Web Audio Visualizer Part II

1) Doing pixel manipulations to the entire canvas.

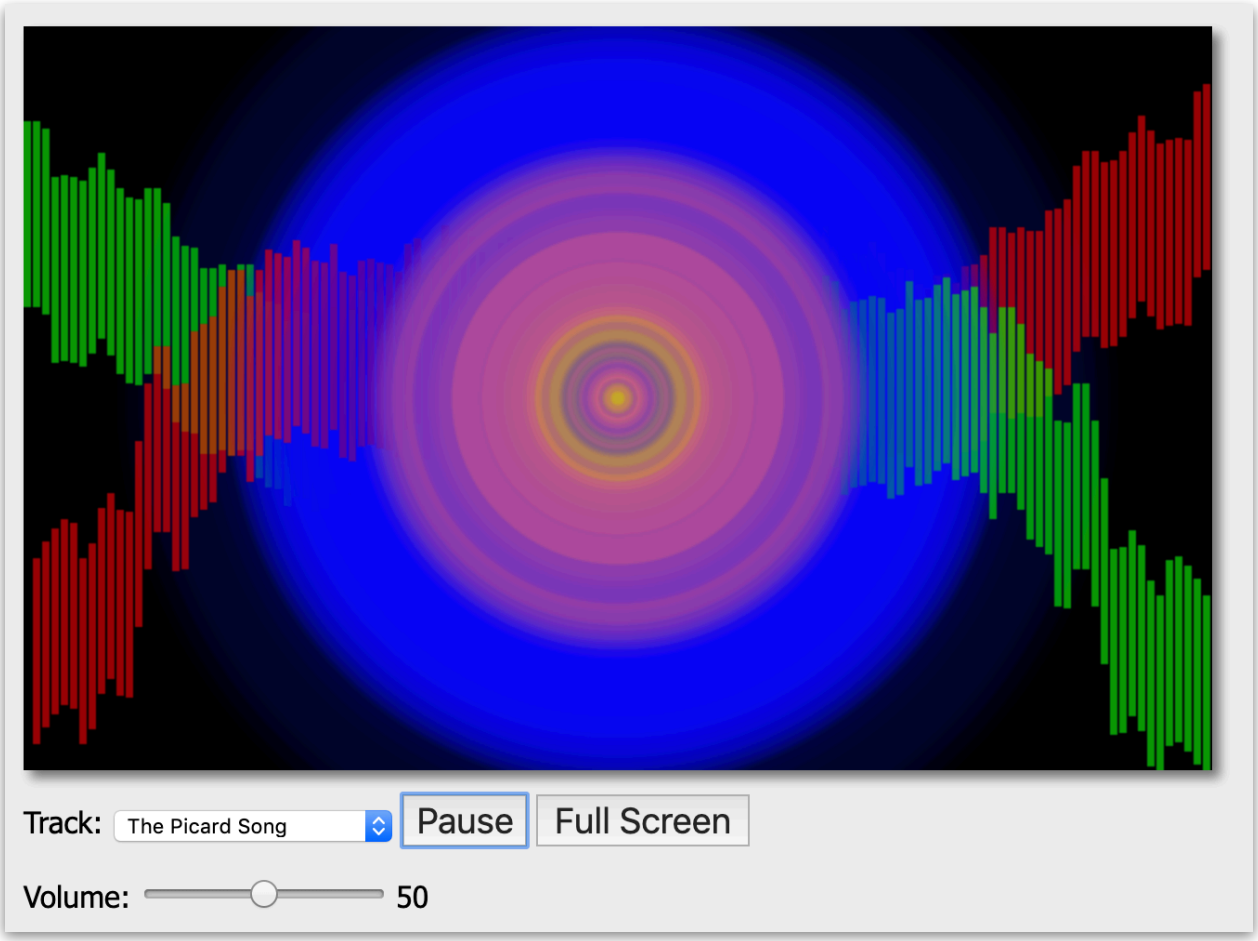
We can grab the RGBA (red, green, blue, alpha) data for the entire canvas, manipulate it, and then copy the modified data back to the canvas. This allows (for example) Photoshop style filters, chroma key effects, edge detection for motion and object recognition applications, and more.

The methods we'll use here:

`ctx.getImageData(x,y,width,height)` - returns an `ImageData` object for the specified x,y,width height. This `ImageData` object has a `.data` property that is an 8-bit typed array of the rgba values of each pixel of the canvas.

`ctx.putImageData(imageData,x,y)` - copies an `ImageData` object onto the canvas at the specified x,y

The starting state of our visualization (yours is supposed to be somewhat different)



A) Grab the Web Audio Visualizer-I done file (the one with the circles, or another working version you've customized) and add 2 *script-scoped variables* at the top of the file (where your `drawCtx` and `canvasElement` variables are):

```
// 26 - these will help with our pixel effects
let invert = true, tintRed = true, noise = true, sepia = true;
```

