GLOBAL ILLUMINATION IN GAMES

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Diffuse Global Illumination in Crysis 2™
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Global illumination in games
Global illumination – Color bleeding

Image credit: Michael Bunnell
Pre-computed indirect lighting (baking, lightmaps)
Pre-computed indirect lighting (baking, lightmaps)

- Slides only

- Annotated slides

- NOTE: The above slides have been used in the lecture and the material therein will be part of the exam!
Details on radiosity normal mapping

(part of precomputed indirect lighting)
Radiosity Normal Mapping

- Combine light mapping and normal maps
- Popularized by Valve for Half-Life 2
- See full slides by Habel & Wimmer: Efficient Irradiance Normal Mapping
  - [https://www.cg.tuwien.ac.at/research/publications/2010/Habel-2010-EIN/](https://www.cg.tuwien.ac.at/research/publications/2010/Habel-2010-EIN/)
Normal maps – Adding details to surfaces

original mesh
4M triangles

simplified mesh
500 triangles

simplified mesh
and normal mapping
500 triangles
Normal maps – Adding details to surfaces
Normal maps – Adding details to surfaces
Normal map examples
Motivation for radiosity normal mapping

Light map only
Motivation for radiosity normal mapping
Motivation for radiosity normal mapping

Irradiance normal mapped no texture
Idea

- **Regular light map**
  - One RGB triplet per texel

- **Radiosity light map**
  - Directional distribution of incident light for each texel
    - That is, essentially an irradiance EM for each texel
  - Question: how to represent it efficiently
    - Irradiance EM: 9 SH coefficients (i.e. RGB triplets) per texel
    - Half-life 2 basis: 3 coefficients per texel
    - H-basis: 6 coefficients per texel
Bases Comparison: 3/6/9 Coefficients

Ground truth

Half-Life 2 basis (3 coeffs)

$H_6$ (6 coefficients)

SH 3 bands (9 coefficients)
Bases Comparison: 3/6/9 Coefficients

- SH irradiance environment maps (9 coeffs)
  - Extremely close to reference but costly and bulky
- Half-Life basis
  - Efficient and light, but a bad approximation of reference
- H6 is a good compromise
Half-Life2 basis

- Cosine lobes around three orthogonal directions

\[
\begin{align*}
\mathcal{H}_1 &= \left\{ -\frac{1}{\sqrt{6}}, \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{3}} \right\} \\
\mathcal{H}_2 &= \left\{ -\frac{1}{\sqrt{6}}, -\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{3}} \right\} \\
\mathcal{H}_3 &= \left\{ \frac{2}{\sqrt{3}}, 0, \frac{1}{\sqrt{3}} \right\}
\end{align*}
\]
Radiosity Normal Mapping with Half-Life 2 basis

- **Precomputation**
  - Traditionally, when computing light map values using a radiosity preprocessor, a single color value is calculated.
  - In Radiosity Normal Mapping, we transform our basis into tangent space and compute light values for each vector.

- **At the pixel level (Half-Life 2 basis)**
  - Transform the normal from a normal map into our basis.
  - Sample three light map colors, and blend between them based on the transformed vector:
    
    \[
    \text{lightmapColor}[0] \times \text{dot}( \text{bumpBasis}[0], \text{normal} ) + \text{lightmapColor}[1] \times \text{dot}( \text{bumpBasis}[1], \text{normal} ) + \text{lightmapColor}[2] \times \text{dot}( \text{bumpBasis}[2], \text{normal} )
    \]
Radiosity Normal Mapping

- H-basis (Habel and Wimmer)
  - Spherical harmonics adapted to the hemisphere
  - [https://www.cg.tuwien.ac.at/research/publications/2010/Habel-2010-EIN/](https://www.cg.tuwien.ac.at/research/publications/2010/Habel-2010-EIN/)

Spherical harmonics
(used e.g. in Ramamoorthi 2001)

H6-basis
(proposed by Habel)
Real-time dynamic GI: Point-based Global Illumination
Point-based global illumination

- Slides only

- Annotated slides
Point-based global illumination
Point-based global illumination

point cloud

fill lights
Point-based global illumination

- Play micro-rendering video
  (https://www.youtube.com/watch?v=Z9u8EdFbmiI)
Point-based global illumination

Literature

■ Original idea
  ▶ M. Bunnell, “Dynamic ambient occlusion and indirect lighting”, GPU Gems 2

■ Application in movie production
  ▶ P. Christensen, “Point-based approximate color bleeding”, Pixar tech memo #08-01

■ Real-time implementation (CUDA)
Real-time dynamic GI: Light-propagation volumes
Light Propagation Volumes

On this page:
- Enabling Light Propagation Volumes
- Basic Scene Setup
- Light Propagation Volume Settings
  - Adjusting the Look and Performance
- Directional Light Settings
- Viewing Global Illumination
- Visualizing Light Propagation Volumes
- GI Replace Material Switch
- Other Notes

Light Propagation Volumes are a feature in development and not ready for production.
Light propagation volumes

- Anton Kaplanyan’s slides form the 2010 course “Global illumination across industries”
THANK YOU!

Questions?

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