Computer Graphics Tutorial 3

In this tutorial, we will handle some more in-depth WebGL code, and write some shaders for lighting effects and displacement mapping.

Running the Code

- Extract the given zip file from the course webpage (`http://www.inf.ed.ac.uk/teaching/courses/cg/index2017.html#Tutorials`).
- Open "tutorial_3.html" in a WebGL 2.0 compatible browser (recent versions of Firefox, Chrome, or Opera). Note, previous exercises did not require WebGL 2.0, so on some browsers you may need to enable this manually. On Chrome, if you get the error: `"Cannot read property 'viewport' of null"`, you can enable WebGL 2.0 via the setting: `chrome://flags/#enable-es3-apis`.
- If using Google Chrome, you must open it via the command line with `google-chrome -allow-file-access-from-files`, which allows the 3D model file to be loaded.
- If using Google Chrome, helpful debugging tools can be opened by pressing `F12`.
- If using Firefox, debugging is opened via `Ctrl + Shift + K`, or via Firebug.
- You can ignore `WebGL:INVALID_VALUE:` warnings for `enableVertexAttribArray` and `vertexAttribPointer` until you have completed all parts of the exercise.

Questions

1: Loading the 3D Model

In Tutorial 2, we loaded a simple 3D cube model, which was defined only by its vertex positions in 3D space. Now, we will load up a more complex model with vetex positions, normals, and texture UV coordinates.

The format of the `sphere.obj` file is similar to the previous `.obj` file we loaded, so you may refer back to that code, or look at the example solutions online.
The different types of lines in the `sphere.obj` file we want to load are as follows:

```
v 1.0 -1.0 -1.0
```

Lines starting with "v" define the 3D coordinates of each vertex in the model.

```
vt 0.5 0.5
```

Lines starting with "vt" define the 2D texture coordinates for each vertex in the model.

```
vn 1.0 -1.0 -1.0
```

Lines starting with "vn" define the 3D normal direction of each vertex in the model.

```
f 1/1/1 28/2/2 27/3/3
```

Lines starting with "f" define a triangular face of the model. Face lines have parts separated by spaces (one for each vertex in the triangular face). Each segment has 3 numbers separated by slashes:

```
pos/tex/norm
```

- `pos` - index of that vertex's 3D position from the list of "v" lines.
- `tex` - index of that vertex's 2D texture UV coordinates from the list of "vt" lines.
- `norm` - index of that vertex's 3D normal direction from the list of "vn" lines.

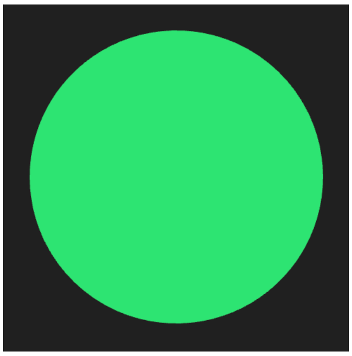
This is similar to the format of the `cube.obj` file from the previous tutorial, but instead of just a single index for for the vertex's position, 3 indices are given for its position, texture coordinates, and normal. NOTE: as before, the indexing scheme starts at 1.
Your task is to fill in the missing code in the `loadMeshData(s)` function of `load_obj.js` such that it fills in the `vertexBuffer` variable with the correct vertex positions, uvs, and normals. This buffer should be a single array of floats. Each face has 3 vertices. Each vertex has 8 floats (3 pos, 2 tex, 3 norm). The final `vertexBuffer` variable will have 122880 values in it. An example of the buffer should be filled in is shown below:

```
v 1.0 1.0 1.0
v 2.0 2.0 2.0
v 3.0 3.0 3.0
vt 0.7 0.7
vt 0.8 0.8
vt 0.9 0.9
vn 0.1 0.1 0.1
vn 0.2 0.2 0.2
vn 0.3 0.3 0.3
f 1/1/1 2/2/2 3/3/3
...
```

would have a vertex buffer filled in like:

```
[1.0, 1.0, 1.0, 0.7, 0.7, 0.1, 0.1, 0.1,
 2.0, 2.0, 2.0, 0.8, 0.8, 0.2, 0.2, 0.2,
 3.0, 3.0, 3.0, 0.9, 0.9, 0.3, 0.3, 0.3,   ...]
```

