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## Interactive Indirect Illumination Using Voxel Cone Tracing: A Preview

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# Interactive Indirect Illumination Using Voxel Cone Tracing

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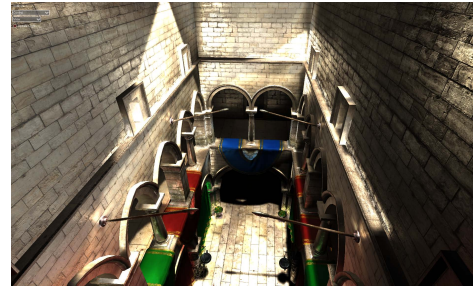
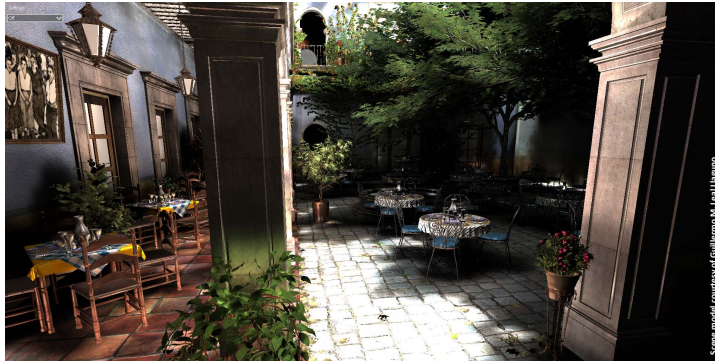
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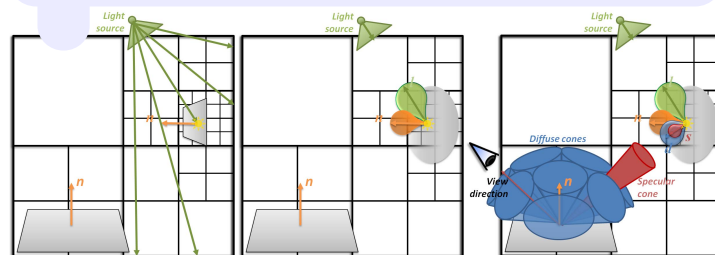
## Overview

**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 surfaces involved. We present a novel algorithm to compute global illumination in **real-time** that avoids costly precomputation steps and is not restricted to low frequency illumination. It is based on a **voxel octree** representation and an **approximate voxel cone tracing** that allows a fast estimation of the visibility and incoming energy. Our approach can manage both **Lambertian and Glossy materials** at interactive framerates (*5-30FPS*).

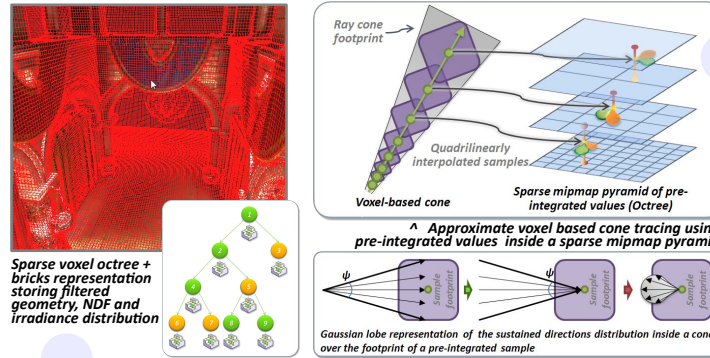


## Global Algorithm

1. **Store** incoming radiance (energy and direction) from **dynamic light sources** into a **sparse voxel octree** hierarchy, by rasterizing scene meshes.
2. **Filter** the values in the higher levels of the octree (mipmap). Done efficiently in parallel by relying on **screen-space quad-tree analysis**.
3. **Render** scene from the **camera**. For each visible surface fragments, we combine the **direct and indirect illumination**. We employ an approximate **cone tracing** to perform a **final gathering**, sending out a few cones over the hemisphere to collect illumination distributed in the octree.

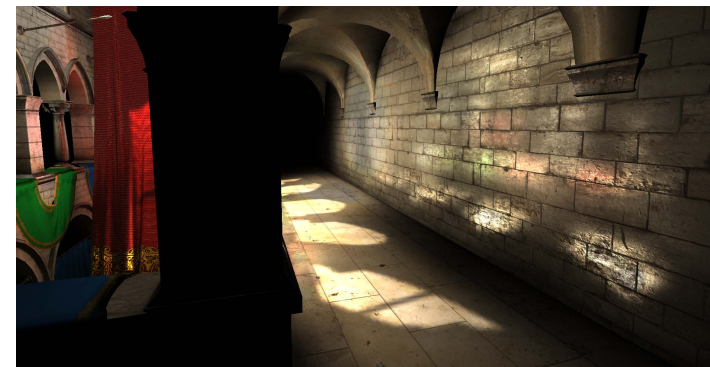


Step 1: Render scene from light sources. Bake incoming radiance and light direction into the octree. Step 2: Filter irradiance values and light directions inside the octree (mipmap). Step 3: Render from camera. Sample diffuse + specular BRDF components using voxel based cone tracing.



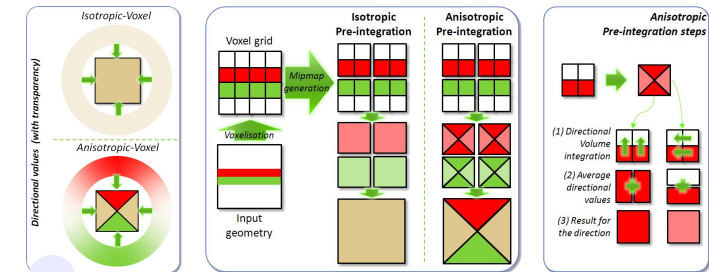
## Sparse Voxel Octree Structure

The core of our approach is built upon a **pre-filtered** hierarchical voxel version of the **scene geometry**. For efficiency, this representation is stored in the form of a **compact pointer-based sparse voxel octree** in the spirit of [Crassin et al. 2009]. We use small  $3^3$  bricks with values located in octree-node corners. This structure exhibits an almost **scene-independent** performance and is suitable to be extended to out-of-core rendering, hereby allowing for arbitrarily complex scenes.



## Pre-integrated Voxel Cone Tracing

Our approach approximates the result of the **visibility, energy and NDF estimation** for a bundle of rays in a cone using only a **single ray** and our **filtered (mipmapped) voxel structure**. The idea is to perform **volume integration** steps along the cone axis with lookups in our hierarchical representation at the LOD corresponding to the local cone radius. During this step, we use **quadrilinear interpolation** to ensure a smooth LOD variation. Our voxel shading convolves the **BRDF**, the **NDF**, the distribution of **light directions** and the **span of the view cone**, all considered as **Gaussian lobes**. These lobes are reconstructed from **direction distributions** stored in a compact way as non-normalized vectors in the structure.



## Anisotropic Pre-Integration

In order to get higher quality visibility estimation and to limit leaking of light when low resolution mipmap levels are used, we propose to rely on an **anisotropic pre-integration** of voxel values stored in a **direction-dependant** way in the structure. We use the 6 main directions and values are reconstructed by linear interpolation of the 3 closest directions. It provides a **better approximation of the volume rendering integral**, at the cost of 1.75x the storage requirement and a slightly slower sampling.

Reference: *GigaVoxels: Ray-guided streaming for efficient and detailed voxel rendering*. I3D 2009. CRASSIN, C., NEYRET, F., LEFEBVRE, S., AND EISEMANN, E.