Assignment Report - OpenGL Museum

Author: Shai Levin, Student ID 59368709
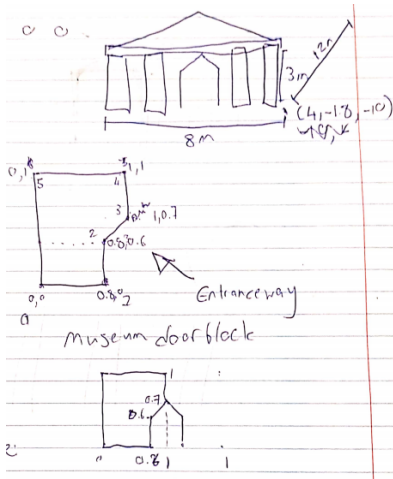
General Information

The scene is designed to be 1:1 scale to real life. The camera height is 0 is human eye-level.

Models

Museum Building & Misc.

The Museum building is constructed with:

1. A cube roof.
2. 3 Walls. For the purpose of having improved lighting and shadows, each wall is devised of nxn array of wall-cubes, each of which consists of just 2 quads, the front and back surfaces of the wall. This is to optimise the number of polygons in the scene. This number n is set to 20, but can be increased for improved shadows and lighting at the cost of performance.
3. A door panel. The door is symmetrical across the middle, so the model consists of 2 polygons and 6 quads which is duplicated, flipped and stitched together.
4. A billboard. This is a simple quad with a texture with text bound to it.
5. Doric Pillars, discussed in the next section.

There is a light switch made of 2 cubes. This is to toggle the light on the pendulum. Also around the scene is several spotlight models, consisting of a cone, a sphere, and for one, a cylinder. These are to improve realism, and to provide a physical location for light sources.

Doric Pillar

The doric pillar is a sweep surface constructed with a polygon rotated around the origin. It is textured using the skyboxes' ground texture, to create a sandstone appearance.

Painting

The Painting is 4 cubes and a quad, which has a texture of a very interesting art exhibit. See references for more information.
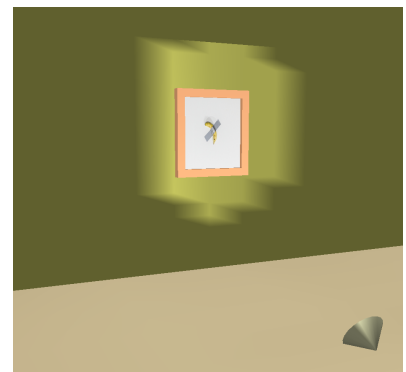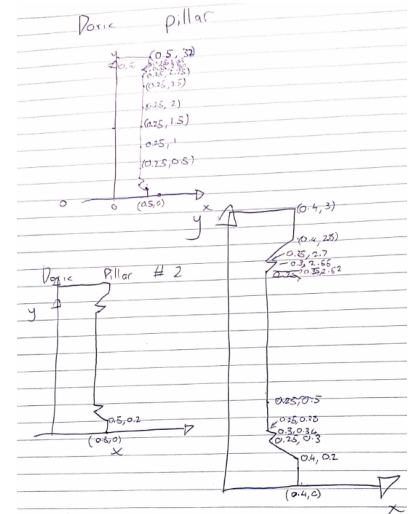
Magic Cylinder

The magic cylinder is a curious animated model consisting of multiple cylindrical disks, with a sphere on the end. Each part of model rotates around a pivot point. It has a planar shadow that is projected onto the back wall.

Pendulum

This stand is made from 2 cubes, and 1 cylinder. The pendulum itself is a 'spotlight'

model, and the string is a tiny cylinder. The spotlight on the pendulum is toggleable by a switch to the right of it. This will illuminate the painting across the room. The pendulum rotates based on a simple physics model. See below.
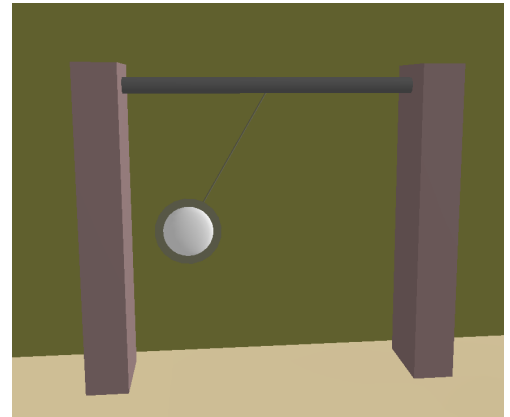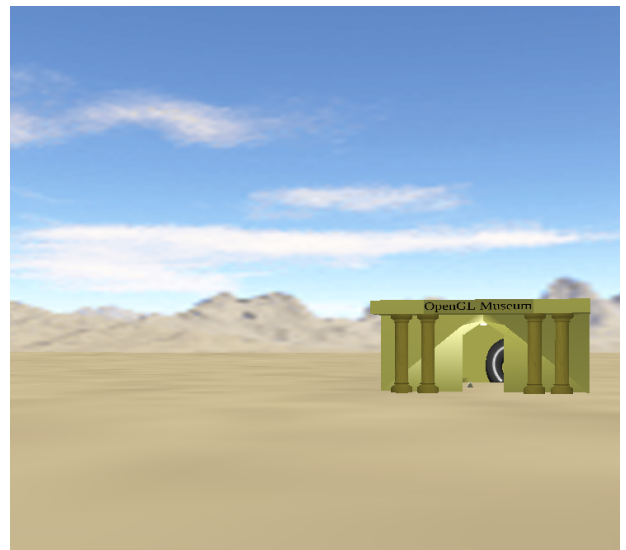
Features

Skybox

Standard skybox implementation such as is discussed in the notes, with one exception.
The floor texture is set to be at y = -1.8, which is intentional. For 2 reasons.

