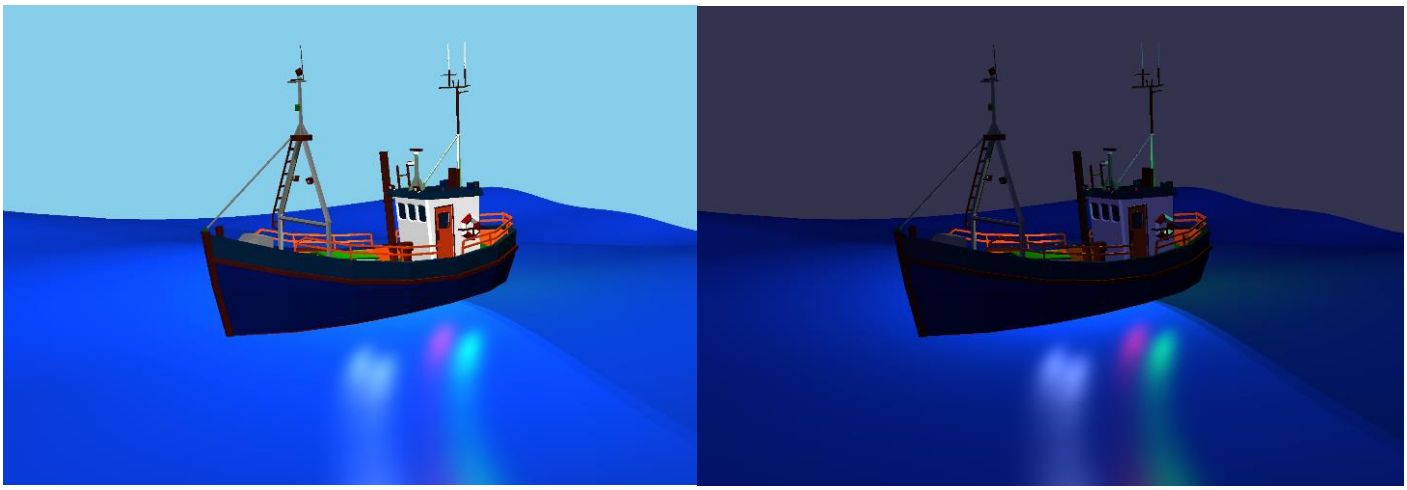
Proseminar Visual Computing
Winter Semester 2023

CG Assignment 2
Hand-out: November 28, 2023
Hand-in: December 11, 2023



Topics

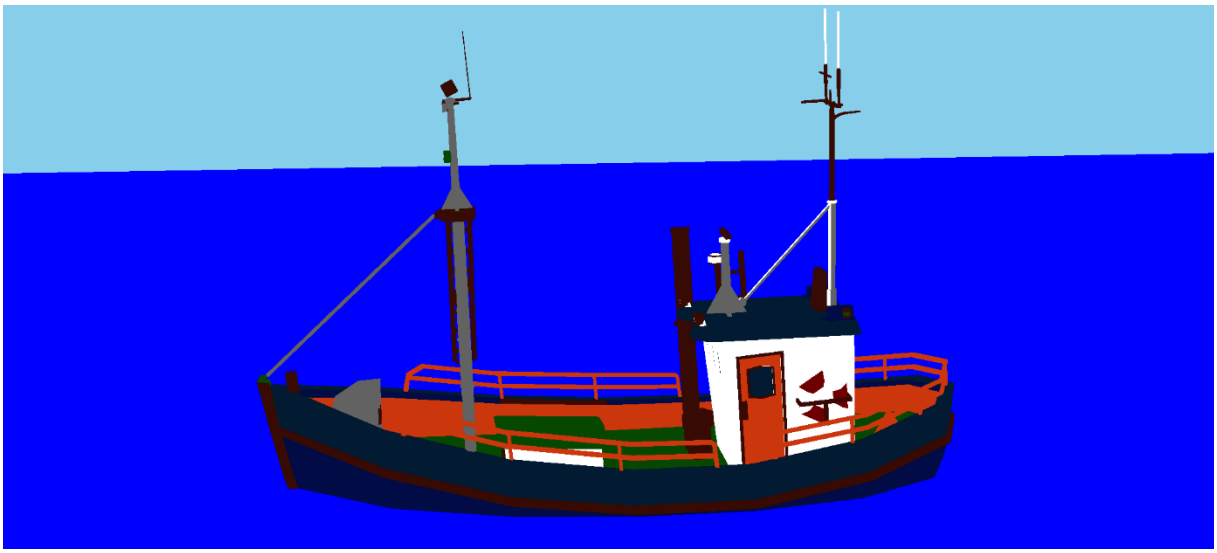
- Shader programming
- Lighting and materials
- Light sources

Outline

The goal of the Computer Graphics assignments of the Visual Computing PS is to build a controllable boat moving on an animated water surface. This work is divided in 3 steps. Each step corresponds to a programming assignment. The objective of this assignment is to a) implement *Blinn-Phong Illumination* (with multiple light sources) in the *Fragment Shader* in GLSL using material properties defined in the .obj data format, and b) animate water waves via the *Vertex Shader*.

Template code

A template code is provided with this assignment. It loads the boat mesh and its material properties from an .obj file. The boat controls and its rotation due to the ocean waves are already implemented. Currently, the fragment shader sets the fragment color according to the diffuse material color.



