CPSC 314
Assignment 1: Hello Armadillo! Introduction to Three.js, WebGL, and Shaders

Due 11:59PM, September 27, 2021

1 Introduction

The main goals of this assignment are to setup your graphics development environment, including checking your browser compatibility, setting up a local server, and an initial exploration of the three.js library, along with the uses of vertex and fragment shaders. For this exploration you will be using a template provided by the instructor, including shader code (`.glsl` files in the `glsl/` folder).

Your main work will be to develop a high level understanding of how the code works, to modify or write shaders, and to use rudimentary communication between the JavaScript program and the shaders. Some of the details of what is going on in the rest of the code will only become clear a bit later in the course. You are of course welcome to take a peek now, especially for the last part of the assignment. Some of the concepts are explained in Appendix A of your textbook, and in the web resources listed on the course web page.

To program a shader, you will use a programming language called GLSL (OpenGL ES Shading Language version 3.0). Note that there are several versions of GLSL, with more advanced features, available in regular OpenGL. Make sure that any code you find while trying to learn GLSL is the correct version.

This assignment uses a simple scene consisting of an “Armadillo” character and a magical “Orb” that it interacts with. You can move the camera around the scene by dragging with a mouse, pan by holding down the right mouse button while dragging, and zoom by scrolling the mouse wheel. Your task for this assignment will be to write simple shaders for the Armadillo, and to make it move by way of three.js API calls.

1.1 Getting the Code

Assignment code is hosted on the UBC Students GitHub. To retrieve it onto your local machine navigate to the folder on your machine where you intend to keep your assignment code, and run the following command from the terminal or command line:

```
git clone https://github.students.cs.ubc.ca/cpsc314-2021w-t1/a1-release.git
```

1.2 Template

- The file `A1.html` is the launcher of the assignment. Open it in your preferred browser to run the assigment, to get started.
- The file `A1.js` contains the JavaScript code used to set up the scene and the rendering environment. You will need to make minor changes in it to answer the questions.
- The folder `glsl` contains the vertex and fragment shaders for the armadillo and light-bulb geometry. This is where you will do most of your coding.
- The folder `js` contains the required JavaScript libraries. You do not need to change anything here.
- The folder `obj` contains the geometric models loaded in the scene.
- The folder `images` contains the texture images used.

1.3 Execution

As mentioned above, the assignment can be run by opening the file `A1.html` in any modern browser. However, most browsers will prevent pages from accessing local files on your computer. If you simply open `A1.html`, you may get a black screen and an error message on the console similar to this:

```
XMLHttpRequest cannot load... Cross origin requests are
  only supported for protocol schemes: http, data, https.
```

Please see this web page for options on how to run things locally:

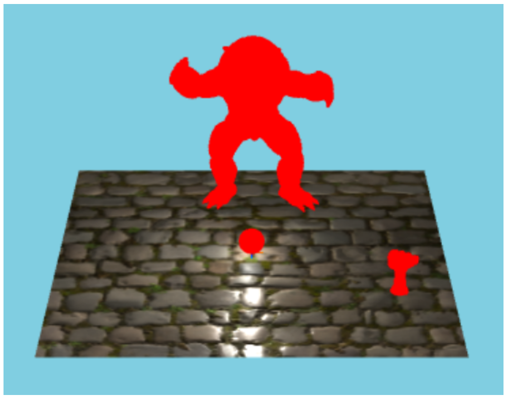
https://threejs.org/docs/#manual/en/introduction/How-to-run-things-locally

We highly recommend that you run a local server, instead of changing browser security settings.

1. Follow the link https://nodejs.org/en/ to download and install Node.js, which comes packaged with npm.
2. Open the link https://www.npmjs.com/package/http-server and follow the instructions to download and install a local command-line http server.
3. Go to the command-line or terminal and run `http-server [path]` where [path] is the path to the assignment folder.
4. Open your preferred browser and copy and paste the URL of the local server specified by the http-server on your command-line.

2 Work to be done (100 pts)

First, ensure that you can run the template code in your browser. See the instructions above. Study the template to get a sense of how it works. The script `js/setup.js` creates the basic scene with the floor, and provides a utility function for loading 3D models. The initial configuration should look as it does in the figure below.



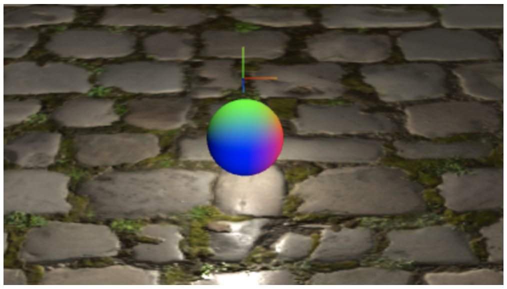
Part 1: Required Elements

(a) **30 pts** Moving the Armadillo.

Your goal for this part of the assignment is to get the Armadillo to respond to keyboard input. You have been given the coordinate frame of the armadillo as `armadilloFrame`. You should manipulate this object, using the three.js API, to get the armadillo to slide forwards/backwards and side-to-side, you should also make the armadillo twirl in place. For the latter, the docs will likely be useful. https://threejs.org/docs/#api/en/core/Object3D.rotation

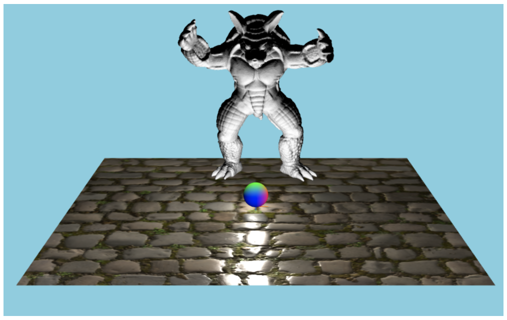
(b) **20 pts** Color the sphere with fragment normals.

