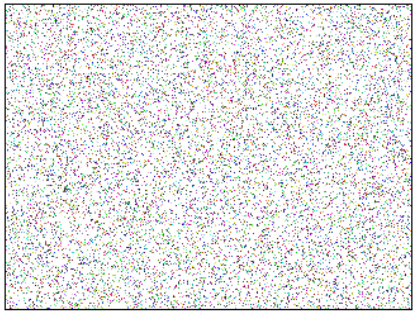
createImage.js

```
var theProgram = {
 Main: function() {
      theCanvas = document.getElementById("myCanvas");
      ctx = theCanvas.getContext("2d");

      // Get the size of the canvas as declared in the HTML
      var width = theCanvas.width;
      var height = theCanvas.height;

      // Create an array of pixels the same size as the canvas
      imageData = ctx.createImageData(width, height);
```

Creating a Noise Image



- **Use context's function: *createImageData()***
- Create a new function: *SetPixel()*
- Use context's function: *putImageData()*

createImage.js

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      // Get the size of the canvas as declared in the HTML
      var width = theCanvas.width;
      var height = theCanvas.height;

      // Create an array of pixels the same size as the canvas
      imageData = ctx.createImageData(width, height);
```

Note the following
imageData.width → width of the image data in PIXELS
imageData.height →height of the image daa in PIXELS
imageData.data → pixel data array of (width * height * 4) elements

Creating a Noise Image

- Use context's function: *createImageData()*
- **Create a new function: *SetPixel()***
- Use context's function: *putImageData()*

createImage.js

```
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      theCanvas = document.getElementById("myCanvas");
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      // Get the size of the canvas as declared in the HTML
      var width = theCanvas.width;
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      // Create an array of pixels the same size as the canvas
      imageData = ctx.createImageData(width, height);
```
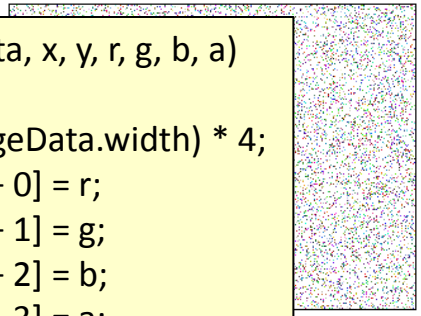

```
SetPixel: function(imageData, x, y, r, g, b, a)
  {
     var index = (x + y * imageData.width) * 4;
     imageData.data[index + 0] = r;
     imageData.data[index + 1] = g;
     imageData.data[index + 2] = b;
     imageData.data[index + 3] = a;
  },
```

SetPixel Function
(x, y) is image coordinate
r = red, g = green, b = blue, a = alpha
for alpha --> 255 is opaque and 0 is transparent

Creating a Noise Image

- Use context's function: *createImageData()*
- Create a new function: *SetPixel()*
- **Use context's function: *putImageData()***



```
SetPixel: function(imageData, x, y, r, g, b, a)
  {
     var index = (x + y * imageData.width) * 4;
     imageData.data[index + 0] = r;
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  },
```

createImage.js

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var theProgram = {
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      // Get the size of the canvas as declared in the HTML
      var width = theCanvas.width;
      var height = theCanvas.height;

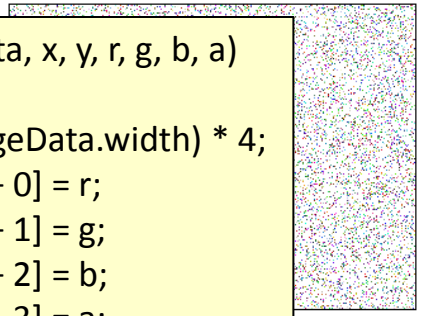
      // Create an array of pixels the same size as the canvas
      imageData = ctx.createImageData(width, height);
```

```
// Draw random dots
      for (var i = 0; i < 15000; i++)  // 15000 is arbitrary
      {
         var x = Math.random() * width | 0;
         var y = Math.random() * height | 0;
         var r = Math.random() * 256 | 0;
         var g = Math.random() * 256 | 0;
         var b = Math.random() * 256 | 0;
         theProgram.SetPixel(imageData, x, y, r, g, b, 255);
      }

      // Put the image data onto the canvas
      ctx.putImageData(imageData, 0, 0);
   },
```

