The Tomorrow Children: Lighting and Mining with Voxels

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Figure 1: *Real-time Global Illumination with a Dynamic User Modifiable Landscape running at 30hz on PS4*

Abstract

The unique visual look and gameplay envisioned for The Tomorrow Children demanded that we implement real-time Global Illumination (GI) as well as dynamically modifiable landscapes all running at 30hz on the PlayStation 4 console hardware. Users needed to be able to dig holes in fallen monsters and create vast structures all at runtime without any pre-baking and have beautiful GI 100% of the time. To achieve this we used a variant of Voxel Cone Tracing [Crassin et al. 2011] to provide both direct and 3 bounce indirect illumination.

1 Lighting

In order to bring Voxel Cone Tracing up to a speed that would enable it to be practical on console hardware we had to make several modifications to the algorithm. The main one being to switch from using Spare Voxel Octrees to a set of 3D volume texture cascades similar in nature to those often used for Light Propagation Volumes [Kaplanyan et al. 2010].

This change of data structure trades space for speed and simplicity. It also worked in conjunction with our decision to cone trace in 16 fixed directions to allow us to further accelerate our implementation by using additional texture cascades to store pre-combined directional coefficients for the anisotropic voxels, thus reducing the bandwidth required for each cone trace step.

We also massively reduced the amount of work we need to perform per pixel by caching the "far" part of the cone traces for each direction in another set of texture cascades, which could then be combined via quadrilinear interpolation with the cone traced results for the "near" part of the cones performed at each pixel.

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2 Effects

Whilst fast enough for lighting opaque surfaces, this technique was still too slow to use for our particles, so we use yet another texture cascade to store a 4 component spherical harmonic representation of the lighting environment that could be queried per vertex by our particles.

This texture is effectively a simplified light field for the scene, and we were able to re-use it for several other purposes. These included emulating sub-surface scattering effects on various materials as well as producing glossy reflections and refractions of the scene by combining it with a per pixel voxel based ray march through a distance field representation we also created at runtime from our voxel dataset.

References

CRASSIN, C., NEYRET, F., AND OTHERS. 2011 Interactive Indirect Illumination Using Voxel-Based Cone Tracing : An Insight.

KAPLANYAN, A., DACHSBACHER, C., 2010. Cascaded Light Propagation Volumes for Real-time Indirect Illumination .