Realtime global illumination in a dynamic 3-D environment

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Abstract

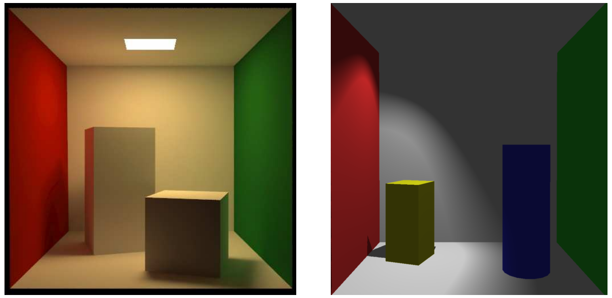
Direct dynamic illumination with shadow casting has been available in interactive 3D graphics for quite some time now. However, indirect illumination, meaning light that has bounced off one or more previous surfaces before reflecting off the surface being observed, has pretty much been stuck with two options: Precalculated light maps and fake approximations. Here I will present techniques used to come one step closer to physically correct global illumination in real time in dynamic environments. I will present pictures from my own implementation.

Precalculated light maps

Especially for games it have been very popular to use precalculated light maps for static geometry. This approach can yield some very good looking and realistic results. It does, on the other hand, have the major disadvantage of being constrained to static geometry and light sources, though, some advances have been made in e.g. allowing for dynamic light power and color.

Different "fake" approximations

The, by far, most used technique for faking indirect illumination is simply to add a constant ambient term to the lighting equation.



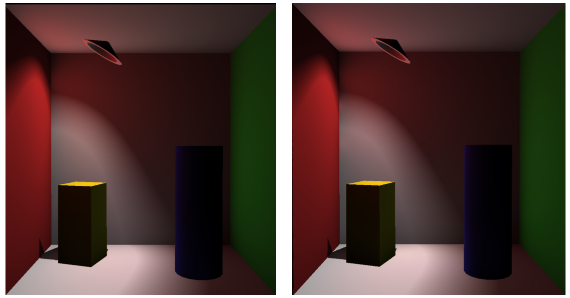
On the left: A classic Cornell box illuminated using Radiosity. Borrowed from cs.cmu.edu.
On The right: A scene rendered with the shadow mapping and a constant ambient term.

Making Radiosity real time

Because regular Radiosity is extremely computational intensive even for simple scenes, Alexander Keller suggested in 1997 that the inter reflection of light from all surfaces to all surfaces were approximated by placing light sources where the primary light would shine. These secondary light sources were referred to as Virtual Point Lights (VPLs). Originally, this was mostly meant to accelerate offline Radiosity calculations, but recent advances in graphics hardware have made it possible to utilize Keller's technique, called Instant Radiosity, to render scenes with indirect illumination in real time.

Deferred shading

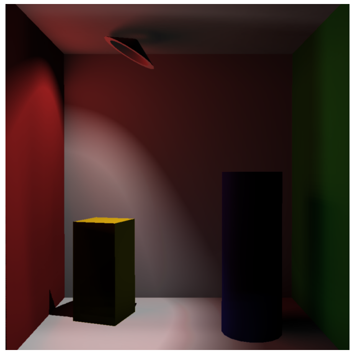
With the advent of deferred shading and have suddenly become possible to render the number of light sources needed to yield pleasing results with Instant Radiosity. Carsten Dachsbacher & Marc Stamminger presented this in 2006 with several enhancements and called it Splatting Indirect Illumination (SII).



Both images are screenshots from my implementation of Splatting Indirect Illumination. The one on the left is rendered with 400 VPLs and the on the right with 64. The differences in this simple scene is practically invisible.

Shadow casting from indirect illumination

Blocking of indirect illumination which causes "indirect shadows" is, in principle, really easy to do but is, in reality, really hard to make efficient. Shadow maps can be rendered from each of VPL and used when rendering the indirect illumination to the deferred light map. This suddenly becomes extremely dependent on geometry complexity and is nowhere near possible in realistic gaming scenarios on today's hardware.



My own implementation of SII with VPL shadow maps