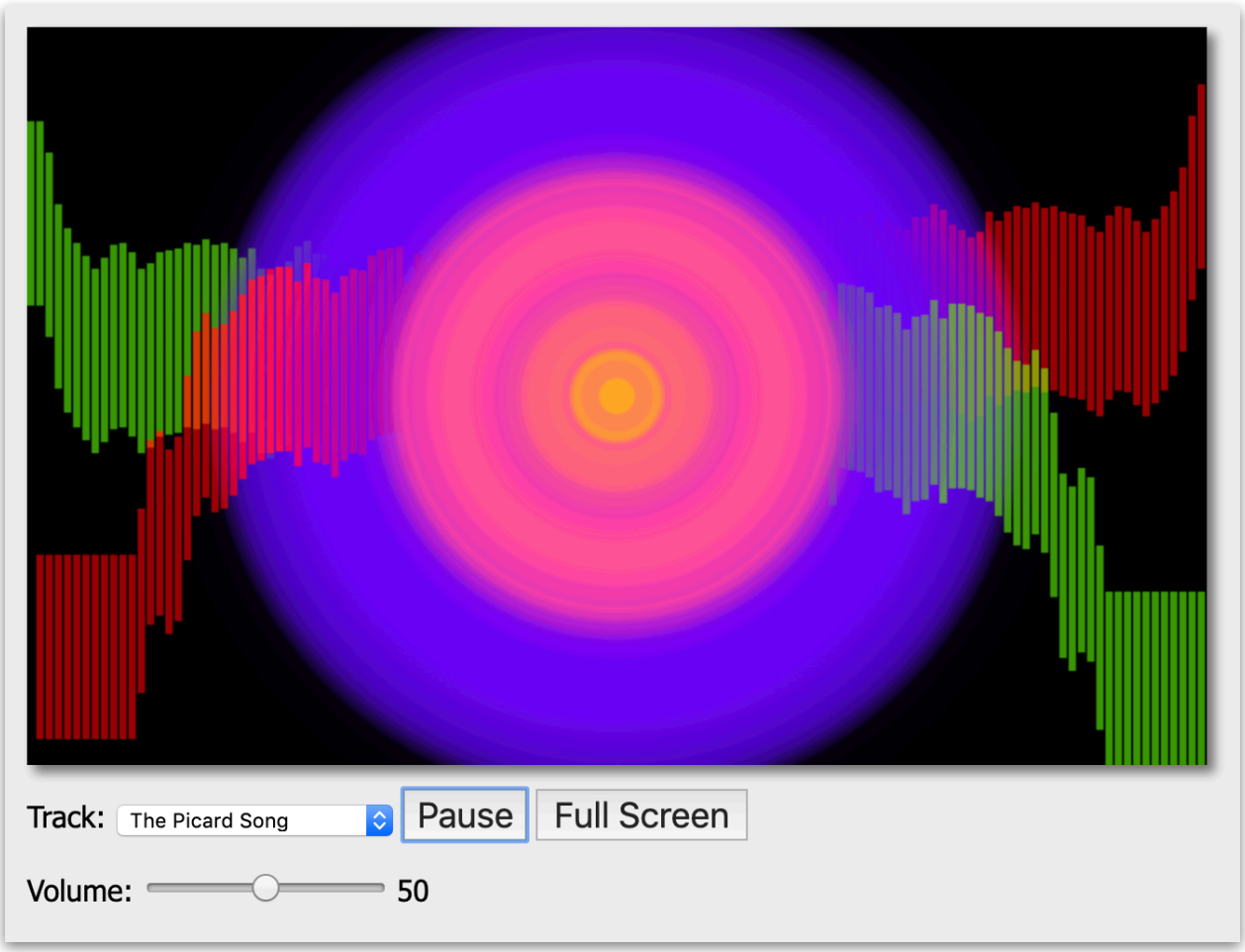
B) At the very end of the `update()` method (NOT inside the `for` loop), add a call to a function (that we are going to write next) called `manipulatePixels(drawCtx)`.

C) Make `manipulatePixels()` look like this, and put it in the `// III. - HELPER FUNCTIONS` area:

```
// III. HELPER FUNCTIONS

function manipulatePixels(ctx){
  // 28 - Get all of the rgba pixel data of the canvas by grabbing the ImageData Object
  // https://developer.mozilla.org/en-US/docs/Web/API/ImageData
  let imageData = ctx.getImageData(0, 0, ctx.canvas.width, ctx.canvas.height);

  // 29 - imageData.data is an 8-bit typed array - values range from 0-255
  // imageData.data contains 4 values per pixel: 4 x canvas.width x  canvas.height = 1,024,000 values!
  // we're looping through this 60 FPS - wow!
  let data = imageData.data;
  let length = data.length;
  let width = imageData.width;

  // 30 - Iterate through each pixel
  // we step by 4 so that we can manipulate 1 pixel per iteration
  // data[i] is the red value
  // data[i+1] is the green value
  // data[i+2] is the blue value
  // data[i+3] is the alpha value

  let i; // declaring `i` outside loop is an optimization
  for (i = 0; i < length; i +=4){
    // 31 - increase red value only
    if(tintRed){
      // just the red channel this time
      data[i] = data[i] + 100;
    }

  }

  // 32 - put the modified data back on the canvas
  ctx.putImageData(imageData, 0, 0);
}
```

Outside of the comments, there's not much code here - and be sure you understand what's going on.

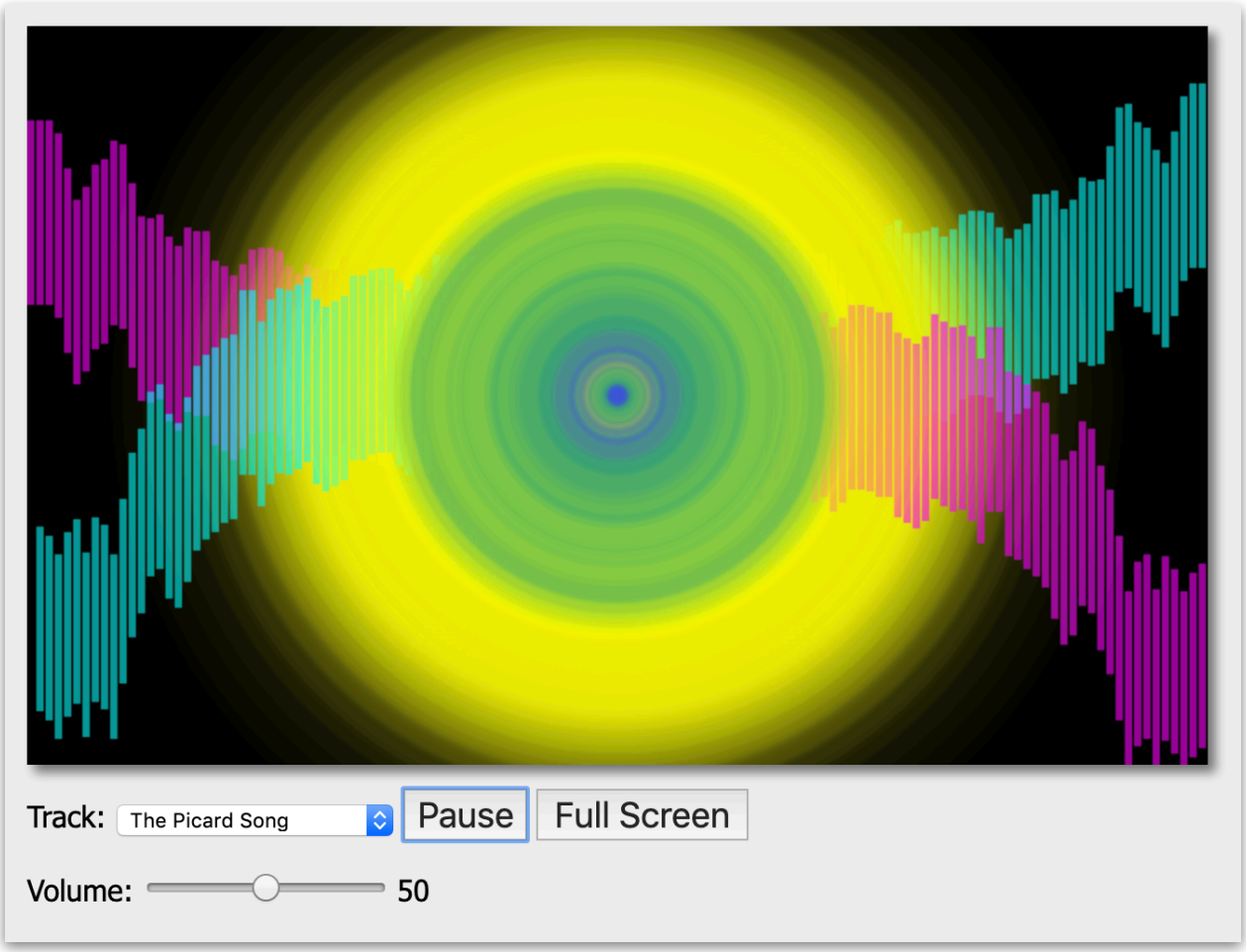
Run this in Chrome, you should get a red tint on the circle pixels:



