Thesis Introduction

Harrison McKenzie Chapter

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1 Problem

A body of work exists in the Computer Graphics community on Precomputed Radiance Transfer (PRT), a method for establishing how much light an object receives and returns to a scene based on the properties of the model and the material\[5\]. Many of these methods suffer from difficulties adapting to all-frequency lighting, rotations, and implementability on conventional hardware. I will be extending the work on PRT by establishing a method for computing all-frequency lighting using Radiance Transfer Fields\[1\] on the GPU in realtime. It is expected that this will lead to an easier adoption of PRT techniques by the graphics community leveraging the existing hardware with flexible representation ability.

2 Context

Computer Graphics has a chief division that separates much of the work done in the field, that of photorealism and speed. Conventionally, Global Illumination methods, have yielded very nice results with respect to photorealism by providing convincing soft-shadows, interreflections, and caustic effects by simulating the movement of light around a scene. These advances are generally hard to apply to realtime graphics, however, because the time and space constraints are far more limited.

Historically, realtime computer graphics has attempted to generate graphics quickly by precomputing whatever data could be obtained before rendering the scene, and storing that for easy lookup. As the graphics pipeline has matured into programmability, with vertex and pixel shaders, these methods have become more robust than just storing textures and lightmaps to attach to surfaces. Techniques such as displacement and bumpmaps have allowed programmers to permute the variables of the classic lighting calculation, rather than utilizing additive light exclusively\[3\].

One of the hardest effects to develop convincingly with the conventional realtime graphics approach is the reflection of one object upon another. Generally, this can be solved by using multiple rendering passes, from the perspective of different objects as the “viewer,” to generate and store the necessary data. This data is then mapped onto the reflecting object as a texture, using the additive properties of light sources. This approach, while convincing, takes a lot of time as another render has to be done for each reflection, and the reflected colors have to be stored temporarily before they’re used. This causes performance problems of both speed and space.

For some static scenes, this process can be done beforehand, resulting in a significant speed increase. Before the scene is rendered (offline), for each object
a “map” of its surroundings can be composed. These are generally called Cube-maps, because they are formed of the 6 sides of a cube enclosing an object. The Cube-map can be used to look up the colors of the scene in each direction, for each “pixel” of each Cube-map face. This is similar to the methods used by PRT, but PRT goes further into encoding the calculation of final lighting.

3 Motivation

Instead of using rendering techniques to solve the reflections problem however, it is possible to precomputed how an object interacts with the world around it in terms of light. While most computer graphics light models concern themselves with only incoming light, PRT techniques can consider not only how light interacts with an object, but how reflected light from the object interacts with itself and with its environment. By encoding this information in a useful representation (conventionally Spherical Harmonics[4]), the color which a light striking an object produces can be solved by integrating the lighting properties of that material with the properties of the light and the orientation of the surface.

If such a lighting representation can be moved to dedicated graphics hardware without requiring much modification, and can be used to represent most lighting effects, it could result in much higher image quality for interactive graphics applications.

4 Contributions

I will be contributing two things to the state-of-the art with respect to computer graphics and PRT.

• Extention of Radiance Transfer Fields to all-frequency lighting conditions, flexibly handling most global illumination effects.

• The utilization of conventional, dedicated graphics hardware to render PRT effects in realtime.

5 Expected Results

The expected results of this work are a solution to the lighting equation for all-frequencies utilizing a minimal number of coefficients, such that the space and performance requirements of the method are minimized. Further, it is hoped that this method will also produce novel storage techniques such that it can be portable to dedicated graphics hardware already in existence, further speeding up the calculation of each object’s color.
6 Bibliography

References


