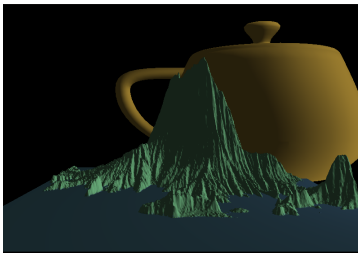
Computer Graphics Workshop 4 - Materials, Advanced Vertex Movement and Lighting

Goals

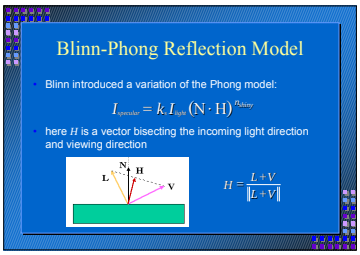
1. Simulation of static water
2. Implement Blinn-Phong specular reflection
3. Simulate "earthshake" effect
4. Simulate wave effect

Problem introduction

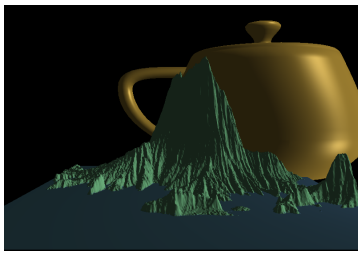
Based on second workshop, you have read a heightmap from disc and displayed it as a surface in 3D space. In the last workshop we displayed diffuse lighting on a teapot. This workshop we will be combining both scenes and add in blinn-phong shading. The teapot is present in this scene to easily showcase the blinn-phong shading. Note that the mountain scene and the teapot are using separate shader programs. The following problems are ordered by difficulty, and should be done in this order. As a general rule, feel free to expand on the shaders and rendering methods to make the terrain look more interesting.



(a) Mountain in the "lake" diffuse lighting for everything.



(b) Blinn-Phong lighting model



(c) Specular lighting for teapot and lake.

Problem 1 (low difficulty)

1. Create static water around your mountains resembling an ocean. Do this by editing `terrain.vs`. Remember that vertices are first processed by the vertex shader and the results are send to the fragment shader. For example the `out vec4 _position` variable in `terrain.vs` corresponds with the `in vec4 _position` variable in `terrain.fs`. Use

this to make the vertex shader indicate that the fragment in the fragment shader should use the `water_mat`. The result should look like Figure 1a.

2. Make the "Q" key toggle between mountain with water and mountain without water.

Problem 2 (medium difficulty)

1. Calculate correct Blinn-Phong specular reflection for the teapot according to the slide in Figure 1b. Do this in the `teapot.fs` fragment shader.

2. Apply the Blinn-Phong specular reflection to the water as well. Do not apply it to the mountain. Take care to use the correct material for each.

Problem 3 (high to very high difficulty)

In this section, we will implement complex vertex movement to simulate some world effects. Vertex movement here depends on the relationship between its coordinates and time and is calculated in the vertex shader. Usually, we chose `sin()` function to simulate periodic motion like wave and shake. There are two options: implement an "earthquake" effect or simulate waves. These problems are high to very high difficulty, feel free to choose either one of them. You will be able to get full credits for completing the "earthquake" effect. The wave simulation is only recommended for students who feel comfortable manipulating the shaders and will give more points.

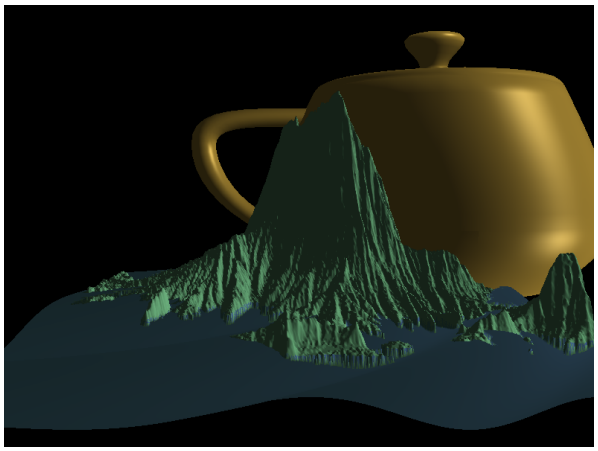


Figure 2: Wave with Blinn-Phong specular reflection.

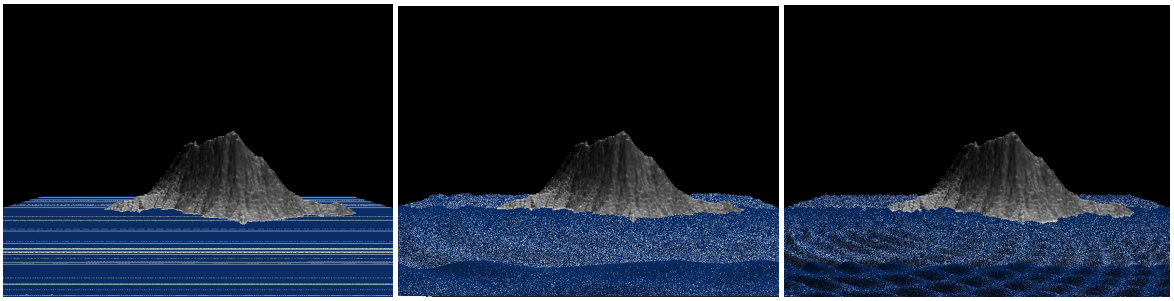
- For the "earthquake" effect, make the "M" key a toggle for the "earthquake" effect. For example, vertex shakes along x and y axis by applying a `sin()` to the vertices based on the time passed, do this in the vertex shader of the terrain `terrain.vs`. (high difficulty)

- For "wave" effect, you can simulate a wave effect with Blinn-Phong specular reflection that has been implemented in Problem 2. Make the "C" key a trigger for the wave

effect. Here we utilize a simplified wave equation to calculate the height of the crest:

$$W_i(x, y, t) = h_{water} + A_i \sin(w_i * t * ((x - x_i^{source})^2 + (y - y_i^{source})^2)), \quad (1)$$

where h_{water} is the height of the horizontal plane, A_i is amplitude , w_i is the frequency of i^{th} wave. You can feel free to set it to e.g., 2, 5 and 10. The x_i^{source} and y_i^{source} is the coordinates of i^{th} wave source. Then, you can use Eq. 1 to calculate the height ($W_i(x, y, t)$) of the water plane at the current time (t) at corresponding position (x, y). Before the waves look as expected we need to update the normals again. we can do this by calculating surrounding points for each vertex and taking a cross product. If done correctly, you would see a series of waves as shown in Figure 2.



a) **b)** **c)**

Figure 3: wave without Blinn-Phong specular reflection and wave with Blinn-Phong specular reflection (note: some white noise due to X Windows server)

Note that if you test your code on a remote X Windows server by "ssh -X", the results may display abnormally with some white noise as shown in Figure 3, which is caused by the X- server's incorrect encoding compacted codes. But the primary effect can be shown. (very high difficulty)

Submission

The deadline is at the end of class, but if necessary, they may be submitted by 6pm of the day of the Workshop. Place in a ZIP file the following and submit on the LML Course Manager:

The top level of the zip file should contain a directory called
firstname.lastname.project as described below:

In a directory called "firstname.lastname.project" (e.g. mary.smith.project)
(1) a file named "AnswerJournal.txt" which should list
- Your full name and student ID
- Mention which of the problems you solved.
(2) The source code, Makefile (the project must compile using "make") and
(3) Working executable of your solution