D) Next we will invert the colors. Add the following right after the `tintRed` code (and inside of the loop):

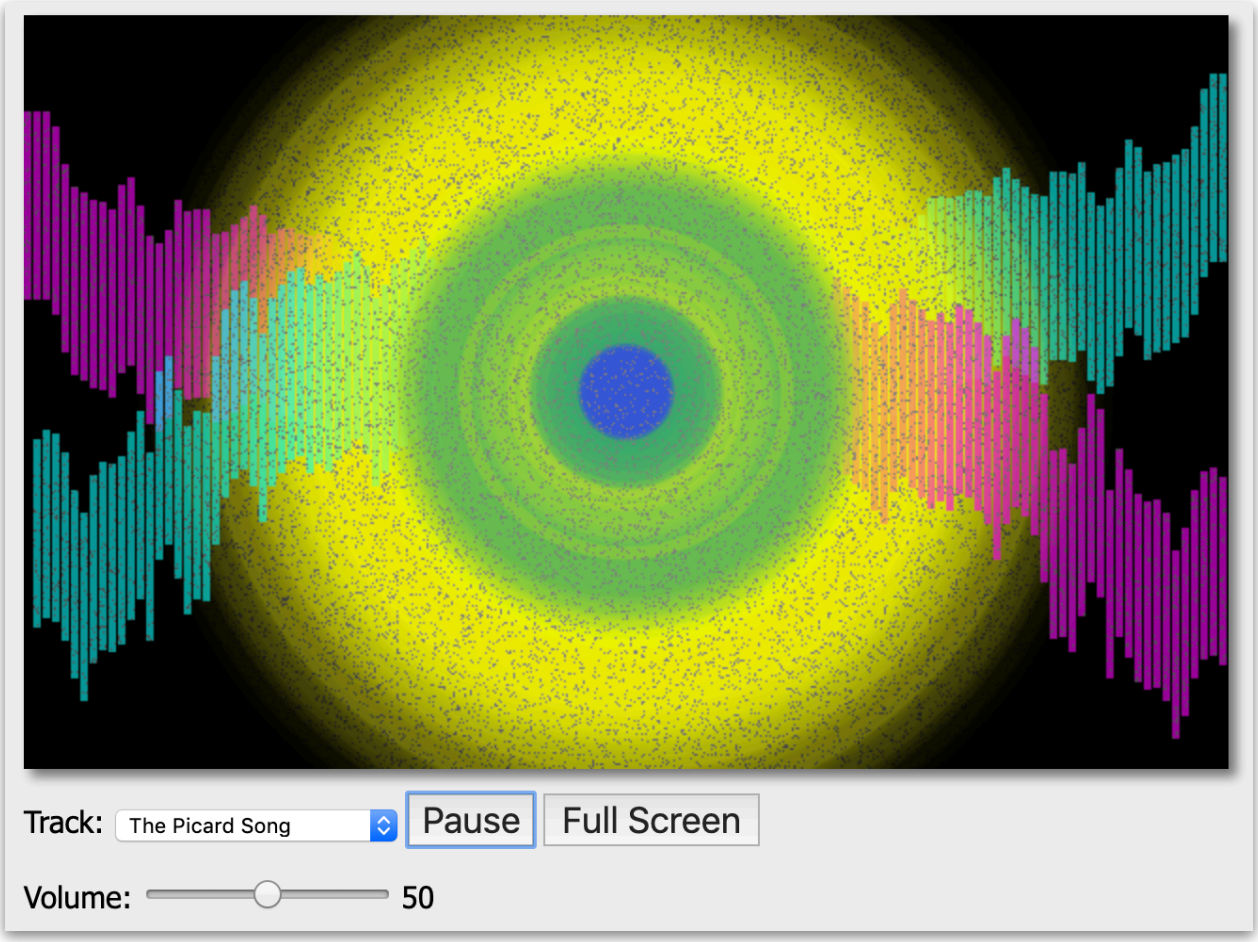
```
// 32 - invert every color channel
if(invert){
  let red = data[i], green = data[i+1], blue = data[i+2];
  data[i] = 255 - red;    // set red value
  data[i+1] = 255 - green;    // set blue value
  data[i+2] = 255 - blue; // set green value
  // data[i+3] is the alpha but we're leaving that alone
}
```

Set your `tintRed` script variable to `false` before you run this. You should see something like the following:



E) How about some noise?

```
// 33 - noise
if  (noise && Math.random() < .10){
  data[i] = data[i +1] = data[i+2] = 128; // gray noise
  //data[i] = data[i +1] = data[i+2] = 255; // or white noise
  //data[i] = data[i +1] = data[i+2] = 0; // or black noise
  data[i+3] = 255; // alpha
}
```

