University of Massachusetts Boston CS460

CS460 Fall 2019
Name: Richard Pan
Student ID: 01726748
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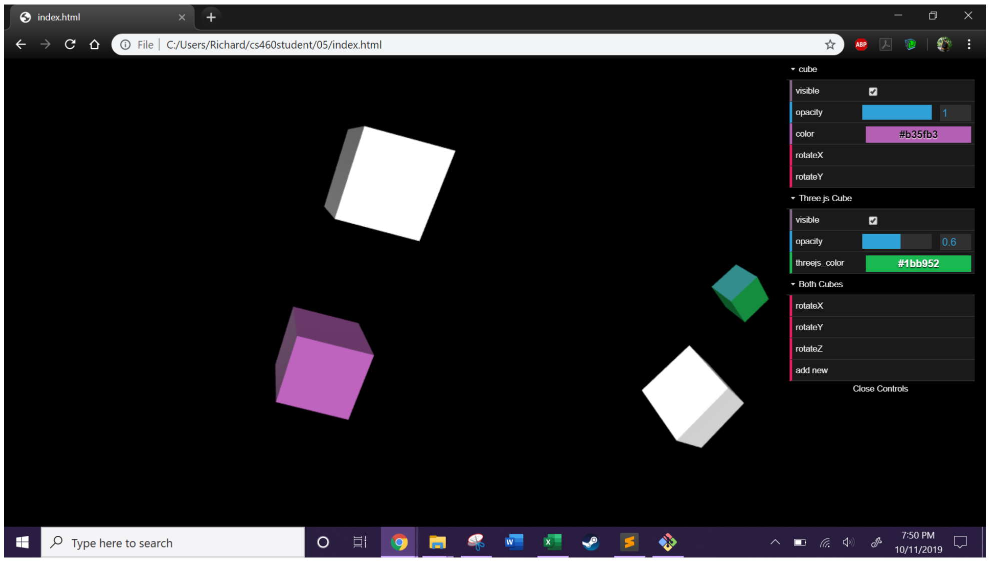
Assignment 5: Scene Control with dat.GUI and Transformations!

Welcome back to framework country! This time we will use XTK and Three.js to study rotations.

In class, we connected the `dat.gui` library with XTK to control properties of a single cube. We also introduced the `transformer` object to rotate the cube along the world `x`- and `y` axis. In this assignment, we will create a website with two 3D scenes. One scene will be based on XTK, and the other will be based on Three.js. Then, we will use `dat.gui` to control objects in the scene. As a final result, each scene will contain two objects. We then can observe two different ways of rotating objects since XTK and Three.js.



There is no starter code for assignment 5. Please start from scratch and save your code your fork as `05/index.html`.

Part 1 Coding: Configure the `<div>`s. (10 points)

We will create two viewports next to each other. Please add two `<div>` containers in the body of the HTML document. Name these containers `r1` and `r2` using the id property. Then, add styling to the header of the HTML document as follows:

```
<style>
  html, body {
    background-color: #000;
    margin: 0;
    padding: 0;
    height: 100%;
    overflow: hidden !important;
  }
  #r1 {
    width:50%;
    height:100%;
    float: left;
  }
  #r2 {
    width:50%;
    height:100%;
    float:left;
  }
</style>
```

You can verify the placement of the `<div>` containers using the Web Developer Tools. They should be next to each other and together, fill the whole window.

Part 2 Coding: Setup the XTK scene. (10 points)

Add the `xtk_edge.js` and `xtk_xdat.gui.js` libraries using the `<script>` tags as we did in class and in assignment 2. Then, create the `window.onload` function to set up the `X.renderer3D` and add a single `X.cube`. **Since we place the renderer into the `r1` container, we need to set `r.container='r1';` just before calling `r.init();`.** Please check if the XTK cube appears by reloading the website.

