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

Due 11:59PM, January 24, 2025

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 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, his hat, 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 to move the Orb around, turn it on to illuminate the armadillo, detect how close it is to the poor Armadillo, and make it interact with the armadillo's body.

1.1 Getting the Code

Assignment code is hosted on the course's GitHub repository: `https://github.students.cs.ubc.ca/CPS`

Students registered in this course should be able to access the repo by logging in with their CWL ID. If you have problems with logging in, please head to the CS departmental account setup page (https://www.cs.ubc.ca/getacct/), log in with your CWL ID and check if your student account has been activated. And if you still have problems, please create a private post on Piazza so the teaching team can have a look into the issue.

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:

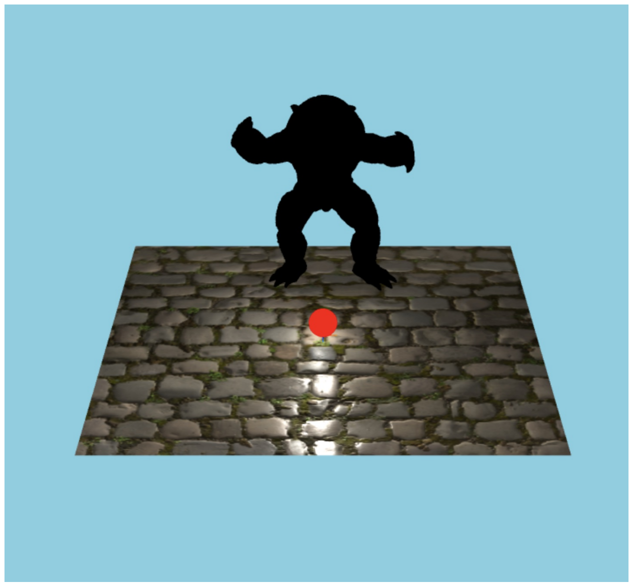
```
XMLHttpRequest cannot load... Cross origin requests are
  only supported for protocol schemes: http, data, https.
```

We highly recommend that you run a local server, instead of changing browser security settings. For example you can do this with VS Code:

1. Follow the link https://code.visualstudio.com/Download to download and install VS Code.
2. Open VS Code and install the Live Server extension. You may also install it from here: https://marketplace.visualstudio.com/items?itemName=ritwickdey.LiveServer
3. In VS Code, open the assignment's root folder.
4. Open `A1.html`, right-click in the editor, click "Open with Live Server".

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.

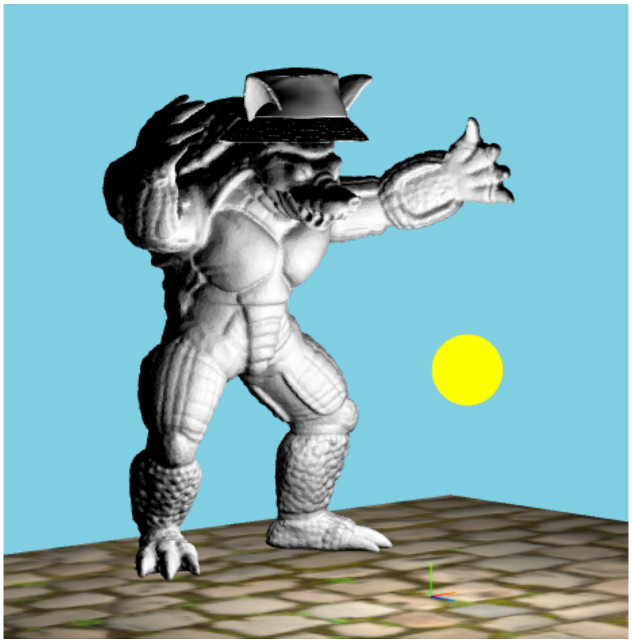


(a) **15 pts** Moving & Coloring the Orb and Hat.