Tasks

1. Contrary to the first assignment, the animation of the water surface should be handled on the GPU with a specialized *Vertex Shader*.
   The height of the water surface is modeled with a sum of periodic waves

$$H(\mathbf{p}, t) = \sum W_i(\mathbf{p}, t)\,,$$

   each defined with varying amplitude A, phase φ, wavelength ω, and direction $\mathbf{d}$:

$$W_i(\mathbf{p}, t) = A\sin(\omega(\mathbf{p}\cdot\mathbf{d}) + t\varphi)$$

   Implement the displacement of the water surface over time in the *Vertex Shader*. That is, for each vertex compute its corresponding wave height and translate the position, accordingly. In addition, you need to provide the surface normal to the *Fragment Shader,* which can be computed by taking the partial derivatives of $H(\mathbf{p}, t)$ with respect to x and y (*i.e.*, the coordinates of $\mathbf{p}$).

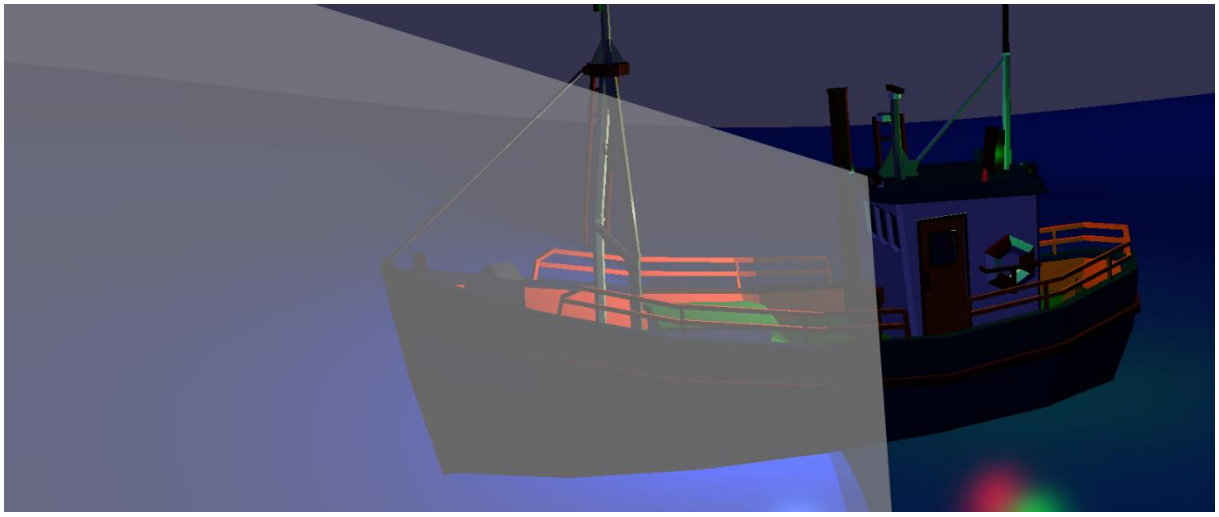
$$\mathbf{n} = \begin{pmatrix} 1 \\ 0 \\ \dfrac{\partial H(\mathbf{p}, t)}{\partial x} \end{pmatrix} \times \begin{pmatrix} 0 \\ 1 \\ \dfrac{\partial H(\mathbf{p}, t)}{\partial y} \end{pmatrix}$$

   Note: By OpenGL convention, the water surface is placed in the xz-plane and the y-axis represents height. Furthermore, you should normalize the vector $\mathbf{n}$.

2. Implement *Blinn-Phong* illumination in the *Fragment Shader* for a directional light source with the material properties (color values and shininess) given in the boat model (loaded from an .obj (.mat) file; already implemented – see model.h).
   Find color values and the direction of the light source to emulate the lighting condition during the day and night. You should be able to switch between them by pressing a key.

3. Next, add point light sources with decaying intensity. There should be *two white lights* at the front of the cabin. A green light on the right-hand-side (starboard) of the cabin and a red light at the left-hand-side (port). Make sure to translate the light source positions as the boat moves.

4. Finally, change the *point lights to spotlights*. You can implement this without a smooth edge and simply cut the lights power if a fragment is not in the light cone (defined with a direction and a cut-off angle).
   You can direct the white lights slightly to the ground and use a large light cone (ca. 75°). The navigation lights can have an angle of 180° (or stay a point light).



Implementation Remarks

Make sure that your code is clear and readable. Write commentaries when necessary. Your solution should contain a readme file with names of the team members, list of keyboard controls, and any explanation that you think is necessary for the comprehension of the code.

Submission and Grading

Submission of your solution is due on December 11th, 2023 (23:59). **Submit the sources** (*i.e.*, only the content of the *src* folder) in a ZIP archive via OLAT. Do not submit the executable and the content of the *build* folder. Do not submit the external dependencies either. Both folder and archive should be named according to the following convention:

Folder: **CGA2_<lastname1>_<lastname2>_<lastname3>**

Archive: **CGA2_<lastname1>_<lastname2>_<lastname3>.zip**,

where <lastname1>, etc. are the family names of the team members. Development in teams of two or three students is requested. Please respect the academic honor code. In total there are 15 marks achievable in this assignment distributed as follows:

- Shader based water surface animation (**4 marks**)
- A directional light source (sun/moon) (**4 marks**)
- Point light sources attached to the boat (**4 marks**)
- Spotlight sources **(1 marks)**
- Code readability, comments, and proper submission: (**2 marks**)

Resources

- Lecture and Proseminar slides as well as code and information are available via OLAT.
- OpenGL homepage
  http://www.opengl.org
- OpenGL 3.3 reference pages
  https://www.khronos.org/registry/OpenGL/specs/gl/glspec33.core.pdf
- OpenGL Tutorial for Blinn-Phong Illumination (Phong Shading)
  https://learnopengl.com/Lighting/Basic-Lighting
  http://www.opengl-tutorial.org/beginners-tutorials/tutorial-8-basic-shading/
- GL Framework GLFW
  https://www.glfw.org/documentation.html

Note: Be mindful of employed OpenGL and GLSL versions!