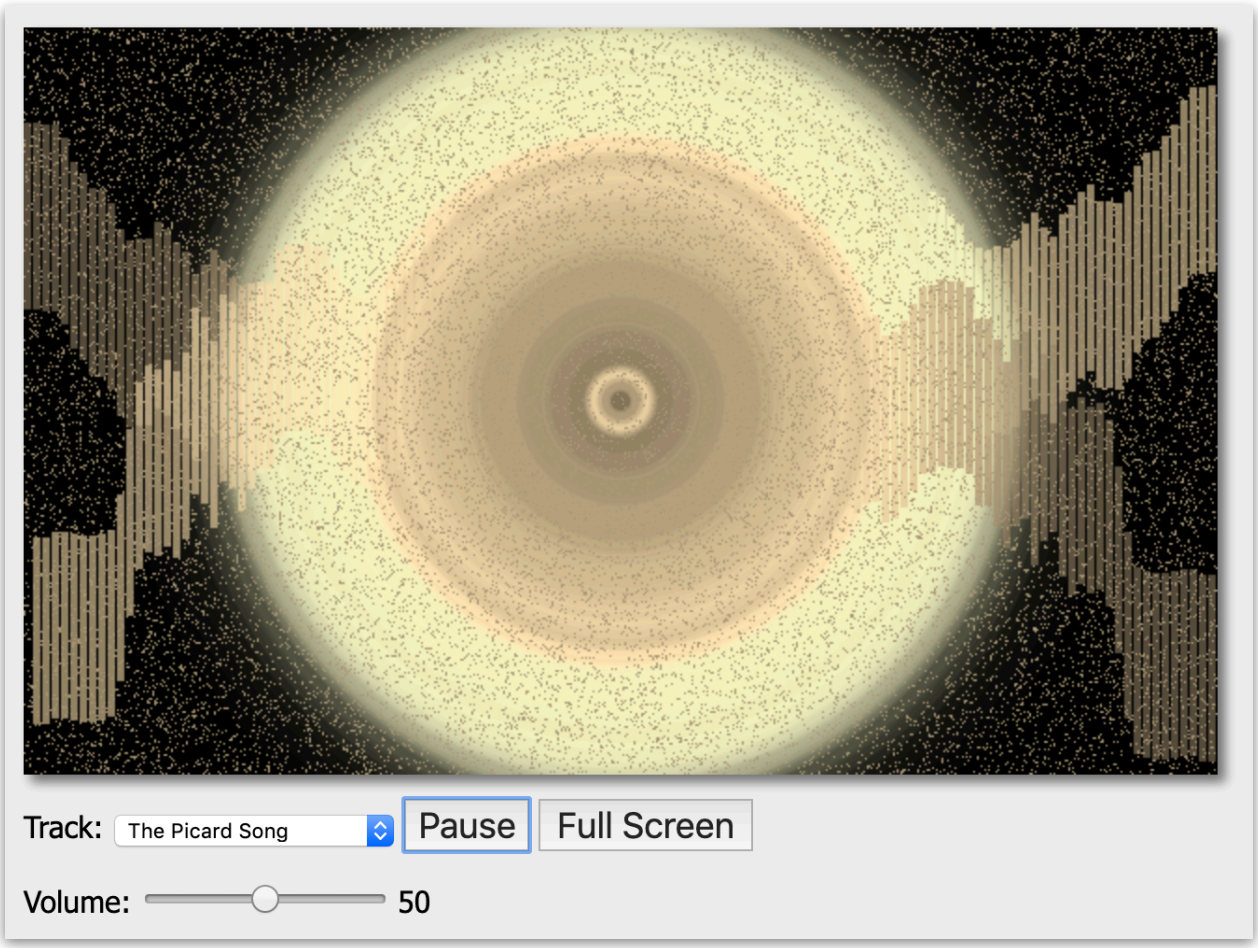


To see noise even on the black areas we haven't drawn to, add this:

```
data[i+3] = 255; // alpha
```

F) How about sepia tone?

```
// 34 - sepia
if (sepia){
      // You write this!
      // https://stackoverflow.com/questions/1061093/how-is-a-sepia-
tone-created
}
```



That's enough for now. These effects often work well if animated, under user control (mouse, keyboard etc), and especially on bitmapped images like photographs and video feeds.

2) Image Processing Links

Image processing is a large field of study - here are some links you might find handy:

http://www.techrepublic.com/blog/how-do-i/how-do-i-convert-images-to-grayscale-and-sepia-tone-using-c/#

http://stackoverflow.com/questions/1061093/how-is-a-sepia-tone-created

http://html5doctor.com/video-canvas-magic/

https://archive.org/details/Lectures_on_Image_Processing

http://stackoverflow.com/questions/13932855/canvas-flip-half-the-image

http://www.html5rocks.com/en/tutorials/canvas/imagefilters/#toc-setup

http://lodev.org/cgtutor/filtering.html

Another application of this (when combined with the webcam) is edge detection, which lets us detect, recognize and track objects and motion, which leads to making a webcam controller that acts like the Kinect. There are JS libraries available that can do this.

