Terrain Modelling and Rendering Report

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Build Command

g++ Terrain.cpp -o terrain -lGL -lGLEW -lglut -lGLU && ./terrain

Terrain Model

The terrain model in this project renders a terrain model of Mt. Ruapehu from a height map. The scene can be changed but substituting the HEIGHT_MAP string in Terrain.cpp with another height map.

Figure 1. The Mt. Ruapehu scene

The terrain scene features dynamic level of detail where the tessellation of patches adjusts based on their distance from the camera, allowing for high detail up close and smoother surfaces at a distance. This was implemented in the tessellation control shader following the method outlined in Lecture 9 and following the below equation.

$$L = \left(\frac{d - d_{\min}}{d_{\max} - d_{\min}} \right) \left(L_{low} - L_{High} \right) + L_{High}$$

The different in level of detail is best seen is wireframe mode as demonstrated in Figure 2.

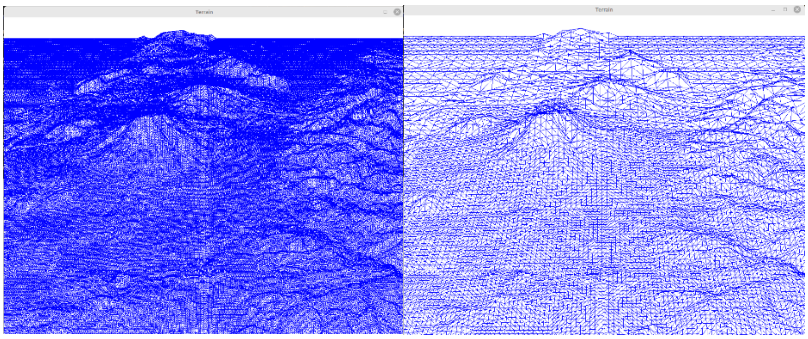

Figure 2. High (Left) and Low (Right) Tessellation Level of Detail

The scenes ambient and diffuse lighting calculations are done in the tessellation geometry shader. The implementation also includes textures for snow and grass over the mountain, with heigh-based texturing the shows a smooth transition between each texture. This is done using a weight transition between snow and grass textures in the geometry shader where the weight is determined by the height of the vertex relative to the snow level. As a vertex approaches the snow level, a smooth transition occurs that blends the snow texture and grass together. This is seen is Figure 3.

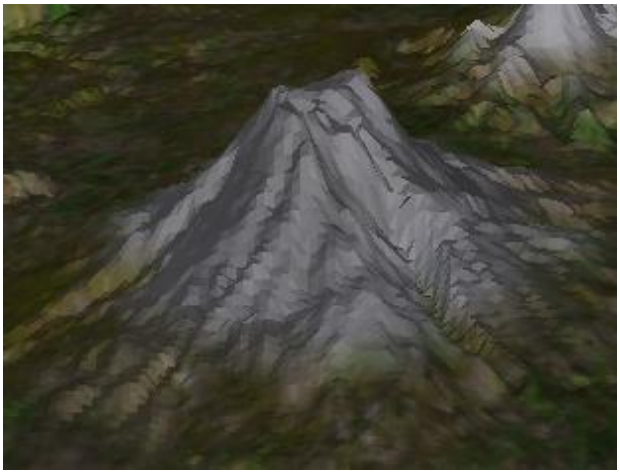

Figure 3. The blending between snow and grass textures

There is also a water texture mapped to a flat terrain base.

Problems/Challenges

The most difficult challenges I faced were in trying to implement procedural terrain generation. This is something I wanted to achieve at the start of the assignment, however, I ran into difficult trying to implement it, but I couldn't fully understand how to generate a terrain map with this approach and got confused by some aspects such as Perlin Noise. Additionally, I didn't have success with implementing particle systems in my program.