Creating a Noise Image

- Use context's function: *createImageData()*
- Create a new function: *SetPixel()*
- **Use context's function: *putImageData()***



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  },
```

createImage.js

```
var theProgram = {
 Main: function() {
      theCanvas = document.getElementById("myCanvas");
      ctx = theCanvas.getContext("2d");

      // Get the size
      var width = theCanvas.width;
      var height = theCanvas.height;

      // Create an array of pixels the same size as the canvas
      imageData = ctx.createImageData(width, height);
```

The " | 0 " is to truncate to integer value

```
// Draw random dots
      for (var i = 0; i < 15000; i++)  // 15000 is arbitrary
      {
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Creating a Noise Image

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      // Create an array of pixels the same size as the canvas
      imageData = ctx.createImageData(width, height);
```

255 is opaque

```
SetPixel: function(imageData, x, y, r, g, b, a)
  {
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      var width = theCanvas.width;
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      // Create an array of pixels the same size as the canvas
      imageData = ctx.createImageData(width, height);
```

place data on the canvas starting at the upper left corner => (0, 0)

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Creating a Noise Image

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   },
}; // end theProgram Variable
```

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   },
```

createImage.js

Creating a Noise Image

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      var height = theCanvas.height;

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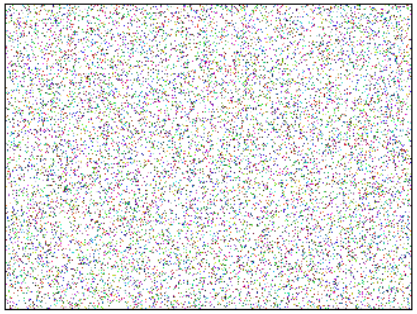


Questions on the JavaScript?

```
// Draw random dots
      for (var i = 0; i < 15000; i++)  // 15000 is arbitrary
      {
         var x = Math.random() * width | 0;
         var y = Math.random() * height | 0;
         var r = Math.random() * 256 | 0;
         var g = Math.random() * 256 | 0;
         var b = Math.random() * 256 | 0;
         theProgram.SetPixel(imageData, x, y, r, g, b, 255);
      }

      // Put the image data onto the canvas
      ctx.putImageData(imageData, 0, 0);
   },
```