For the hat, look at how the `loadAndPlaceOBJ` function is used to place the armadillo on the scene and use it to load the hat onto the scene; modifying the position, rotation and scale of the hat to fit the armadillo snugly. The hat should use the same material as the armadillo. For the Orb, the shape of the Orb is represented by `SphereGeometry`, and manipulated using the vertex shader `sphere.vs.glsl`. The variable `orbPosition` (the position of the orb center in world coordinates) is declared in `A1.js`. It is changed using the keyboard, and passed to the sphere vertex shader using a `uniform` variable. First, modify the sphere shader to move the sphere in response to keyboard input. Then, change the color of the sphere to yellow in the sphere fragment shader (in `sphere.fs.glsl`). Important: **do not** use Three.js functions; you must modify the shader for credit. Credit: Bucket Hat 3D Model asset by Boxroom 3D, available on Sketchfab.

(b) **15 pts** Lighting the Armadillo.

The light from the orb should light up the armadillo and his hat. 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.

(c) **25 pts** Proximity detection.

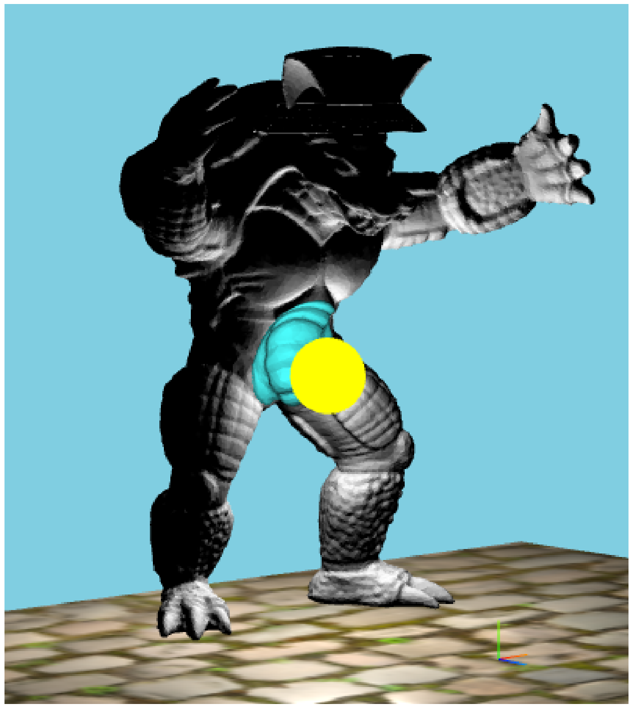
The armadillo has sensors on its skin that can detect objects in close proximity. For this part you will need to modify `armadillo.fs.glsl` to further color the armadillo fragments cyan when in close proximity to the sphere, as illustrated in the figures below. One simple way is to check if an armadillo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

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

(d) **30 pts** Body Deformation.

In this part you will indent the armadillo’s mesh and it’s hat when pushed in by the Orb, as illustrated in the figure below. This is a preview of how vertex shaders can be used for changing a shape. For this you will need to change `armadillo.vs.glsl` and `A1.js`. One simple way is to check if a vertex is within the Orb, and if it is, move the vertex to the surface. You should pass the necessary information about the Orb to the armadillo shader.

Hint 1: See how uniforms are passed on the sphere shaders.



(e) **15 pts** Feature Extension.

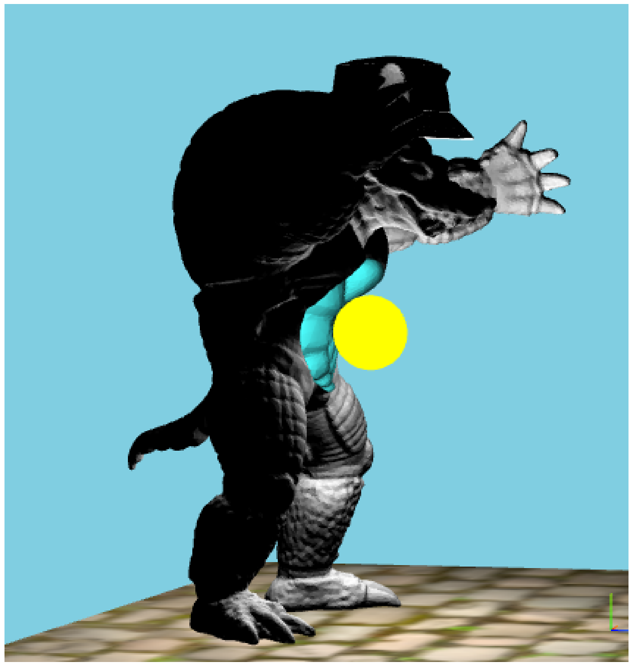
In this part, you are required to extend the assignment to add a feature of your own choosing. The goal is to encourage you to explore the capabilities of Three.js and WebGL. For full credit for this part, the feature does not have to be complex or creative, but must be non-trivial (e.g., not just changing a color). Roughly requiring about 10 lines of new code. Some possible suggestions are:

