Bennington College

Fortune Telling with Lights and Shadows

Advanced Work Proposals

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As Confucius once said: “To learn without thinking is blindness, to think without learning is idleness. Learning without reasoning leads to confusion, thinking without learning is wasted effort.” Another year of studying at Bennington College shapes the way I think, defines theway I grow and most importantly, recognizes the way I want to contribute to the world. Thus, I would carry on to be a naïve programmer hoping one day I could see my solution to the problems we have in the cities makes the world a more robust, livable, and sustainable place. At the very beginning of my career, I wished I could build a tool that benefits the design and construction of a city’s model, for instance, an interactive 3D reconstruction program that allows people to rebuild a city of their own with real-life buildings. By taking “Advanced Computer Graphics” this term, I realize how math and computer graphics can beautifully resolve and connect to the city problems I am looking at. However, “Rome is not built in one day”, similarly, my Smart City idea cannot be implemented just after a short academic year. Although as a fifth term student, my knowledge is still shallow to handle such a huge project. I would like to take on the challenge because of my financial situation, which urges my early graduation.

I started this project because of my final project in my Physics class “The Physics of Light and Shadow.” It teaches me knowledge of light and color and inspires me to look at our real life as the interaction between multiple objects and multiple types of lights in a small sand box. Therefore, I am analyzing a “Cornell Box” to talk about how I could separate each object and light from its original context and put them back to rebuild the scene. A Cornell Box is a box that contains several objects with a given arrangement in a small box and an opening on the side and on the top of the box for light to come in and for people to view the product of the light and objects. In my Cornell Box, there would be only one single light source lighting up two same-sized smooth spheres in the box. And the box would be constituted by just paper for simplification. In this scenario, I am testing whether my program understands how a single light

source creates shadows, and how the interaction between multiple objects casts shadows on each other.

In order to make my rendering closer to what we have in real life with my 3D renderer, I need to divide the huge problem into different categories and write my program approximate to what we see everyday step by step. My physics project is a perfect example of a variable-controlled experiment on light and shadows of various same-sized objects in a stable environment. However, in real life nothing could be always constant. Therefore, there are going to be three predominant categories in a Cornell Box: object, light and environment and in each of them there are different characteristics to manipulate in order to create a more complicated Cornell Box.

In order to fully understand what an object involves, there are many sub-categories to talk about: shape of the object, material of the object, size of the object, etc. Therefore, taking from what I have from the Physics experiment, I will first manipulate the size of the objects, by switching two same sized spheres to one large and one small. The arrangement of these two spheres would create an entirely new shadowing situation. The large sphere would definitely casts longer shadow than the smaller one. From there, I will be looking at what would happen if I switch them to be two transparent spheres. Lights will definitely shine through the spheres and may be no shadows would be created. In this situation, I may need to develop code for representation of reflection and refraction in order to approximate this situation in my project. Also, because in real-life not everything is a sphere, involvement of multiple different shapes is necessary. I should be looking at how cubes, spheres and even cylinders would create a new scene in my Cornell Box.

Moreover, when we look at the light, we need to talk about the angle, the intensity, and the number of different lights that is used in the scene. I will expand from the Cornell Box I have already built in the section that I only talks about the objects and look at how multiple colors,

different angles and different intensities of light would give an entirely different feeling of the scene. Therefore, I will need to refine the light class and add more functionalities for better approximation of the real-life scene.

Furthermore, about the environment of a Cornell Box, I am going to talk about how paper enclosed Cornell Box is different entirely from a mirror enclosed Cornell Box. In the example from our textbook in "Advanced Computer Graphics" course, "The Ray Tracer Challenge", the author talks about how a glass floor would reflect the light and diminish the shadows. Also, in real life, the media of light is not always air. We could replace this media with water, oil, or fog. In different media, the reflection and refraction should all obey the Snell's law, which makes the rendering much more difficult.

After putting all these together, I will be able to understand better how the scenes we see every day is formed and my renderer could understand better how to recreate a scene.

Math in this project is straight forward. I am going to create algorithms based on linear algebra for computer to better comprehend the light and shadows of an object in a scene. Furthermore, I could apply math for optimization of algorithms. And there would be more involvement of math for perfection of my program when I start to work on the project. On the other hand, I would like to build on from the Putnam Contest material I have to develop some investigations of math techniques throughout the rest of my career as an undergraduate. These techniques could not only serve as an challenge for my current math skills, but also offer me an opportunity to think how to make shortcuts in programming with my knowledge in math.

As what I said in my Plan Proposal, "Building a Smart City is more than connecting sensors to servers", it also takes time for careful investigations and considerations for the people living in it. Although this project is a period on my undergraduate education, it would never be a period on my enthusiastic and curiosity of making more comfortable cities to live in and helping better community to form.