```
 SetPixel: function(imageData, x, y, r, g, b, a)
   {
      var index = (x + y * imageData.width) * 4;
      imageData.data[index + 0] = r;
      imageData.data[index + 1] = g;
      imageData.data[index + 2] = b;
      imageData.data[index + 3] = a;
   },
}; // end theProgram Variable
```

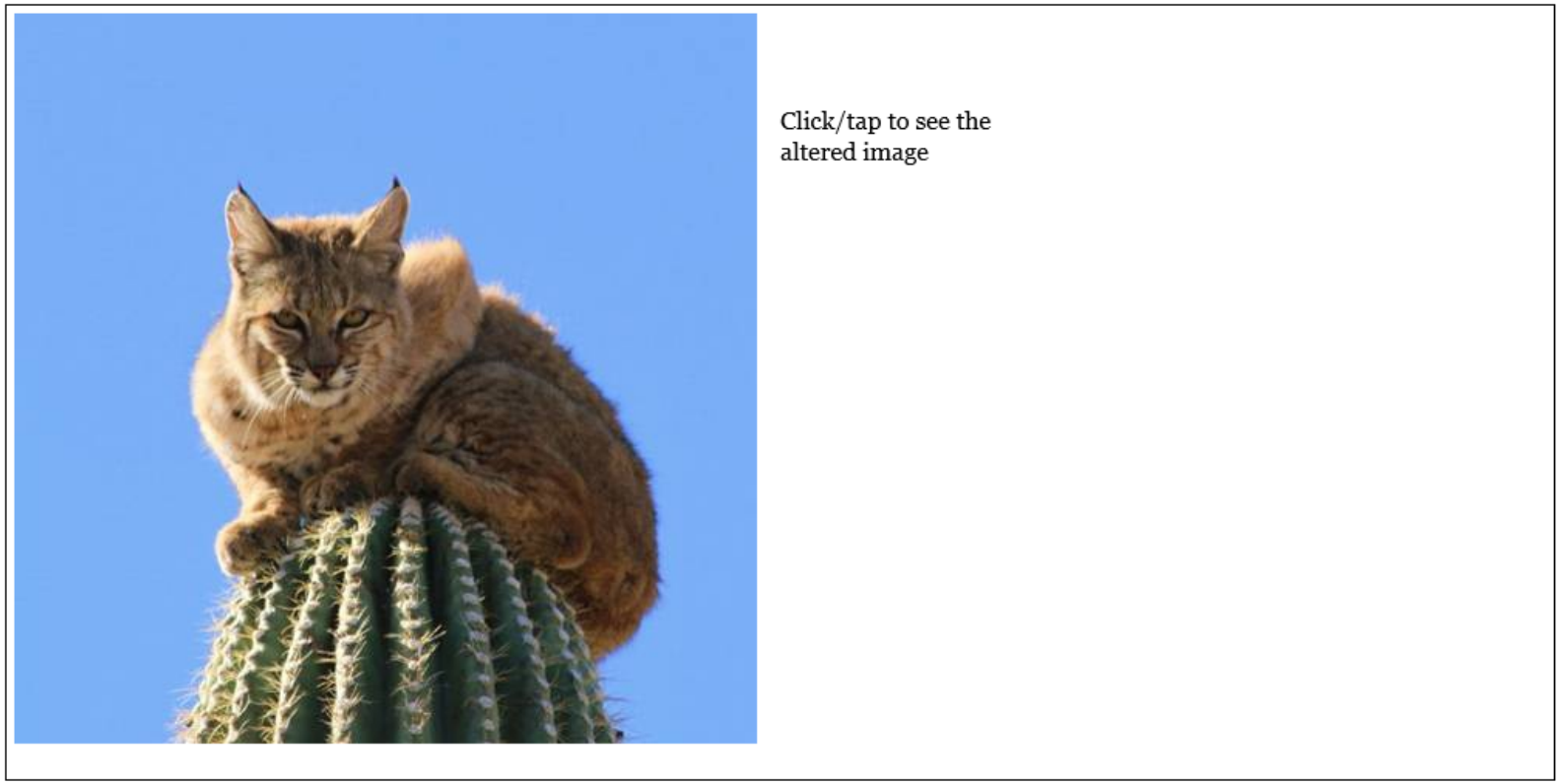
```
window.onload = function()
{
   theProgram.Main();
};
```

Challenge

- Modify the previous program to display an image that is not so random
  - make it make circles
  - or alternating colored lines
  - or…

Load Image

- We will now walk through a program that starts like:



Turn it Red

- And when the user clicks on the right side…

loadImage.html

```
<!DOCTYPE html>
<html lang="en">
<head>
   <meta content="text/html; charset=utf-8" http-equiv="content-type">
   <meta name="author" content="Brent Dingle">
   <meta name="description" content="Image Data Example in HTML5 and JavaScript by Brent M Dingle">
   <title>Example: Load Image Data</title>
                <script src="loadImage.js" type="text/javascript"></script>
</head>

<body>
<div>
     <canvas id="mainImageCanvas" width="1000" height="500" style="border:1px solid #000000;">
        Your browser does not support the HTML5 canvas tag.
      </canvas>
   </div>
</body>
</html>
```

Same as previous examples… but using a more detailed id name for the canvas

Questions on the HTML file ?

loadImage.html

```
<!DOCTYPE html>
<html lang="en">
<head>
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   <meta name="author" content="Brent Dingle">
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</head>

<body>
<div>
      <canvas id="mainImageCanvas" width="1000" height="500" style="border:1px solid #000000;">
         Your browser does not support the HTML5 canvas tag.
      </canvas>
   </div>
</body>
</html>
```

loadImage.js

