The "Hello World!" of a 3D Graphics Engine

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Author    : Evan Bertis-Sample
NetID     : eab0652
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Course    : CS 351 - Introduction to Computer Graphics
Assignment: Project A - Moving, Jointed 3D Assemblies
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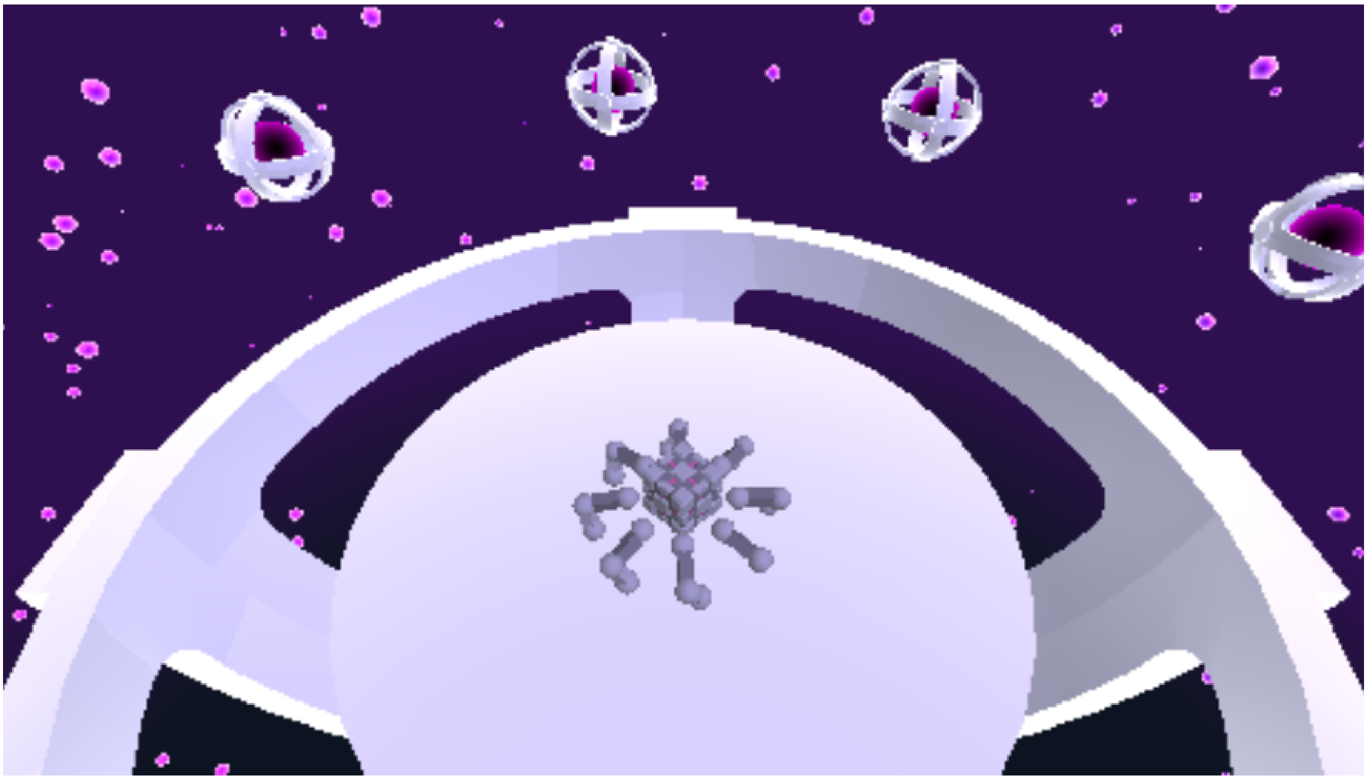


A render of the final scene, featuring a cube robot with 8 legs on a platform that multiple dyson spheres orbit around.

Goals and Ambitions

I'm going to keep it pretty casual for this report, while explaining my otherwise overengineered first project.

