

Practice 3: Lighting and Textures

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1. Introduction

The objective of this practice was to extend the 3D scene developed in previous sessions by incorporating lighting models and texture mapping using OpenGL. The application now features a scene with a hierarchical model (robot), a triangle mesh (cow), and a floor plane. The focus was on implementing different types of light sources, material properties, and texture application with various filtering modes.

2. Implementation Details

2.1. Lighting (Light Class)

A dedicated class named Light (in Light.h and Light.cpp) was created to manage OpenGL light sources. This class encapsulates functionality for:

- Point Lights: Light emitted from a specific position in all directions.
- Directional Lights: Light coming from an infinite distance (simulating the sun), defined by direction rather than position.
- Spotlights: Light emitted in a cone shape, defined by a position, direction, cutoff angle, and exponent.

The setupLights method in igvInterface initializes three specific lights:

- GL_LIGHT0: A Point Light used for the dynamic animation.
- GL_LIGHT1: A Directional Light providing general illumination.
- GL_LIGHT2: A Spotlight focused on the scene.

2.2. Materials and Floor (Floor Class)

The floor of the scene is implemented in the Floor class. It supports dynamic switching between different material properties (Rubber, Plastic, Metal). These materials are defined using OpenGL parameters for Ambient, Diffuse, and Specular reflection, as well as Shininess (GL_SHININESS).

2.3. Textures

Texture mapping was implemented using the lodepng library to load PNG images. The Texture class handles generating OpenGL texture IDs, binding textures, and setting parameters. Three specific textures were included:

- Grid: A chessboard-like pattern (required by instructions).
- Water: A blue water texture.
- Bricks: A brick wall pattern.

Users can switch between these textures and apply different filtering modes (Nearest Neighbor vs. Linear Interpolation) for both minification and magnification filters (GL_TEXTURE_MIN_FILTER, GL_TEXTURE_MAG_FILTER).

2.4. Animation

A custom animation feature was added for the Point Light. In the idleFunc, a trigonometric calculation updates the position of the light source in a circular path around the scene.

3. User Manual and Functionality

3.1. Menu Options (Right-Click)

The application is controlled primarily through a hierarchical context menu:

- Toggle Global Ambient: Turns global ambient lighting on/off.
- Toggle Point Light: Turns the point light on/off.
- Toggle Directional Light: Turns the directional light on/off.
- Toggle Spotlight: Turns the spotlight on/off.
- Move Light: Selects which light source to move using keyboard controls:
- Toggle Textures: Enables or disables texture mapping on the floor.
- Grid / Water / Bricks: Selects the active texture image.
- Filters: Submenu to select combinations of GL_NEAREST and GL_LINEAR.
- Allows selection between Rubber, Plastic, and Metal materials.
- Switches between Flat (GL_FLAT) and Smooth (GL_SMOOTH) shading.
- Switches between Keyboard control and Mouse Picking.
- Toggle Model Animation.
- Toggle Camera Animation.
- Toggle Light Animation.
- Select Cow / Select Robot - Chooses the active object for manipulation.

3.2. Keyboard Controls:

- ESC: Exit the application.
- c: Toggle Camera Mode (switch between moving the camera and moving objects). Camera Control (when Camera Mode is active):
 - Arrow Keys: Orbit the camera around the scene.
 - +/-: Zoom in and out.
 - p: Toggle between Orthographic and Perspective projection.

Object Control (when an object is selected):

- Arrow Keys: Translate (move) the object along X and Y axes.
- X / x: Rotate object around X-axis.
- Y / y: Rotate object around Y-axis.
- Z / z: Rotate object around Z-axis.
- S / s: Scale the object up or down.

Light Control:

- j / l: Move selected light along X-axis.
- i / k: Move selected light along Y-axis.
- u / o: Move selected light along Z-axis.

Robot Control (when Robot is selected):

- 4 / 5: Select previous/next Degree of Freedom (DoF).
- Up / Down Arrows: Increase/Decrease the selected DoF angle.

3.3. Mouse Control

- Right Click: Open the context menu.
- Left Click: If "Mouse (Picking)" mode is active, clicking on the robot parts selects them for manipulation. Dragging the mouse up/down changes the angle of the selected part.