Extra Features

Cracking

Cracking was fixed in the tessellation control shader by adjusting the outer tessellation levels. The shader calculates the tessellation levels for the outer edges of a patch based on the average position of the control points from adjacent patches. By averaging the positions of the shared control points, the shader derives tessellation levels that are consistent across the edges of adjoining patches. This fixes the cracking problem but at the cost of minor detail. Cracking and no cracking is shown in Figure 4.

Figure 4. Cracking (Left) and No Cracking (Right)

Adjustable Snow Level

The snow level is adjustable through use of a stored float value that can be changed. The adjustable snow level is shown in Figure 5.

Adjustable Water Level

The water level is adjustable through use of a stored float value that can be changed. The adjustable water level is shown in Figure 5.

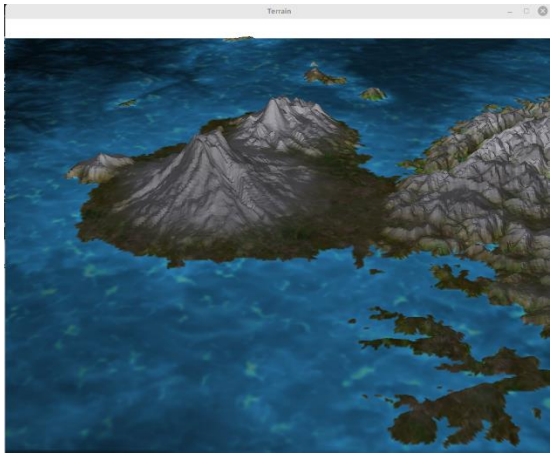

Figure 5. Adjusted snow and water levels

Fog

The fog effect is done using an exponential decay function to simulate fog intensity. This is then used to blend the vertex colour with the fog colour, creating the appearance of fog in the scene as seen in Figure 6.

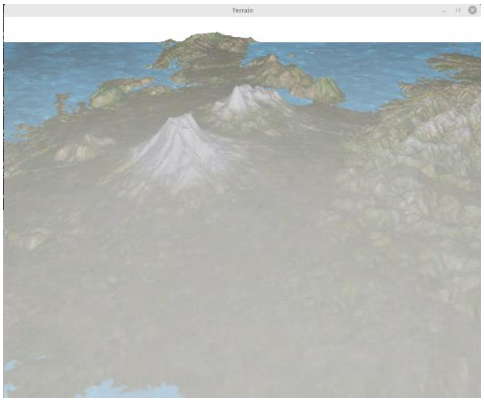

Figure 6. The scene with fog

Water Colour Variation with Depth

The water depth colouring is handled in the tessellation geometry shader. First, the distance between the vertex's original height and the adjusted water level is calculated. This distance is then divided by the maximum water depth, reducing the lighting accordingly before being passed to the tessellation fragment shader. This variations in water colour with depth is shown in Figure 7.

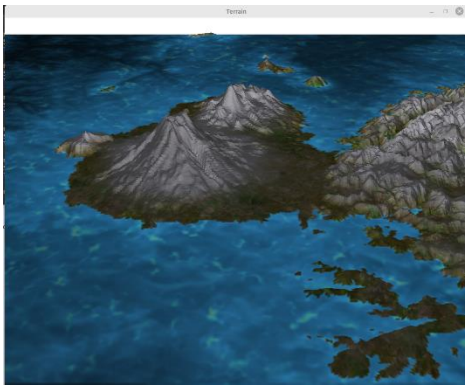

Figure 7. Variation in water colour due to depth

Keyboard Controls

Key	Action
Up Arrow	Move Camera Forward
Down Arrow	Move Camera Backwards
Left Arrow	Move Camera Left
Right Arrow	Move Camera Right
Space	Toggle Between Wireframe and Solid-fill (textured)
L	Toggle Level of Detail
C	Toggle Cracking
W	Increase Water Level
E	Decrease Water Level
S	Increase Snow Level
D	Decrease Snow Level
F	Toggle Fog

References

All content found in COSC422 course material.