Coming from the game development world, I was extremely excited to take this class, especially after seeing the syllabus. I grew up as an artist, but a few years back, I pivoted towards programming and game development. As such, I figured that this first project would be a great oppurtunity to show my guns as an artist, and a game developer.

Going into the project, I had a few goals in mind:

- **To implement a scene graph, and a system for rendering it** - I know the professor advised against this, but I had done it before using C++, and figured it'd allow me to design more complex assemblies.
- **To implement a system for loading and rendering 3D models** - I don't really like hard coding things if I can avoid it.
- **To implement an entity-component system** - Game development has spoiled me with its flexibility, and I wanted to bring that into this project.

- **To create an abstraction for a "Material"** that could be applied to any 3D model - this is just a luxury that I am used to from game development.
- **To implement Phong shading**, and stlyized "toon" shading - I'm a big fan of stylized rendering, and have done a lot of work with it in the past.
- **To implement a basic IK system** for the legs of a robot - This is something that I've always wanted to do, but never had the chance to.

I'd say I have acheivedm most of these goals, but with varying degrees of success. While functionally all of these systems work, they are not as polished as I would like them to be. Namely, my material system is a bit of a mess, and my IK system is not as robust as I would like it to be.

Early development of Phong Shading, before the material abstraction was fully created.

Help Guide

Running the project is simple. Just double click on the `index.html` file, and it should open in your default web browser. The controls are as follows:

- **WASD** - Move player around
- **Mouse** - Look around - only works on the y-axis (this was a design choice)
- **Toggle Lighting** - Switches between Phong shading and showing the normals of the models (added retroactively to furfill the per-vertex normal requirement in a more obvious way)

I endured a lot of pain at the beginning of this project, trying to figure out how to talk to the GPU.