- add interesting objects to the scene.
- explode the armadillo or orb.
- animate colors, lights, in fun ways.
- animate or deform the orb as a function of time

For this question, first duplicate your current work into a new directory named 'part2', then implement your feature in this new directory. Write a brief description of your feature in the README file. You will be graded on both how it works and how well you can explain your feature.

3 Bonus Points

You have many opportunities to unleash your creativity in computer graphics! In particular, if you create a particularly novel and unique feature extension, you may be awarded bonus points. A small number of exceptional extensions may be shown in class, with the student's permission.



4 Submission Instructions

4.1 Directory Structure

Your submission should contain two subdirectories - the first should be named 'part1' and should contain all parts except part e (no feature extension), the second subdirectory should be named 'part2' and should contain your feature extenstion. Under the root directory of your assignment, please add both subdirectories including all the source files 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 which 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 the file under the root directory of your assigment.

4.2 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.

5 Grading

5.1 Face-to-face (F2F) Grading

Submitting the assignment is not the end of the game; to get a grade for the assignment, you must meet face-to-face with a TA in an 8-min slot during or outside lab hours, on Zoom, to demonstrate that you understand how your program works. To schedule that meeting, we will provide you with an online sign-up sheet. Grading slots and instructions on how to sign up will be announced on Canvas and on Piazza. During the meeting, the TA will (1) ask you to run your code and inspect the correctness of the program; (2) ask you to explain parts of your code; (3) ask you some questions about the assignment, and you will need to answer them in a limited timeframe. The questions will mostly be based on ThreeJS or WebGL concepts that you must have come across while working on the assignment; but also you may get conceptual questions based on lecture materials that are relevant to the assignment, or technicalities that you may not have thought about unless you really "digged deep" into the assignment. But no need to be nerveous! We evaluate your response based mainly if not entirely on the coherence of your thoughts, rather than how complete or long your response is: e.g. if the full answer to a question includes A+B+C+D and you mentioned A+B only in the provided time, but your thread of thought is logical then you may still get full marks.

5.2 Point Allocation

All questions before Feature Extension has a total of 85 points. The points are warranted based on

- The functional correctness of your program, i.e. how visually close your results are to expected results;
- The algorithmic correctness of your program, e.g. applying transformation matrices in the right order;
- Your answers to TAs' questions during face-to-face (F2F) grading.

The Feature Extension part is worth 15 points. As long as you have one extension that the TA who grades you deems novel and unique, you will get the full 15 points. However, we may reward bonus marks to students who come up with exceptional feature extensions. Therefore it is possible to receive a score above 100 for an assignment. Note that your total course mark will be capped at 100.

5.3 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 check the time of your last submission to determine if you are late or not.

No-show penalty. Please sign up for a grading slot on the provided sign-up spreadsheet (link will be posted later on Piazza) before the submission deadline of the assignment, and show up to your slot on time. 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. Unless otherwise stated, the period closes at the same time as the submission deadline.

(b) Not showing up at your grading slot.

If none of the provided slots work for you, or if you have already missed your slot, follow instructions outlined in this Piazza post to get graded after the F2F grading period ends. Also, please note that

(a) you'll need to explain to your TA why you're getting graded late, and may be asked to present documents to justify your hardship. The TA may remove the no-show penalty as long as he/she deems the justification to be reasonable.

(b) In the past some students reported that their names disappeared mysteriously due to technical glitches, and the spreadsheet's edit history has no trace of it. So double check that your name is on the sign-up sheet after you sign up by refreshing the page.