https://github.com/mtschirs/js-objectdetect

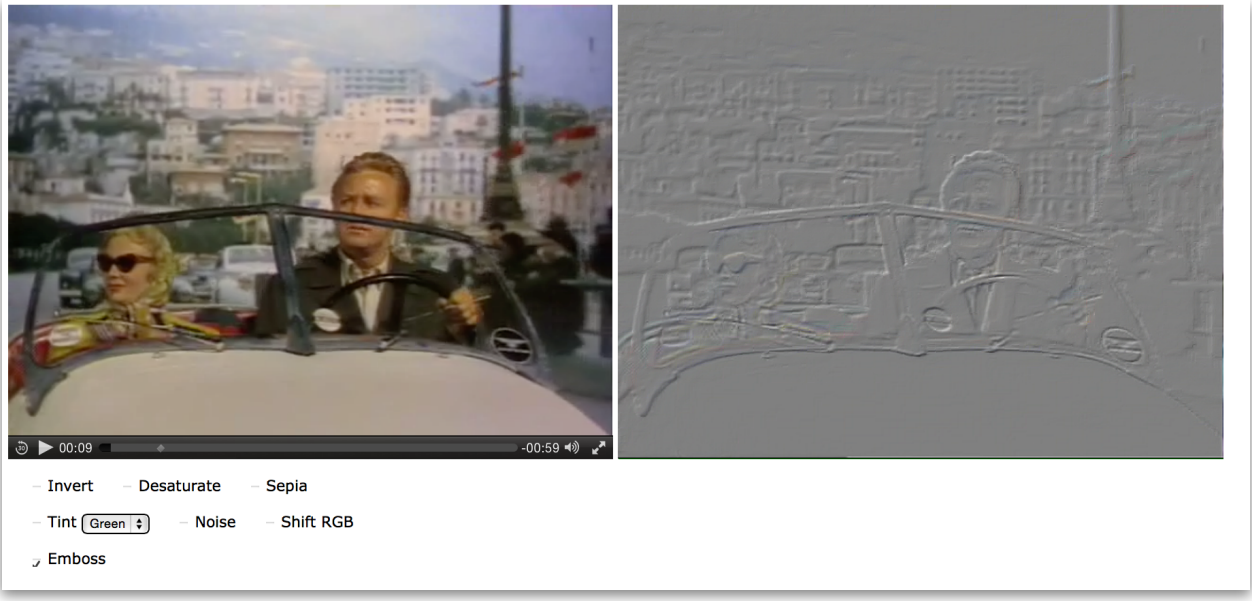
http://trackingjs.com/docs.html

3) A few demos - fun with Canvas and Video

So far our Audio Visualizer is performing pixel effects on procedurally generated drawings - but what if we wanted to do this on still images or even video?

It's easy - just copy the image or video frame to the canvas, then grab the canvas image data, manipulate it, and then copy it back to the canvas.

A) The screenshot below is from:
https://igm.rit.edu/~acjvks/courses/2014-spring/450/code/getImageData-putImageData-demo/video-image-data-demo-3.html



Here we see some additional effects applied to a video, such as *Desaturate*, *Sepia*, and *Shift RGB* (I made that one up). Feel free to "view source" to check out the code.

The above effects look at only one pixel at a time. More interestingly, the *Emboss* effect looks at neighboring pixels .

Here's the code for the emboss effect for the above app:

```
// emboss
if (emboss){
    // Loop through the subpixels, convoluting each using an edge-detection matrix.
    for(var i = 0; i < length; i++) {
        if( i%4 == 3 ) continue;
        data[i] = 127 + 2*data[i] - data[i + 4] - data[i + width*4];
    }
}
```

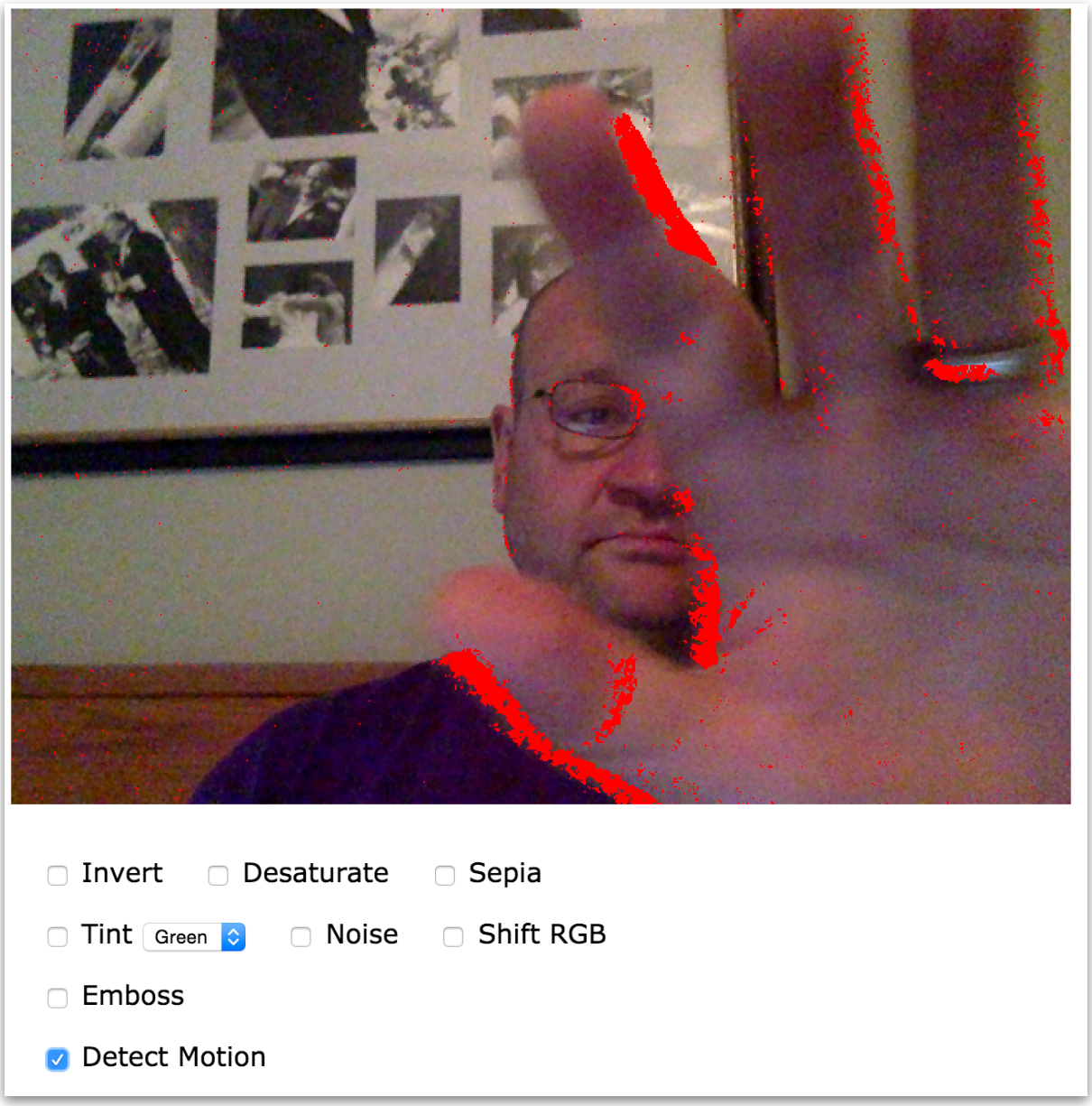
And here's a good explanation of how the emboss effect is accomplished from:
http://html5doctor.com/video-canvas-magic/

Then I just loop through the pixels, like I did before. If the pixel happens to be for the alpha channel (every fourth number in the array), I can just skip it — I don't want to change the transparency. Otherwise, I'll do a little math to find the difference between the current pixel's color channel and the similar channels of the pixels below and to the right, then just combine that difference with the "average" gray value of 127. This has the effect of making areas where the pixels are the same color a flat medium gray, but edges where the color suddenly changes will turn either bright or dark.

