Interactive Global Illumination – Importance Sampling

Luís Paulo Santos[1] – CCTC/UM

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Introduction

The goal of physically based global illumination is to render a realistic and physically accurate (up to a given error bound) image of a virtual world. The most relevant light paths from the light sources to the viewer's position have to be traced, simulating light interactions with the transmitting medium, e.g. air or water, and with objects in the scene. Since these interactions are simulated using physically based illumination models, the resulting image is a correct depiction of what would be seen in a real situation.

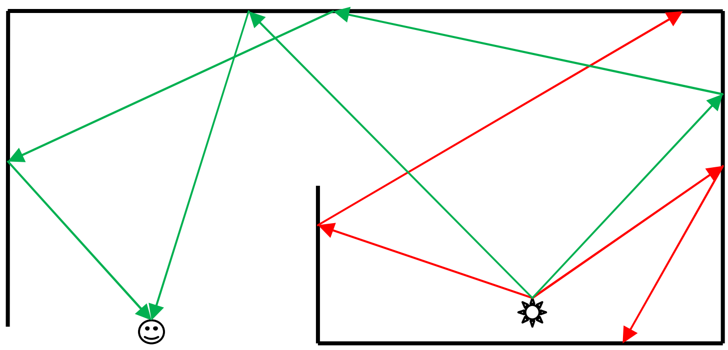

Figure 1 - Tracing light paths from the light sources

Tracing the light paths from the light sources, however, implies tracing many paths that never reach the observer (red paths in Figure 1). The most common alternative is to trace rays from the observer towards the scene and connecting the intersection points with the light sources to make sure that energy emitted from these is taken into account in the shading process. This process has its own limitations: some types of interactions between the light and the objects cannot be efficiently modeled.

A more efficient approach is to follow a bidirectional, three steps approach:

1. **Importance shooting** – shoot rays from the observer that identify regions that are visible and thus are ***important*** for the image being rendered;
2. **Energy shooting** – shoot rays from the light sources towards the important regions of the scene and store this radiant energy information at the intersection points;
3. **Energy gather** – shoot rays from the observer towards the scene and gather stored energy from a given neighborhood.

The importance shooting stage creates a probability distribution over the scene, identifying regions that have larger probability of being *important*. The energy shooting stage stochastically selects the shooting directions according to this distribution. Since these are computationally expensive techniques,

[1] psantos@di.uminho.pt

efficiency is dependent on the quality of these distributions, i.e. on the quality of the sampling strategies used to select the shooting directions.

In an animation many frames have to be rendered. From frame to frame some properties of the virtual scene change, such as the viewer's position, the model geometry, the objects materials' properties or the lighting conditions. Since these changes are often incremental many results from previous frames can be reused, thus reducing the rendering workload. This property is known as **temporal coherence**. When applied to importance shooting techniques it is referred to as **temporally coherent importance shooting**. Temporal coherence and temporally coherent importance shooting are not well understood yet and are seldom exploited in current rendering systems.

"Interactive Global Illumination within Dynamic Environments" is a research project headed by CCTC and funded by FCT, whose goal is to achieve global illumination rendering at interactive within these all-dynamic virtual worlds. To achieve this goal several different research axes will be pursued, including parallel processing, utilization of multiple high performance Graphics Processing Units (GPU) and the exploitation of different forms of temporal coherence. This thesis fits within this project scope and should run in the same period.

Goals

- Contribute to a better understanding and propose a clearer definition of coherence; ; this definition should allow quantification of coherence along a given domain, thus guiding coherence exploitation methods;
- Propose and evaluate importance-based rendering algorithms using the interactive renderer developed within the above cited research project context;
- Extend and evaluate the previous algorithms to animations, exploiting temporally coherent importance shooting.