Part 3 Coding: Setup the Three.js scene. (15 points)

For Three.js, please add the `three.min.js` and `TrackballControls.js` as we did in assignment 3. Then, follow our old code to setup a `THREE.Scene` with the `THREE.PerspectiveCamera`, the `THREE.WebGLRenderer`, the `THREE.AmbientLight`, the `THREE.DirectionalLight`, and the `THREE.TrackballControls`. **Since we now use a `<div>` container as our viewport, we need to do the following:**

```
var r2 = document.getElementById('r2'); // get the div container!!!
// ...
var ratio = r2.clientWidth / r2.clientHeight; // use the container's clientWidth and clientHeight
                              // rather than window.innerWidth and window.innerHeight
// ...
var camera = new THREE.PerspectiveCamera(fov, ratio, zNear, zFar);

var renderer = new THREE.WebGLRenderer({antialias:true});
renderer.setSize( r2.clientWidth, r2.clientHeight ); // again use the container
r2.appendChild( renderer.domElement ); // and append the domElement to the container

// ...

var controls = new THREE.TrackballControls( camera, r2 ); // pass the container to the camera
```

Please don't forget the `animate` loop! Then, please add the `THREE.BoxBufferGeometry` and the `THREE.MeshStandardMaterial` to create a new `THREE.Mesh` and add it to the scene. **When you reload the page, there should be now two cubes - one with XTK and one with Three.js!**

Part 4 Coding: Connect XTK to `dat.GUI` to control cube properties. (10 points)

Please create the `dat.GUI()` user interface for XTK. For this, we will use `gui.addFolder` and access the `visible`, `opacity`, and `color` properties as we did in class. After reloading, this should work right away.

Part 5 Coding: Introduce the helper object for `dat.GUI`. (5 points)

XTK's properties connect well with `dat.GUI` but for more advanced functionality, and especially to control Three.js, we will need a helper object. Please add the following code just before the `dat.GUI()` setup.

```
var controller = {

  'threejs_color': 0xffffff

};
```

Part 6 Coding: Connect Three.js to `dat.GUI` to control cube properties. (5 points)

To connect `dat.GUI` and Three.js, we will first use `gui.addFolder` to group the controls. Then, we want to access the same properties as in the XTK case. However, connecting Three.js with `dat.GUI` is not as straight forward—even with a helper object :(. It requires the following code:

```
var threejsUI = gui.addFolder('Three.js Cube');
threejsUI.add(cube, 'visible');
threejsUI.add(cube.material, 'opacity', 0, 1).onChange( function() {
  cube.material.transparent = true;
});
threejsUI.addColor(controller, 'threejs_color').onChange( function() {
            cube.material.color.set( controller.threejs_color );
          } );
threejsUI.open();
```

After reloading, this should allow to control the visibility, opacity, and color for both the XTK cube and the THREE.js cube.

Part 7 Coding: Extend the helper object for `dat.GUI` and rotate both cubes. (10 points)

We now want to rotate both cubes with three buttons. For this, we will add a new folder to `dat.GUI` as follows:

```
var both = gui.addFolder('Both Cubes');
both.add(controller, 'rotateX');
both.add(controller, 'rotateY');
both.add(controller, 'rotateZ');
both.open();
```

Then, we will extend the `controller` helper object with three rotate methods that rotate by 20 degrees:

```
var controller = {
  'threejs_color': 0xffffff,

  'rotateX': function() {
    c.transform.rotateX(20);
    cube.rotateX(20);
  },
  'rotateY': function() {
    c.transform.rotateY(20);
    cube.rotateY(20);
  },
  'rotateZ': function() {
    c.transform.rotateZ(20);
    cube.rotateZ(20);
  }
};
```

In the code above, we assume that the XTK cube is accessible as `c` and the THREE.js cube is accessible as `cube`. **After reloading, this should allow to rotate the cubes in X,Y, and Z using the three new buttons.**

Part 8 Coding: Add a second cube. (10 points)

Please extend the `controller` helper object with a new method 'add new' and update the `dat.GUI` controls.

```
var controller = {
    // ...
    'add new': function() {
        // TODO!
    }
};

// ...

both.add(controller, 'add new');
both.open();
```

Now, please replace the `//TODO!` above with code that creates for both, XTK and Three.js, a second cube and adds it the viewport. **The new cube should be positioned at (50, 50, 50).** After reloading, and pressing 'add new', both viewports should show two cubes (maybe hidden by the dat.GUI panel).

Part 9 Explaining: Different rotations? (20 points)

So, if we rotate the cubes before adding the second cube, the rotations in XTK and Three.js are very similar. But, after adding the second cube the rotations are very different. Please try to explain what happens.

