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Interactive Indirect Illumination Using Voxel Cone Tracing

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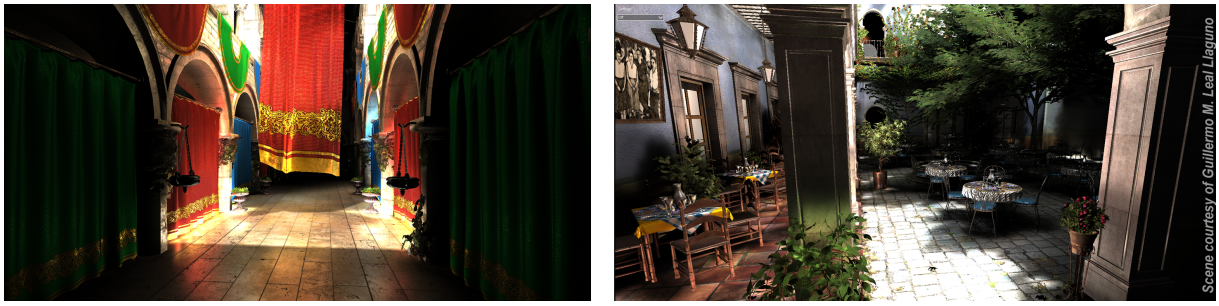

Figure 1: *Real-time indirect illumination (25-70 fps on a GTX480): We rely on a voxel-based cone tracing to ensure efficient integration of 2-bounce illumination and support diffuse and glossy materials on complex scenes.* *(Right scene courtesy of G. M. Leal Llaguno)*

Abstract

Indirect illumination is an important element for realistic image synthesis, but its computation is expensive and highly dependent on the complexity of the scene and of the BRDF of the involved surfaces. While off-line computation and pre-baking can be acceptable for some cases, many applications (games, simulators, etc.) require real-time or interactive approaches to evaluate indirect illumination. We present a novel algorithm to compute indirect lighting in real-time that avoids costly precomputation steps and is not restricted to low-frequency illumination. It is based on a hierarchical voxel octree representation generated and updated on the fly from a regular scene mesh coupled with an approximate voxel cone tracing that allows for a fast estimation of the visibility and incoming energy. Our approach can manage two light bounces for both Lambertian and glossy materials at interactive framerates (25-70FPS). It exhibits an almost scene-independent performance and can handle complex scenes with dynamic content thanks to an interactive octree-voxelization scheme. In addition, we demonstrate that our voxel cone tracing can be used to efficiently estimate Ambient Occlusion.

Categories and Subject Descriptors (according to ACM CCS): I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Color, shading, shadowing, and texture

Keywords: global illumination, indirect lighting, final gather, cone-tracing, voxels, GPU, real-time rendering

1. Introduction

There is no doubt that indirect illumination drastically improves the realism of a rendered scene, but generally comes at a significant cost because complex scenes are challenging to illuminate, especially in the presence of glossy reflections. Global illumination is computationally expensive for several reasons. It requires computing visibility between arbitrary points in the 3D scene, which is difficult with rasterization based rendering. Secondly, it requires integrating lighting information over a large number of directions for each shaded point. Nowadays, with the complexity of rendering content approaching millions of triangles, even in games, computing indirect illumination in real-time on such scenes is a major challenge with high industrial impact. Due to real-time constraints, off-line algorithms used by the special-effect industry are not suitable, and fast, approximate, and adaptive solutions are required. Relying on precomputed illumination is very limiting because common effects such as dynamic light sources and glossy materials are rarely handled.

In this paper, we present a novel algorithm that computes two light bounces (using final gathering [Jen96]) and is entirely implemented on the GPU. It does not suffer from noise or temporal discontinuities, avoids costly precomputation steps, and is not restricted to low-frequency illumination. It exhibits almost scene-independent performance because we manage to mostly avoid involving the actual mesh in our computations. Further, our solution can be extended to out-of-core rendering, hereby handling arbitrarily com-