```
// -------------------------------------------------------------------------
// theProgram (singleton) Object
// -------------------------------------------------------------------------
// -------------------------------------------------------------------------
var theProgram =
{
    // ---------------------------------------------------------------------
    // Pseudo-constants
    // ---------------------------------------------------------------------
    IMAGE_CANVAS_ID: "mainImageCanvas",     // canvas id used in html

    // ---------------------------------------------------------------------
    // Variables
    // ---------------------------------------------------------------------
    width:        400,        // canvas width... likely will be reset
    height:       400,        // canvas height... likely will be reset
    imageObj:      null,

    xOffset:      5,
    yOffset:      5,
```

Declare and initialize the
Member variables
of the
singleton object *theProgram*

loadImage.js

```
 // Variables
// ---------------------------------------------------------------------
width:        400,         // canvas width... likely will be reset
height:       400,         // canvas height... likely will be reset
imageObj:      null,

xOffset:       5,
yOffset:       5,

// ---------------------------------------------------------------------
// Functions
// ---------------------------------------------------------------------
//                                        Main
// ---------------------------------------------------------------------
Main: function()
{
  var canvas = document.getElementById(this.IMAGE_CANVAS_ID);
  canvas.addEventListener('click', theProgram.onClick, false);
  canvas.addEventListener('touch', theProgram.onClick, false);

  this.imageObj = new Image();
  this.imageObj.onload = function()
                         {
                              theProgram.drawOrigImage();
                         };
 this.imageObj.src = 'bobcatCactus.png';
},

// ---------------------------------------------------------------------
// EventHandler                                  onClick
```

Our desired Entry-point function

loadImage.js

```
 // Variables
// ---------------------------------------------------------------------
width:        400,         // canvas width... likely will be reset
height:       400,         // canvas height... likely will be reset
imageObj:      null,

xOffset:       5,
yOffset:       5,

// ---------------------------------------------------------------------
// Functions
// ---------------------------------------------------------------------
//                                        Main
// ---------------------------------------------------------------------
Main: function()
{
  var canvas = document.getElementById(this.IMAGE_CANVAS_ID);
  canvas.addEventListener('click', theProgram.onClick, false);
  canvas.addEventListener('touch', theProgram.onClick, false);

  this.imageObj = new Image();
  this.imageObj.onload = function()
                         {
                              theProgram.drawOrigImage();
                         };
 this.imageObj.src = 'bobcatCactus.png';
},

// ---------------------------------------------------------------------
// EventHandler                                  onClick
```

Register a call-back function for click and touch events

loadImage.js

```
 // Variables
// ----------------------------------------------------------------------
width:      400,        // canvas width... likely will be reset
height:     400,        // canvas height... likely will be reset
imageObj:     null,

xOffset:     5,
yOffset:     5,

// ----------------------------------------------------------------------
// Functions
// ----------------------------------------------------------------------
//                                      Main
// ----------------------------------------------------------------------
Main: function()
{
  var canvas = document.getElementById(this.IMAGE_CANVAS_ID);
  canvas.addEventListener('click', theProgram.onClick, false);
  canvas.addEventListener('touch', theProgram.onClick, false);

  this.imageObj = new Image();
  this.imageObj.onload = function()
                         {
                             theProgram.drawOrigImage();
                         };
 this.imageObj.src = 'bobcatCactus.png';
},

// ----------------------------------------------------------------------
// EventHandler                                onClick
```

Load the image file named:
bobcatCactus.png

Register a callback function
to draw it to the canvas when the
file is loaded into the browser

Yes it is important to set the onload function BEFORE setting the src

loadImage.js

```
// EventHandler                                onClick
// ---------------------------------------------------------------------
onClick: function(e)
{
   theProgram.drawOrigImage();
   theProgram.drawBWimage();
},