In this part, you need to color the sphere in its fragment shader `sphere.fs.glsl` with fragment normals. In the vertex shader `sphere.vs.glsl`, you can pass the attribute `normal` to the fragment shader. In the fragment shader, replace the RGB color using the fragment normal. This method is normally used to visualize the normal for debugging purposes.



(c) **20 pts** Lighting the Armadillo.

The light from the orb should light up the armadillo. Here you will implement a simple model of how light from the orb would interact with the armadillo, a simple shading model called "Gouraud shading." We will study more realistic models later in the course. Modify `A1.js` and `armadillo.vs.glsl` to color each vertex of the armadillo based on the cosine of the angle between its normal and the direction vector to the center of the sphere. When correctly coded, the orb will be "activated", lighting up different parts of the armadillo as it's moved around, as illustrated in the figure below.



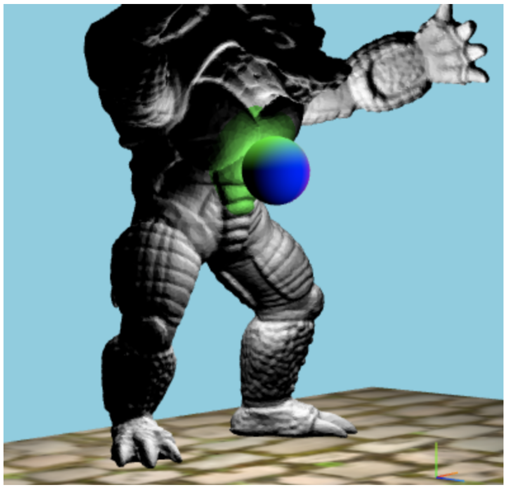
Hint 1: See how uniforms are passed to the sphere shader.

Hint 2: You should pass the necessary information about the sphere to the armadillo shaders.

Hint 3: See how varying variables are passed to the armadillo fragment shader.

(d) **30 pts** Proximity detection.

The armadillo has sensors on its skin that can detect objects in close proximity. For this part you will need to modify `armadillo.fs.glsl` to further color the armadillo fragments green when in close proximity to the sphere, as illustrated in the figures below. One simple way is to check if an armadillo fragment is within a specified distance to the sphere, and if it is, set its color to green.



Hint: You should use the appropriate uniform variable in the armadillo shader.

Part 2: Creative License (Optional)
You have many opportunities to unleash your creativity in computer graphics! In this **optional** section, and you are invited to extend the assignment in fun and creative ways. We'll highlight some of the best work in class. A small number of exceptional contributions may be awarded bonus points. Some possible suggestions might be:

- turn the Orb into a Coronavirus... very topical.
- explode the armadillo or orb along face normals.
- animate colors, lights, in fun ways.
- add interesting objects to the scene.

3 Submission Instructions

3.1 Directory Structure

Under the root directory of your assignment, create two subdirectories named "part1" and "part2", and put all the source files, your makefile, and everything else required to run each part in the respective folder. Do not create more sub-directories than the ones already provided.
You must also write a clear README.txt file that includes your name, student number, and CWL username, instructions on how to use the program (keyboard actions, etc.) and any information you would like to pass on to the marker. Place README.txt under the root directory of your assigment.

3.2 Submission Methods

Please compress everything under the root directory of your assignment into `a1.zip` and submit it on Canvas. You can make multiple submissions, but we will grade only the last one.

4 Grading

4.1 Point Allocation

Each assignment has 100 points for Part 1. Part 2 is optional and you can get bonus points (0-10 points) at the instruction team's discretion. Percentage wise, we use Part 1's total points as the denominator: e.g. if you get 95 out of 100 points from Part 1, but no points from Part 2, then your percentage grade would be 95/100. If you get full points from both Parts, then your percentage grade would be 110/100.

4.2 Face-to-face (F2F) Grading

For each assignment, you are required to meet face-to-face with a TA on Zoom or in person to demonstrate that you understand why your program works. Details regarding how to sign up a grading session with a TA will be announced on Canvas and on Piazza.

4.3 Penalties

Aside from penalties from incorrect solution or plagiarism, we may apply the following penalties to each assignment:
Late penalty. You are entitled up to three grace (calendar) days in total throughout the term. No penalties would be applied for using them. However once you have used up the grace days, a deduction of 10 points would be applied to each extra late day. Note that

(a) The three grace days are given for all assignments, **not per assignment**, so please use them wisely;

(b) We consider the time of only your last submission;

(c) We do not consider Part 1 and Part 2 submissions separately. Say if you submitted Part 1 on time but updated your submission for Part 2 one day after the deadline, we would count one late day.

No-show penalty. You are required to sign up a grading slot at least one day before F2F grading starts, and show up at your slot on time. So a 10-point deduction would be applied to each of the following circumstances:

(a) Not signing up a grading slot before the sign-up period closes;

(b) Not showing up at your grading slot.

Note that we would not apply the penalty if you are unable to sign up/show up on time due to an emergency, or if you cannot sign up because none of the slots work for you. In those cases, please contact the course staff immediately on Piazza.