B) Turns out we can do this with webcam video too:
https://igm.rit.edu/~acjvks/courses/2014-spring/450/code/video/webcam-image-data-demo.html

C) We can also use pixel data for motion detection.

https://igm.rit.edu/~acjvks/courses/2014-spring/450/code/video/webcam-image-data-demo-2.html

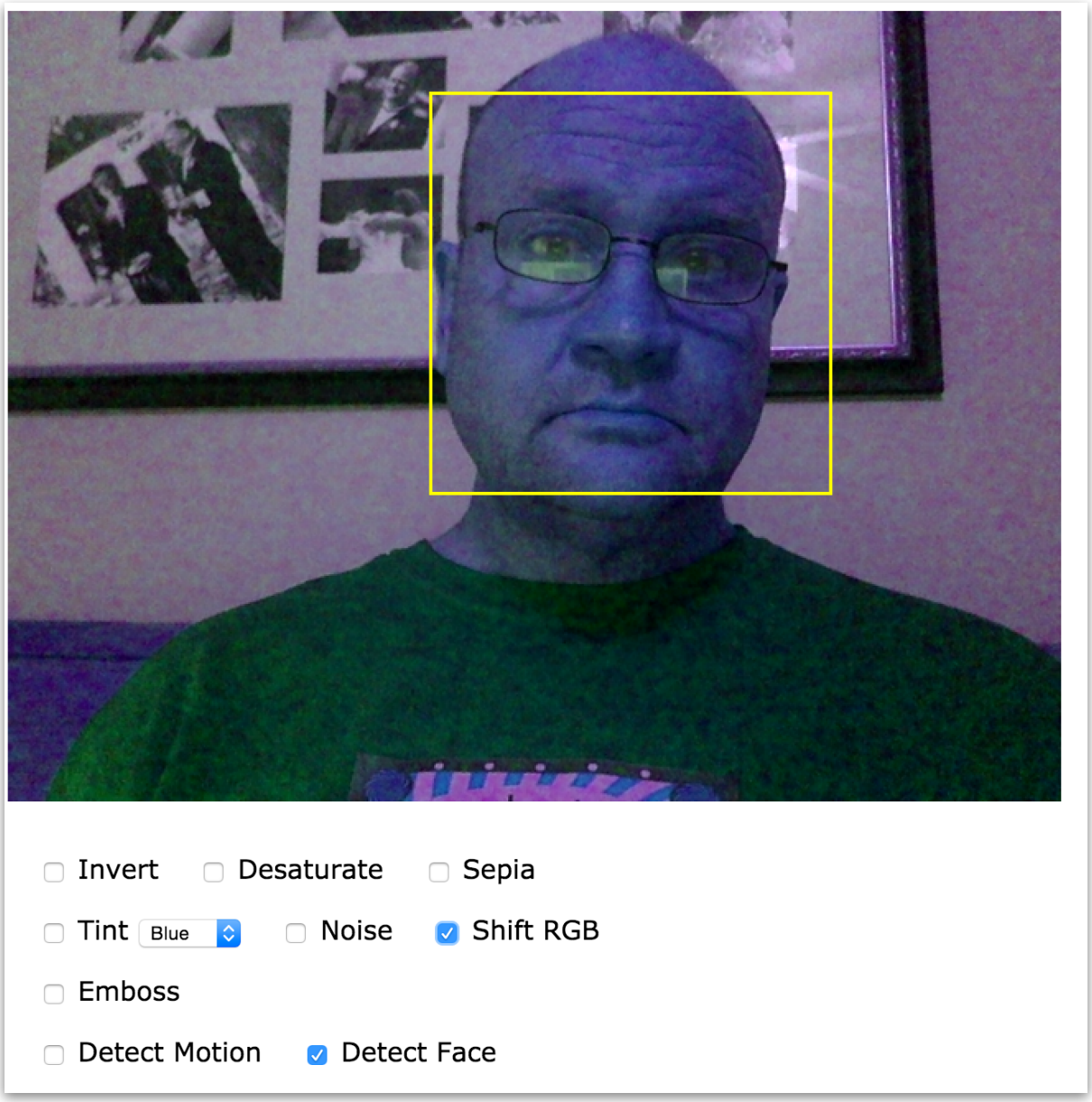


Feel free to view the source code. Here we just look at the current and previous `ImageData` captures and compare the pixel data. Wherever any of the color components has varied by 15 units or more, we color that entire pixel red. This has the effect of giving us motion detection for very little effort.

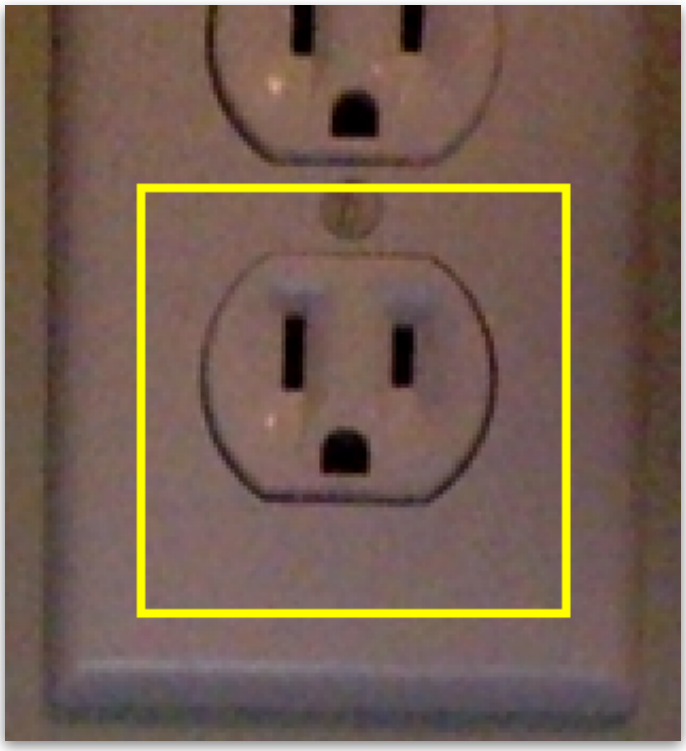
D) This captured pixel data can now be used for face and object detection.