// ---------------------------------------------------------------------
// drawOrigImage
// ---------------------------------------------------------------------
drawOrigImage: function()
{
   var canvas = document.getElementById(this.IMAGE_CANVAS_ID);
   var ctx = canvas.getContext('2d');
   ctx.clearRect(0, 0, canvas.width, canvas.height);

   ctx.drawImage(this.imageObj, this.xOffset, this.yOffset);

   ctx.font="16px Georgia";
   ctx.fillText("Click/tap to see the", this.imageObj.width+20, 80);
   ctx.fillText("black and white image", this.imageObj.width+20, 100);
},


// ---------------------------------------------------------------------
// drawBWimage  -- must call drawOrigImage before this
```

Function that is called when the image file named:

bobcatCactus.png

is loaded into the browser

loadImage.js

```
// EventHandler                                onClick
// ---------------------------------------------------------------------
onClick: function(e)
{
   theProgram.drawOrigImage();
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// ---------------------------------------------------------------------
// drawOrigImage
// ---------------------------------------------------------------------
drawOrigImage: function()
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   var canvas = document.getElementById(this.IMAGE_CANVAS_ID);
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   ctx.font="16px Georgia";
   ctx.fillText("Click/tap to see the", this.imageObj.width+20, 80);
   ctx.fillText("black and white image", this.imageObj.width+20, 100);
},


// ---------------------------------------------------------------------
// drawBWimage  -- must call drawOrigImage before this
```

Gets the canvas and context

loadImage.js

```
// EventHandler                                    onClick
// ------------------------------------------------------------------
onClick: function(e)
{
   theProgram.drawOrigImage();
   theProgram.drawBWimage();
},

// ------------------------------------------------------------------
// drawOrigImage
// ------------------------------------------------------------------
drawOrigImage: function()
{
   var canvas = document.getElementById(this.IMAGE_CANVAS_ID);
   var ctx = canvas.getContext('2d');
   ctx.clearRect(0, 0, canvas.width, canvas.height);

   ctx.drawImage(this.imageObj, this.xOffset, this.yOffset);

   ctx.font="16px Georgia";
   ctx.fillText("Click/tap to see the", this.imageObj.width+20, 80);
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},


// ------------------------------------------------------------------
// drawBWimage  -- must call drawOrigImage before this
```

Clears the canvas

loadImage.js

```
// EventHandler                                onClick
// ---------------------------------------------------------------------
onClick: function(e)
{
   theProgram.drawOrigImage();
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},

// ---------------------------------------------------------------------
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drawOrigImage: function()
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   var canvas = document.getElementById(this.IMAGE_CANVAS_ID);
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   ctx.fillText("black and white image", this.imageObj.width+20, 100);
},


// ---------------------------------------------------------------------
// drawBWimage  -- must call drawOrigImage before this
```

Draws the loaded image

loadImage.js

```
// EventHandler                                    onClick
// ------------------------------------------------------------------
onClick: function(e)
{
   theProgram.drawOrigImage();
   theProgram.drawBWimage();
},

// ------------------------------------------------------------------
// drawOrigImage
// ------------------------------------------------------------------
drawOrigImage: function()
{
   var canvas = document.getElementById(this.IMAGE_CANVAS_ID);
   var ctx = canvas.getContext('2d');
   ctx.clearRect(0, 0, canvas.width, canvas.height);

   ctx.drawImage(this.imageObj, this.xOffset, this.yOffset);

   ctx.font="16px Georgia";
   ctx.fillText("Click/tap to see the", this.imageObj.width+20, 80);
   ctx.fillText("altered image", this.imageObj.width+20, 100);
},


// ------------------------------------------------------------------
// drawBWimage  -- must call drawOrigImage before this
```

Displays message telling user to click or tap on the area to see the altered version of the image

loadImage.js

```
// EventHandler                                    onClick
// -----------------------------------------------------------------
onClick: function(e)
{
   theProgram.drawOrigImage();
   theProgram.drawAlteredImage();
},