Requirement Fulfillment

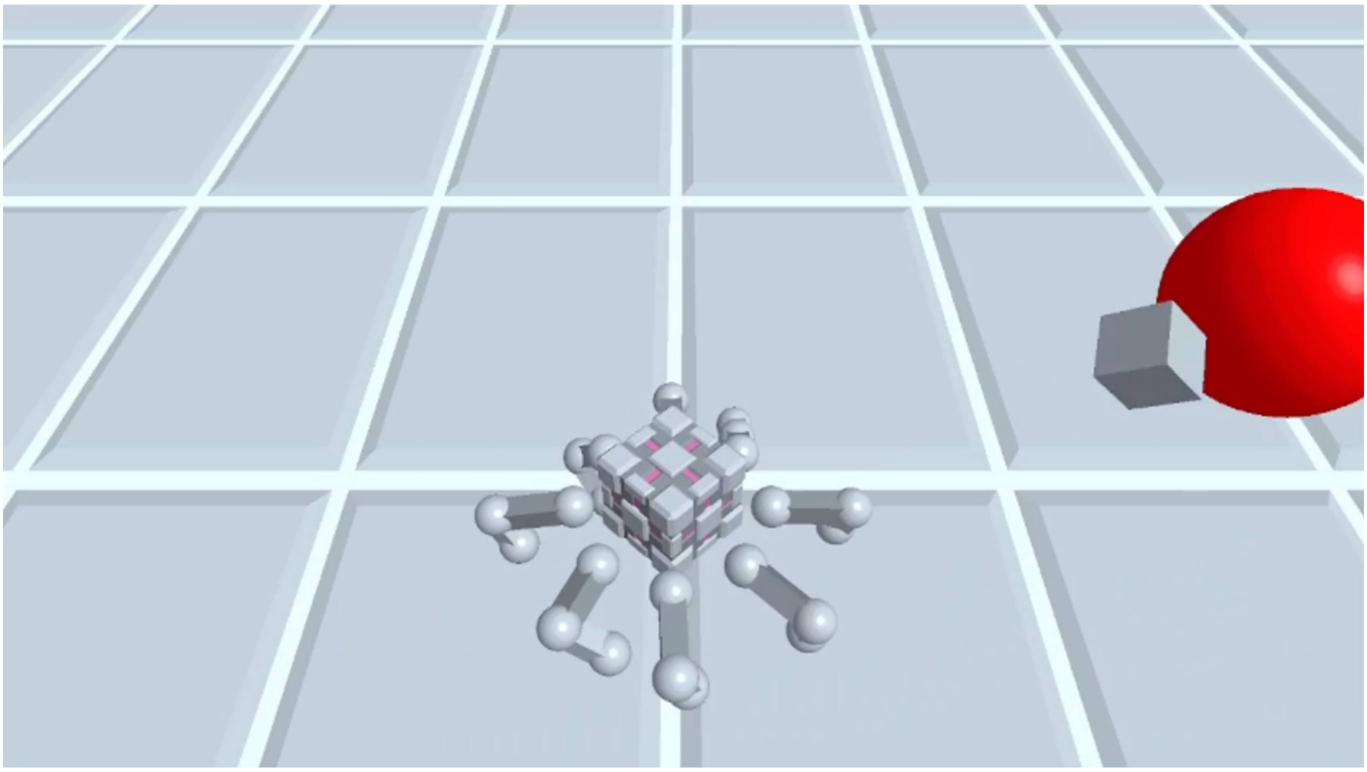
Standard Credits

- **All file-naming, correct with illustrated PDF report** - You're reading it!
- **Sensible, Complete On-Screen User Instructions** - In `index.html`, featured under the canvas.
- **At least two different rigid 3D parts that YOU designed** - The robot, the dyson spheres, and the platform.
- **Rasterized per-vertex colors-everywhere** - Phong Shading system entails that I have to have per-vertex normals (which is the same thing as per-vertex colors). But I also have a debug mode that shows the normals of the models, and these colors do not change based on the position of the meshes (to show that they are per-vertex).
- **Traveling Assembly** - The robot moves in world space, and the dyson spheres orbit around the platform.
- **Flexing/Spinning Joints** - The robot is always bobbing up and down, without input from the user, causing the joint angles to change. The dyson spheres are always spinning around the platform.
- **KINDS: Two or more obviously-different kinds of assemblies of rigid 3D parts** = The robot and the dyson spheres. The robot consists of a body, and 8 legs (which are made from 5 parts each -- the hip, the upper leg, the knee, the lower leg, and the foot). The dyson spheres are made from 2 parts each -- the black hole and the ring.
- **At least one kind of assembly must have two or more sequential, moving joints** - The robot's legs are made of 5 joints each (body to hip, hip to upper leg, upper leg to knee, knee to lower leg, lower leg

to foot).
- **Keyboard Interaction** - WASD for movement.
- **Mouse-Drag Interaction** - Look around on the y-axis.

Extra Credit

- **Additional Webpage Controls** - not attempted
- **User-Adjustable Color** - The toggle between Phong shading and showing the normals of the models.
- **User Adjustable Flex-Angle** - not attempted
- **Accurate Scene Graph Diagram** - not attempted, the scene graph would be really overcomplicated to draw out.



The scene the day after demo day, featuring a robot with 8 legs, and some weird balls that are kind of like planets.

Acknowledgement

I recognize that the work that I have done covers topics that have not been covered in this class yet. I also do recognize the possible suspicisons that the code here is not my own, but I assure you that it is. I am not too sure how to prove this, beyond redirecting you to my GitHub, where you can look at other projects that I have done, and see that they are of similar quality. For example, feel free to check out my work-in-progress 3D engine that I made that runs in the terminal using ASCII art using C++ here, or any of my game projects here. I would be willing to share my github repository with you, but Northwestern has a policy against public repositories, so I cannot easily do that without inviting you to my private repository.

I figured that I'd add this section because I recognize that the work that I have done on this project is far beyond what was expected of me, and upon inspection of this project, could reasonably be assumed to be using a library like Three.js. I assure you that I have not, and that I have done all of this work myself. I am simply very passionate about programming for artistic expression.