

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.