After adding a second cube, the Three.js cube rotates in the same way it did before, yet somehow adding a second cube changes how the XTK cube rotates. I think that when adding a cube in XTK, the position of the viewpoint origin moves somewhere in-between the two cubes. This fact is evident in that if you rotate the original cube around the Z axis enough, it will match up with the second cube in Z coordinates. Also, XTK possibly groups the cubes together into one viewport frame of reference. For Three.js, each cube would probably rotate on their own until you group them together (possibly by making one cube the child of the other).

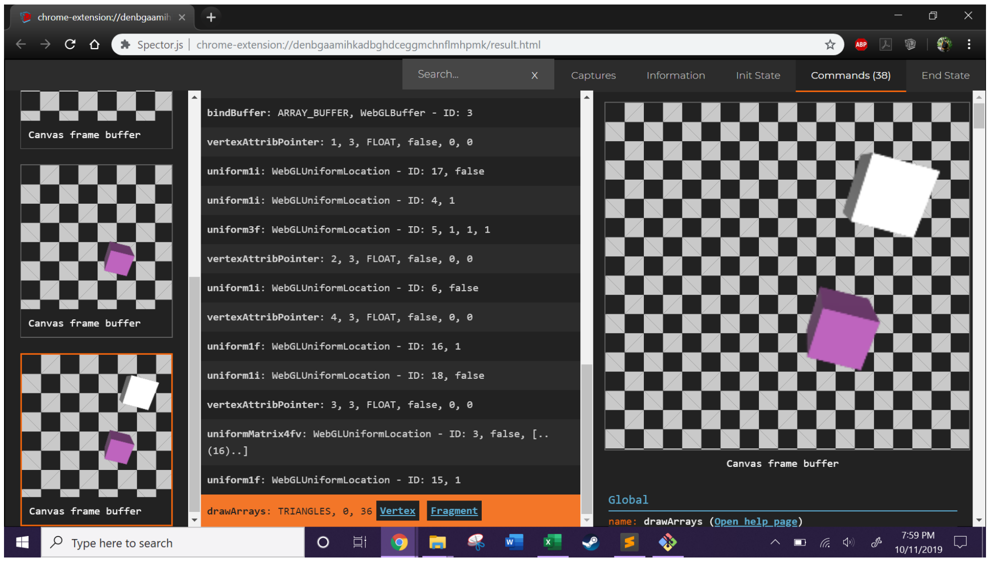
Part 10 Cleanup: Replace the screenshot above, activate Github pages, edit the URL below, and add this PDF to your repo. Then, send a pull request or assignment submission (or do the bonus first). (5 points)

Link to your assignment: `https://rpan001.github.io/cs460student/05/index.html`

Bonus (33 points):

We will use `spector.js` to analyse the two viewports. If you did not install this extension yet, please do so by following the instructions at `https://spector.babylonjs.com/`. Then, you can use the extension to capture/record WebGL activity.

