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CS 405 Project 3: Scene Graph + Illumination - Implementation Report

Task 1: Scene Graph Implementation

In this task, I implemented the draw function in the SceneNode class to handle hierarchical transformations in the scene graph. Applied the node's local transformation using TRS (Translation, Rotation, Scale) which is an important order for scene graph calculation. Then, I combined parent transformations with local transformations using matrix multiplication (model \rightarrow view \rightarrow projection). I created transformed matrices Model matrix (world space positioning), ModelView matrix (camera space), Normal matrix (for lighting calculations), MVP matrix (final screen projection). Then I drew the current node if it had a mesh. Recursively propagated transformations to child nodes and made sure child transformations were relative to their parent.

This implementation allowed objects like the Moon to properly orbit the Earth while the Earth orbits the Sun, maintaining the correct hierarchical relationships.

Task 2: Illumination Implementation

For this task, I enhanced the fragment shader to implement the Phong lighting model. I used existing ambient light (0.35 intensity). I also implemented diffuse lighting using normal and light direction. In addition, I added specular highlights using view and reflection vectors. For the lighting calculations, calculated light direction vector, used dot product between normal and light direction then I applied max function to prevent negative values. I added a specular component by calculating view direction from fragment to camera. I calculated the reflection direction then applied a Phong exponent (8.0) for controlling highlight size.

For final coloring I made sure to combine all components (ambient,diffuse, specular) and used separate handling for light source objects. Finally, I added lighting to the texture color.

Task 3: Mars Addition

In the final task, I added Mars to the solar system scene graph.

For node creation; I Created a new MeshDrawer for Mars. Used the existing sphere mesh for geometry. I applied the Mars texture from the provided URL. Then, I set Mars as a child of the Sun node. For the transformation; I positioned Mars at -6 units on the X-axis relative to the Sun as it was given to us. Then applied 0.35 scale uniformly to X, Y, and Z and also implemented rotation at 1.5 times the Sun's rotation speed. For final, added Mars rotation updates in the render loop which ensured proper transformation inheritance from Sun.

Final result shows a complete solar system with the Sun at the center, Earth with its Moon, and Mars.