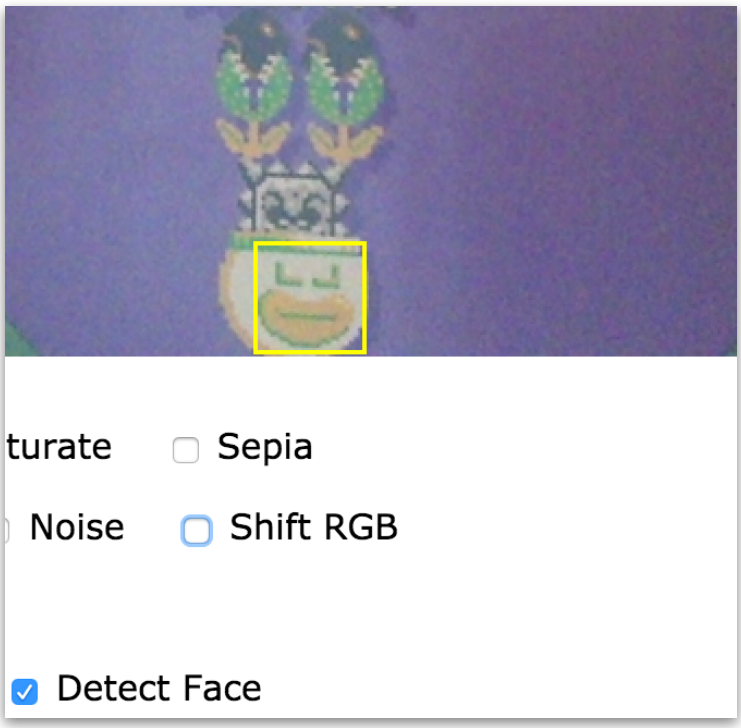
https://igm.rit.edu/~acjvks/courses/2014-spring/450/code/video/webcam-image-data-demo-3.html

And to do this, we're going to go ahead and use an existing JS library rather than write this object detection code from scratch.



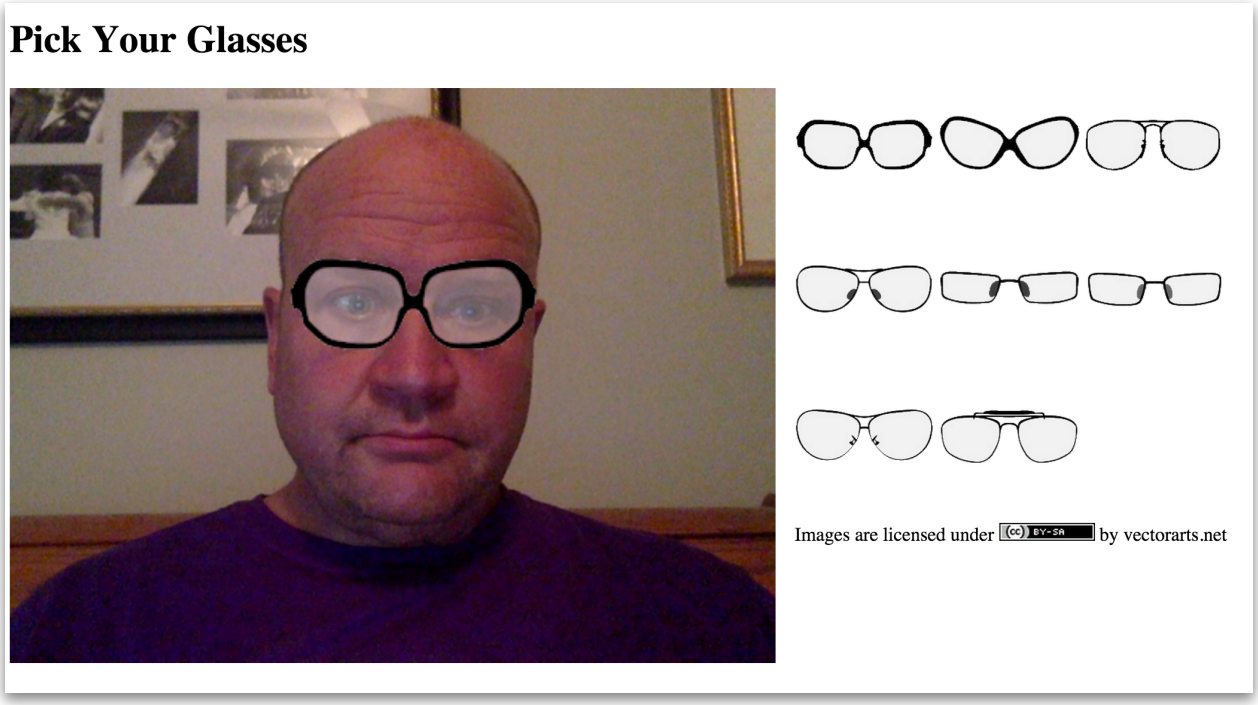
Turns out that wall outlets and Bowser Jr. Propeller Ship's have faces too:





E) Now we can see how a sunglass app (or mustache app) works. This also uses a JS library.

https://igm.rit.edu/~acjvks/courses/2014-spring/450/code/video/JS-Object-Detect/js-objectdetect-master/examples/example_sunglasses_jquery.htm



F) Another application we'll look at is motion tracking, which could be used as a game controller, or as input to a visualizer (hint, hint - see project 1). This example is demoing a JS library.

https://igm.rit.edu/~acjvks/courses/2014-spring/450/code/headtracker/headtracker2.html