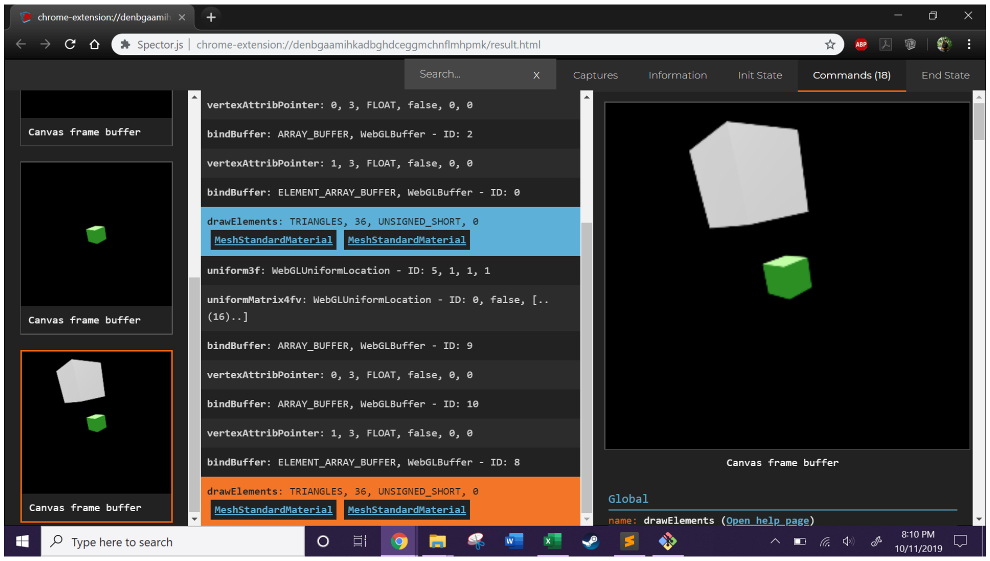
Part 1 (5 points): Please use spector.js to capture the viewport that uses XTK and insert a screenshot here.



```
bindBuffer: ARRAY_BUFFER, WebGLBuffer - ID: 3
vertexAttribPointer: 1, 3, FLOAT, false, 0, 0
uniform1i: WebGLUniformLocation - ID: 17, false
uniform1i: WebGLUniformLocation - ID: 4, 1
uniform3f: WebGLUniformLocation - ID: 5, 1, 1, 1
vertexAttribPointer: 2, 3, FLOAT, false, 0, 0
uniform1i: WebGLUniformLocation - ID: 6, false
vertexAttribPointer: 4, 3, FLOAT, false, 0, 0
uniform1f: WebGLUniformLocation - ID: 16, 1
uniform1i: WebGLUniformLocation - ID: 18, false
vertexAttribPointer: 3, 3, FLOAT, false, 0, 0
uniformMatrix4fv: WebGLUniformLocation - ID: 3, false, [..
(16)..]
uniform1f: WebGLUniformLocation - ID: 15, 1
drawArrays: TRIANGLES, 0, 36 Vertex Fragment
```

```
Global
name: drawArrays (Open help page)
```

Part 2 (5 points): Please use spector.js capture the viewport that uses Three.js and insert a screenshot here.



```
vertexAttribPointer: 0, 3, FLOAT, false, 0, 0
bindBuffer: ARRAY_BUFFER, WebGLBuffer - ID: 2
vertexAttribPointer: 1, 3, FLOAT, false, 0, 0
bindBuffer: ELEMENT_ARRAY_BUFFER, WebGLBuffer - ID: 0
drawElements: TRIANGLES, 36, UNSIGNED_SHORT, 0
 MeshStandardMaterial MeshStandardMaterial
uniform3f: WebGLUniformLocation - ID: 5, 1, 1, 1
uniformMatrix4fv: WebGLUniformLocation - ID: 0, false, [..
(16)..]
bindBuffer: ARRAY_BUFFER, WebGLBuffer - ID: 9
vertexAttribPointer: 0, 3, FLOAT, false, 0, 0
bindBuffer: ARRAY_BUFFER, WebGLBuffer - ID: 10
vertexAttribPointer: 1, 3, FLOAT, false, 0, 0
bindBuffer: ELEMENT_ARRAY_BUFFER, WebGLBuffer - ID: 8
drawElements: TRIANGLES, 36, UNSIGNED_SHORT, 0
 MeshStandardMaterial MeshStandardMaterial
```

```
Global
name: drawElements (Open help page)
```

Part 3 (23 points): Compare the `spector.js` recordings. (a) Please report if either XTK or Three.js use an indexed geometry. (b) Also, please explore and compare the length of the GLSL shader codes both libraries use. (c) And, please figure out how the object transformations are passed to the shaders.

a) Neither XTK nor Three.js seem to use an indexed geometry. I looked into the "Uniforms()" section of the spector.js window and found that they used large lists of viewpoint coordinates.

b) Three.js has a much longer Vertex Shader and an extremely longer Fragment Shader code than XTK. The Three.js Fragment shader must be at least 10 times longer than the XTK Fragment shader. For the Vertex shaders, it's probably 5 times longer.

c) For XTK, I took a look at this line... "fTransformedVertexNormal = mat3(view[0].xyz, view[1].xyz, view[2].xyz) * mat3(objectTransform[0].xyz, objectTransform[1].xyz, objectTransform[2].xyz) * vertexNormal;" ... and figured that XTK may use something similar to quaternions to do transformations for the cubes. Here, you can see the original matrix (view), the transform matrix (objectTransform), and some other matrix (vertexNormal) which I'm unsure about.

For Three.js... the code is really long so I couldn't figure it out.