// -----------------------------------------------------------------
// drawOrigImage
// -----------------------------------------------------------------
drawOrigImage: function()
{
   var canvas = document.getElementById(this.IMAGE_CANVAS_ID);
   var ctx = canvas.getContext('2d');
   ctx.clearRect(0, 0, canvas.width, canvas.height);

   ctx.drawImage(this.imageObj, this.xOffset, this.yOffset);

   ctx.font="16px Georgia";
   ctx.fillText("Click/tap to see the", this.imageObj.width+20, 80);
   ctx.fillText("altered image", this.imageObj.width+20, 100);
},


// -----------------------------------------------------------------
// drawAlteredImage  -- must call drawOrigImage before this
```

This function is called when the user clicks or taps on the area

It will draw the original image and then the altered image

loadImage.js

```
// drawAlteredImage  -- must call drawOrigImage before this
// ---------------------------------------------------------------------
drawAlteredImage: function()
{
   var canvas = document.getElementById(this.IMAGE_CANVAS_ID);
   var ctx = canvas.getContext('2d');

   // Get the image data from the canvas context
   var imageData = ctx.getImageData(this.xOffset, this.yOffset,
                           this.imageObj.width, this.imageObj.height);
   var data = imageData.data;

   // This gives us the image data in RGBA format - one byte for each
   // So to iterate over all pixels we would do:
   //for(var i = 0, n = data.length; i < n; i += 4)
   // {
      // var red = data[i];
      // var green = data[i + 1];
      // var blue = data[i + 2];
      // var alpha = data[i + 3];
   // }

   // We must 'create' a new image
```

Function to draw the altered image

loadImage.js

```
// drawAlteredImage  -- must call drawOrigImage before this
// ------------------------------------------------------------------------
drawAlteredImage: function()
{
   var canvas = document.getElementById(this.IMAGE_CANVAS_ID);
   var ctx = canvas.getContext('2d');

   // Get the image data from the canvas context
   var imageData = ctx.getImageData(this.xOffset, this.yOffset,
                                    this.imageObj.width, this.imageObj.height);
   var data = imageData.data;

   // This gives us the image data in RGBA format - one byte for each
   // So to iterate over all pixels we would do:
   //for(var i = 0, n = data.length; i < n; i += 4)
   // {
      // var red = data[i];
      // var green = data[i + 1];
      // var blue = data[i + 2];
      // var alpha = data[i + 3];
   // }

   // We must 'create' a new image
```

Get the original image
pixel data array

CAUTION:
This assumes the image is drawn on the canvas already, at (xOffset, yOffset)
and is size *width* x height

Hence the need for drawOrigImage to be called before this function

There are other ways to do this and avoid this assumption

loadImage.js

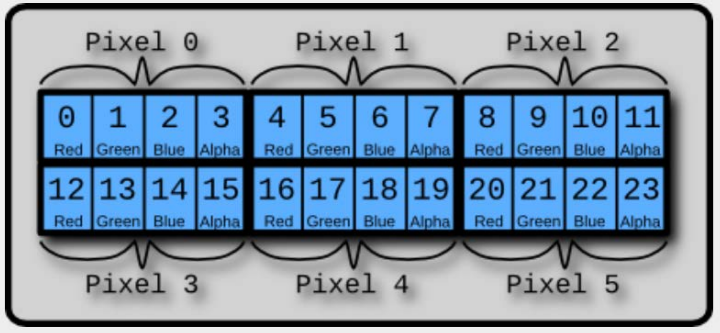
```
// drawAlteredImage  -- must call drawOrigImage before this
// ------------------------------------------------------------------------
drawAlteredImage: function()
{
   var canvas = document.getElementById(this.IMAGE_CANVAS_ID);
   var ctx = canvas.getContext('2d');

   // Get the image data from the canvas context
   var imageData = ctx.getImageData(this.xOffset, this.yOffset,
                                    this.imageObj.width, this.imageObj.height);
   var data = imageData.data;

   // This gives us the image data in RGBA format - one byte for each
   // So to iterate over all pixels we would do:
   //for(var i = 0, n = data.length; i < n; i += 4)
   // {
      // var red = data[i];
      // var green = data[i + 1];
      // var blue = data[i + 2];
      // var alpha = data[i + 3];
   // }