When finished, you should see a flat green sphere on the screen:



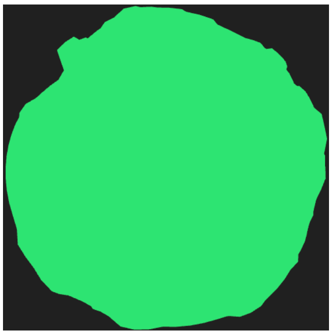
2: Displacement Mapping

Now, we will edit the vertex shader in `shaders.js` so that it performs displacement mapping. Edit the vertex shader so that it:

- Samples a colour from `displacementMapTexture` at the coordinates `vertUV`.

- Takes the "red" component of that colour (the image is greyscale, so r=g=b).
- Multiples this by the weighting factor of `displacementScale`
- Displaces the output vertex position by this amount along the normalized direction of the vertex normal from `vertNormal`

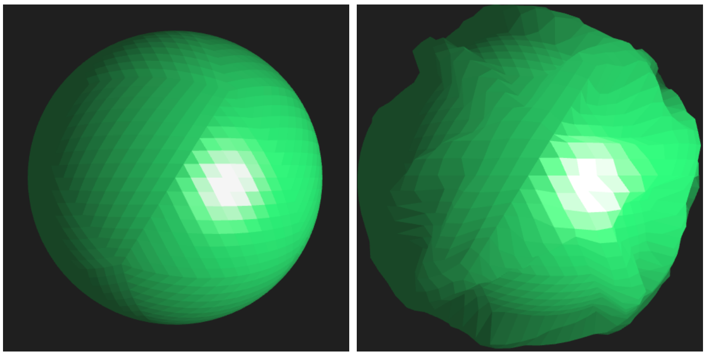
The displaced sphere should look like:



This displacement map is generated from the texture loaded from `displ.png`. Feel free to edit this, or examine the texture loading code in `common/texturing.js` and the binding code in the `renderModel()` function of `common/simple_drawing` if you are interested in how the texture is loaded and bound to the shader variables in WebGL.

3: Flat Phong Lighting

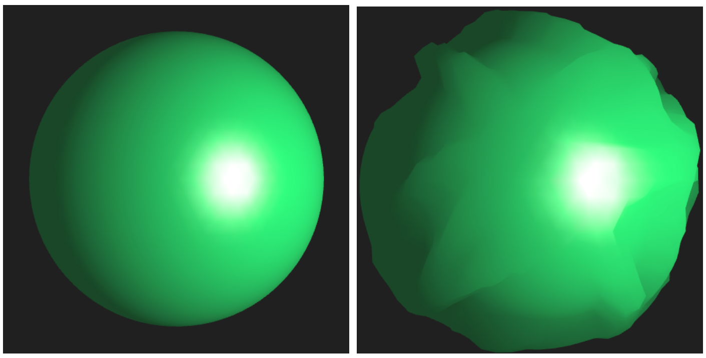
Edit the vertex shader in `shaders.js` to performs phong illumination (see the lecture slides and textbook). Use the transformed normal value `n`, the vertex's position in global space (apply the correct transformation matrix to it), and the included lighting and material properties. Assign the final colour to `outCol` for the fragment shader to use.



(a) Sphere (b) Displaced

4: Gouraud Shading

We can make this smoother by using per-vertex, rather than per-face lighting, and having the fragment shader interpolate the colours smoothly between the values at each vertex of the relevant triangle. This interpolated per-vertex lighting is known as Gouraud shading. Doing this is very simple in GLSL. By default, `out` variables from the vertex shader are interpolated between the triangle's vertices. This means the corresponding `in` variables already contain interpolated values by default.
However, the variable `outCol` has used the GLSL `flat` keyword when defining it. This means that a single value from a single vertex is used across the entire triangular face. To enable smooth Gouraud shading, simply delete the `flat` keyword in front of `outCol` in both the fragment and vertex shaders, and observe the results:



(c) Sphere (d) Displaced