1. To allow the camera height to be 1.8m from the ground, i.e. the height of a human's eyes.
2. To give the feeling of movement as one traverses over the scene, as the ground textures will update faster than if it was set lower.

Movement System

The movement system uses a mouse-look feature. The arrow keys control the x,z position of the camera, but clicking and dragging the mouse controls the direction of the camera. When the mouse is clicked and dragged, the x and y distance from the position it was clicked is recorded and updated. This allows for a lot more flexibility in movement, as one can easily adjust angles

in the left right and up down directions. The view axis is locked when looking directly up and down, just like a human cannot turn its head upside down.

Collision Detection

The collision detection is fairly simple. If a player attempts to move in a direction that would enter an out-of-bound region, the movement system will disallow that specific movement. This prevents getting stuck in out-of-bound regions. Rather than using a single out-of-bound region for each wall, there is an out-of-bound square, with 2 smaller in-bound squares inside it. See the depiction above.
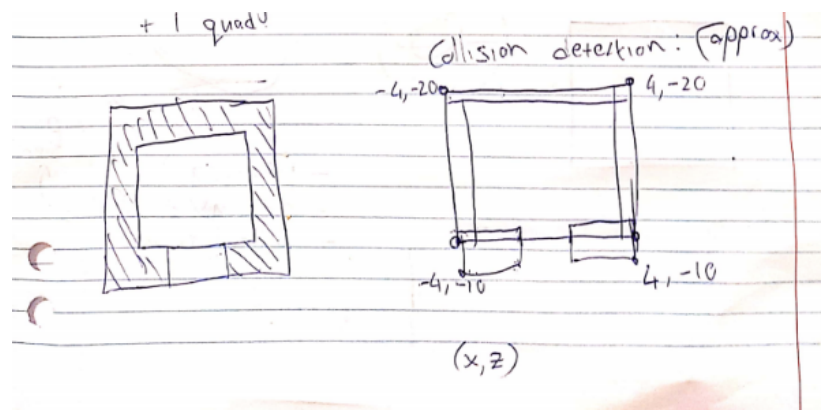
Physics Model

The physics model demonstrates the simple harmonic oscillation of a pendulum. The motion can be described as a system of differential equations, but simplified to a linear solution of θ as a function of t, where theta is the angle of the pendulum from downwards direction along the x (or z) plane. The function is dependent on the starting angle of the pendulum, the length of the string, and the acceleration due to gravity. These can be adjusted to change the motion of the pendulum.

Given starting angle θ_0, length L, and gravitational acceleration g, our function is:

$$\theta(t) = \theta_0 cos(\omega t)$$

Where: $\omega = \sqrt{g/L}$. See references for more information regarding these derivations.

Planar Shadows

The planar shadows are the model of the magic cylinder projected onto a Z-plane. I had trouble designing this as there was not much information in the notes regarding the 4x4 shadow matrix when the plane is not Y, so I had to play around to get it to perform as intended.

Moving Spotlight

There is a moving spotlight on the pendulum, which illuminates the wall across. By default this is toggled off,
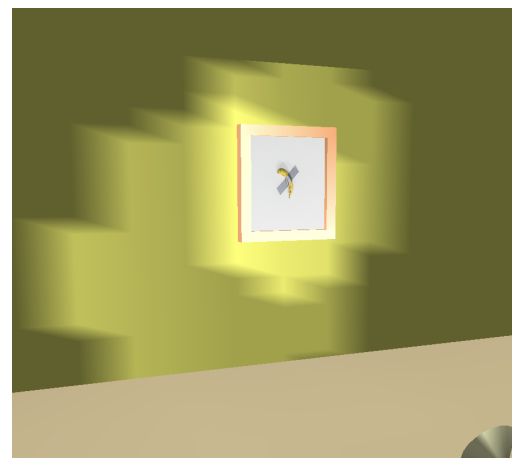
but can be toggled on by approaching the lightswitch next to the pendulum and pressing the key 'a'.

Additional Lighting Details

I have 4 lights in the scene.
1. Light 0, which is the ambient light for the scene to prevent shadows being too dark.
2. Light 1, which is a spotlight that actually serves the purpose of 2 lights in the scene. The door lamp, and the spotlight for the magic cylinder. Initially this was an accident, but the way the light behaved with the door panel was appealing, so it was integrated into the design.
3. Light 2, which is a spotlight to illuminate the painting, fixed below on the ground.
4. Light 3, which is the toggleable, pendulum spotlight.

Controls

Up Arrow - Move Forward
Down Arrow - Move Backward
Left Arrow - Move Left
Right Arrow - Move Right
Mouse Click and Drag - Look Left/Right/Up/Down
'a' Key - Toggle Pendulum Lamp (if in proximity of light switch)

Note here the design specifications have been modified to utilize mouse control for rotation. This has been approved by Mukundan.

Build Instructions:

Build project exactly as the labs. Select the CMakeLists.txt when importing the project into QTCreator.

References:

- Skybox textures taken from Learn resources.
- Derivation of pendulum harmonic function https://www.acs.psu.edu/drussell/Demos/Pendulum/Pendulum.html
- For banana.tga, see article https://www.gq.com/story/suddenly-the-koons-is-this-100k-banana
- Original template code from lab 3 yard.cpp, but has been significantly changed to be no longer recognizable.
- Planar shadows, rotational surface construction, inputs etc. are adapted code from notes.