   // We must 'create' a new image
```

Recall the ordering of the pixel data



Pixel layout in the pixel array for a 3-by-2 image of 6 pixels. Each pixel takes 4 elements in the array for red, green, blue, and alpha, for a total of 24 array elements, 0-23.

loadImage.js

```
            // var alpha = data[i + 3];
        // }

        // We must 'create' a new image
      var SecondImageData = ctx.createImageData(this.imageObj.width, this.imageObj.height);

        for (var pixelIndex=0; pixelIndex < SecondImageData.data.length; pixelIndex += 4)
        {
           SecondImageData.data[pixelIndex    ] = data[pixelIndex] * 3;         // More red
           SecondImageData.data[pixelIndex + 1] = data[pixelIndex +1] / 2;  // Less green
           SecondImageData.data[pixelIndex + 2] = data[pixelIndex +2] / 2;  // Less blue
           SecondImageData.data[pixelIndex + 3] = data[pixelIndex +3];      // alpha unchanged
        }

        // Want to draw the altered image to the right of original
        // Offset gives spacing between
        var SecondImageX = 2*this.xOffset + this.imageObj.width;
        var SecondImageY = this.yOffset;
        ctx.putImageData(SecondImageData, SecondImageX, SecondImageY);

    },

};  // end theProgram variable

// ---------------------------------------------------------------------------
//                                        window.ONLOAD
```

Create a new pixel data array of the same size as the original

loadImage.js

```
            // var alpha = data[i + 3];
        // }

        // We must 'create' a new image
      var SecondImageData = ctx.createImageData(this.imageObj.width, this.imageObj.height);

      for (var pixelIndex=0; pixelIndex < SecondImageData.data.length; pixelIndex += 4)
      {
         SecondImageData.data[pixelIndex    ] = data[pixelIndex] * 3;         // More red
         SecondImageData.data[pixelIndex + 1] = data[pixelIndex +1] / 2;  // Less green
         SecondImageData.data[pixelIndex + 2] = data[pixelIndex +2] / 2;  // Less blue
         SecondImageData.data[pixelIndex + 3] = data[pixelIndex +3];      // alpha unchanged
      }

        // Want to draw the altered image to the right of original
        // Offset gives spacing between
        var SecondImageX = 2*this.xOffset + this.imageObj.width;
        var SecondImageY = this.yOffset;
        ctx.putImageData(SecondImageData, SecondImageX, SecondImageY);

    },

};  // end theProgram variable

// ---------------------------------------------------------------------------
//                                      window.ONLOAD
```

Loop through the pixel data
Increasing the red values
Decreasing the green and blue

Alpha remains the same

loadImage.js

```
            // var alpha = data[i + 3];
        // }

        // We must 'create' a new image
      var SecondImageData = ctx.createImageData(this.imageObj.width, this.imageObj.height);

        for (var pixelIndex=0; pixelIndex < SecondImageData.data.length; pixelIndex += 4)
        {
           SecondImageData.data[pixelIndex    ] = data[pixelIndex] * 3;         // More red
           SecondImageData.data[pixelIndex + 1] = data[pixelIndex +1] / 2;  // Less green
           SecondImageData.data[pixelIndex + 2] = data[pixelIndex +2] / 2;  // Less blue
           SecondImageData.data[pixelIndex + 3] = data[pixelIndex +3];       // alpha unchanged
        }

        // Want to draw the altered image to the right of original
        // Offset gives spacing between
        var SecondImageX = 2*this.xOffset + this.imageObj.width;
        var SecondImageY = this.yOffset;
        ctx.putImageData(SecondImageData, SecondImageX, SecondImageY);

    },

};  // end theProgram variable

// ---------------------------------------------------------------------------
//                                      window.ONLOAD
```

Calculate the offset position to draw the second image

→ calculate where the upper left corner of the new image is to be placed on the canvas

Answer: at position (*secondImageX*, *secondImageY*) in canvas coordinates

loadImage.js