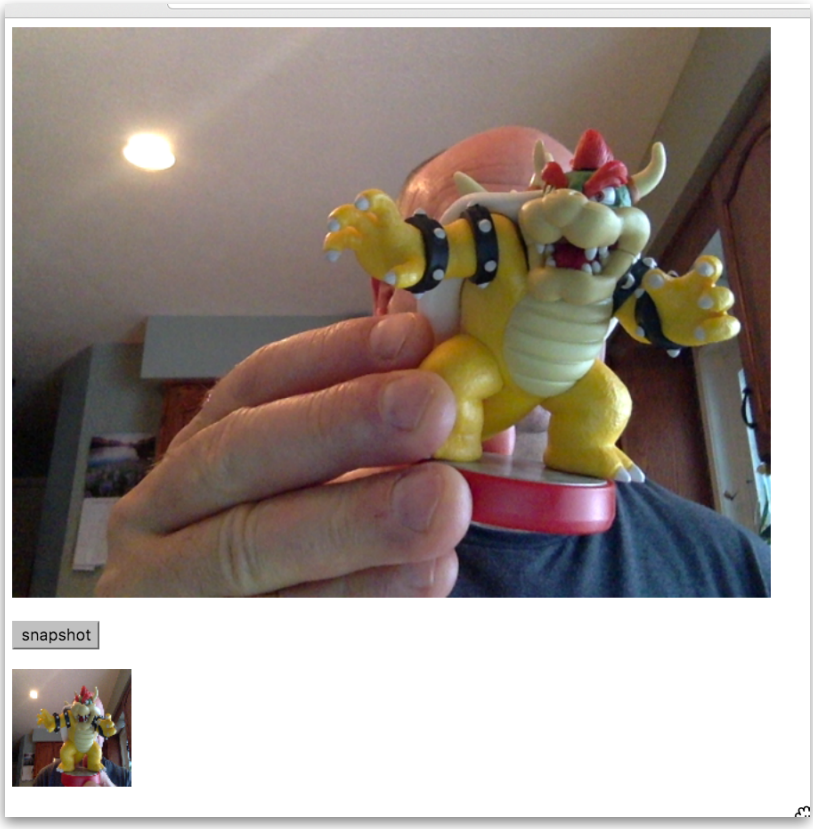
Here the x, y, and z of the subject's face is computed and displayed. Below we're not doing anything fancy, just showing the x/y/z values. Note that the x is negative because the subject is leaning left.

x=-11.71, y=12.83, z=54.91

G) Lastly, you can grab a frame of the video and save it as an image:

https://igm.rit.edu/~acjvks/courses/2014-spring/450/code/video/webcam2.html

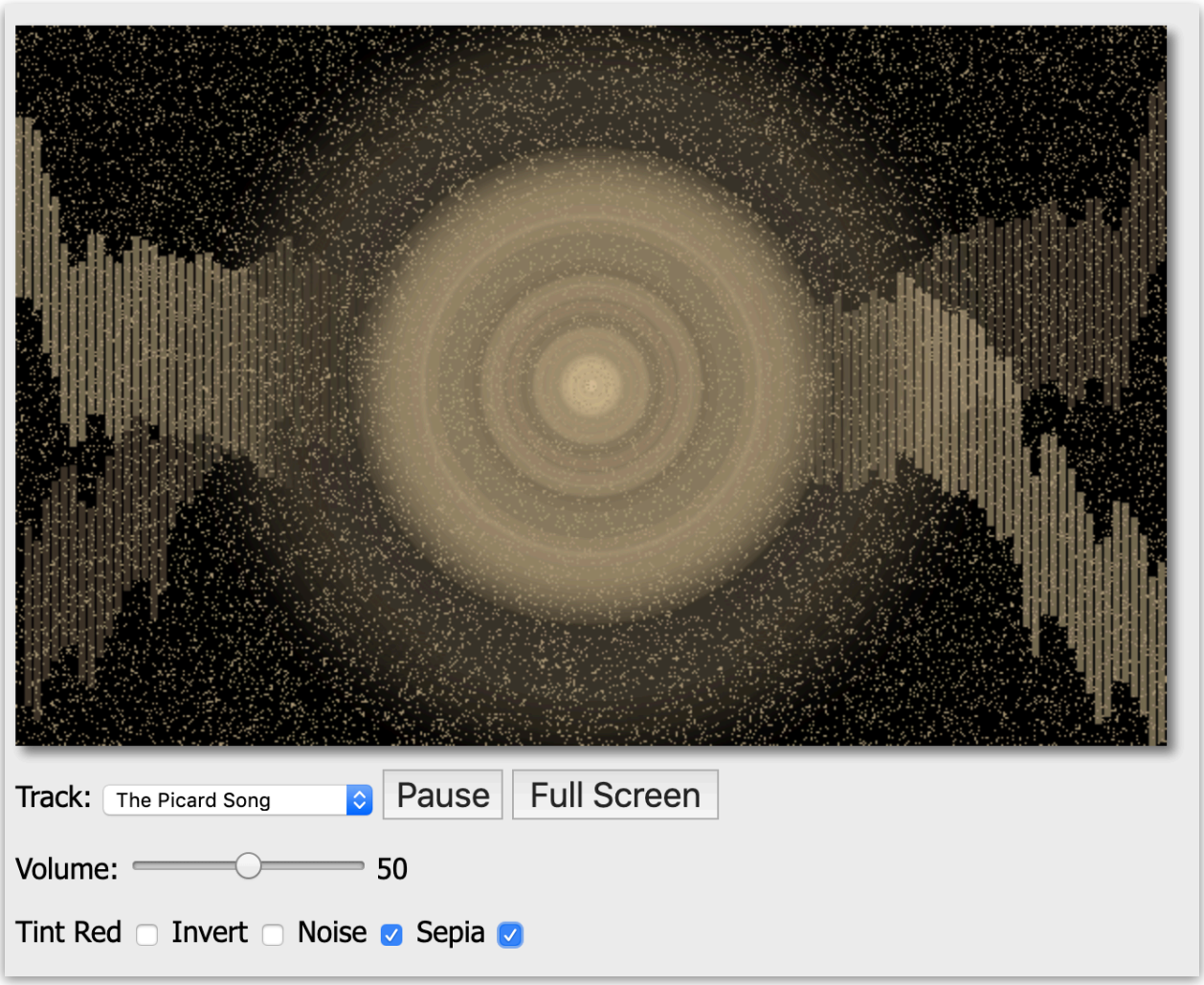
https://igm.rit.edu/~acjvks/courses/2014-spring/450/code/video/webcam3.html



HW and Rubric!

- Add all 4 of the above pixel effects (tint red, invert, noise, sepia) from way back in section #1 to your completed Audio Visualizer-1 from last time. (2 points)

- Add check boxes (see below) to change the various pixel effect boolean variables so that a user can toggle the effects on and off. Have the initial state of the effects be “off”. See the Speed Circles Starter file in mycourses for how to do checkboxes. (8 points)



Bonus

- for 5 bonus points, add an additional pixel effect that is also user controllable. For example, a *Brightness* slider.