```
            // var alpha = data[i + 3];
        // }

        // We must 'create' a new image
      var SecondImageData = ctx.createImageData(this.imageObj.width, this.imageObj.height);

        for (var pixelIndex=0; pixelIndex < SecondImageData.data.length; pixelIndex += 4)
        {
           SecondImageData.data[pixelIndex    ] = data[pixelIndex] * 3;         // More red
           SecondImageData.data[pixelIndex + 1] = data[pixelIndex +1] / 2;  // Less green
           SecondImageData.data[pixelIndex + 2] = data[pixelIndex +2] / 2;  // Less blue
           SecondImageData.data[pixelIndex + 3] = data[pixelIndex +3];      // alpha unchanged
        }

        // Want to draw the altered image to the right of original
        // Offset gives spacing between
        var SecondImageX = 2*this.xOffset + this.imageObj.width;
        var SecondImageY = this.yOffset;
        ctx.putImageData(SecondImageData, SecondImageX, SecondImageY);

    },

};  // end theProgram variable

// ---------------------------------------------------------------------------
//                                      window.ONLOAD
```

Draw the altered image
on the canvas
at the calculated offset

loadImage.js

```
        SecondImageData.data[pixelIndex + 2] = data[pixelIndex +2] / 2;  // Less blue
        SecondImageData.data[pixelIndex + 3] = data[pixelIndex +3];      // alpha unchanged
      }

      // Want to draw the altered image to the right of original
      // Offset gives spacing between
      var SecondImageX = 2*this.xOffset + this.imageObj.width;
      var SecondImageY = this.yOffset;
      ctx.putImageData(SecondImageData, SecondImageX, SecondImageY);

   },

};  // end theProgram variable

// ---------------------------------------------------------------------------
//                                    window.ONLOAD
// ---------------------------------------------------------------------------
window.onload = function()
{
   // Initialize and Start the game
   theProgram.Main();

};

// ---------------------------------------------------------------------------
// ---------------------------------------------------------------------------
// end of file
```

And make sure when all the contents of the HTML page are loaded into the browser that our program begins

i.e. call *theProgram.Main()*

loadImage.js

```
        SecondImageData.data[pixelIndex + 2] = data[pixelIndex +2] / 2;  // Less blue
        SecondImageData.data[pixelIndex + 3] = data[pixelIndex +3];      // alpha unchanged
      }

      // Want to draw the altered image to the right of original
      // Offset gives spacing between
      var SecondImageX = 2*this.xOffset + this.imageObj.width;
      var SecondImageY = this.yOffset;
      ctx.putImageData(SecondImageData, SecondImageX, SecondImageY);

   },

};  // end theProgram variable

// ---------------------------------------------------------------------------
//                                      window.ONLOAD
// ---------------------------------------------------------------------------
window.onload = function()
{
   // Initialize and Start the game
   theProgram.Main();

};

// ---------------------------------------------------------------------------
// ---------------------------------------------------------------------------
// end of file
```

Any questions on the JavaScript?

Challenge

- Alter the above program to change the color image into a grey-scale image

- Apply a luminance algorithm of:
  - 0.3*red + 0.59*green + 0.11*blue

  - Also, come to the next class with an explanation of why the green would be such a higher weight

Questions?

- Beyond D2L
  - Examples and information can be found online at:
    - *http://docdingle.com/teaching/cs.html*

    - *Continue to more stuff as needed*

Extra Reference Stuff Follows

Credits

- Much of the content derived/based on slides for use with the book:
  - *Digital Image Processing,* Gonzalez and Woods

- Some layout and presentation style derived/based on presentations by
  - Donald House, Texas A&M University, 1999
  - Bernd Girod, Stanford University, 2007
  - Shreekanth Mandayam, Rowan University, 2009
  - Igor Aizenberg, TAMUT, 2013
  - Xin Li, WVU, 2014
  - George Wolberg, City College of New York, 2015
  - Yao Wang and Zhu Liu, NYU-Poly, 2015
  - Sinisa Todorovic, Oregon State, 2015
  - Beej's Bit Bucket / Tech and Programming Fun
    - http://beej.us/blog/
    - http://beej.us/blog/data/html5s-canvas-2-pixel/
  - w3schools.com