GLOBAL ILLUMINATION IN GAMES

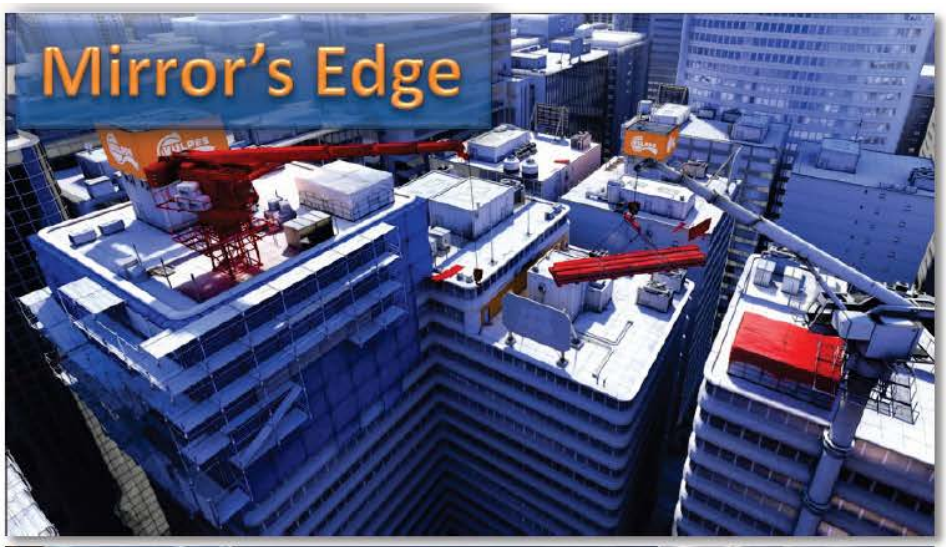
Jaroslav Křivánek

Charles University in Prague


Diffuse Global Illumination in Crysis 2™


Diffuse Global Illumination in Crysis 2™

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
  - http://cgg.mff.cuni.cz/~jaroslav/gicourse2010/giai2010-06-david_larsson-slides.pdf
- Annotated slides
  - http://cgg.mff.cuni.cz/~jaroslav/gicourse2010/giai2010-06-david_larsson-notes.pdf
- **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

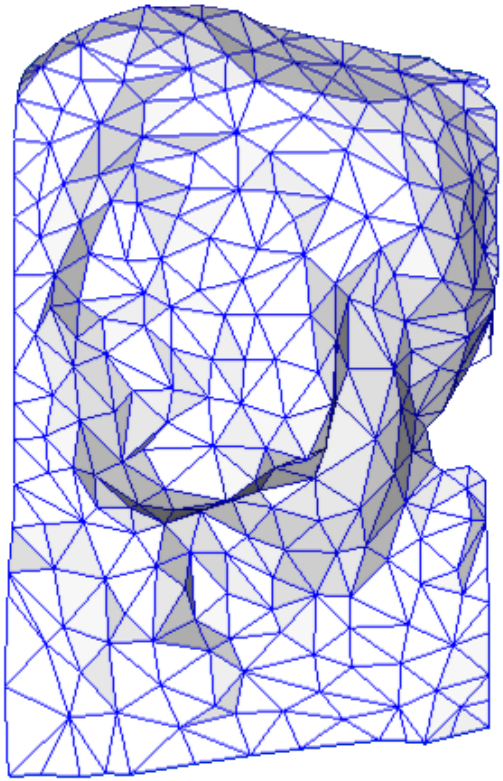
(part of precomputed indirect lighting)

Radiosity Normal Mapping

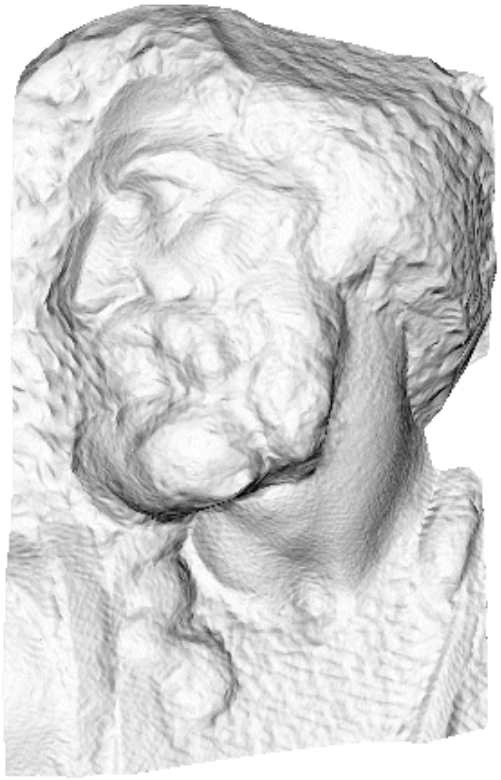
- Combine light mapping and normal maps
- Popularized by **Valve** for **Half-Life 2**
- See full slides by Habel & Wimmer: Efficient Irradiance Normal Mapping
  - https://www.cg.tuwien.ac.at/research/publications/2010/Habel-2010-EIN/

Normal maps – Adding details to surfaces

original mesh
4M triangles

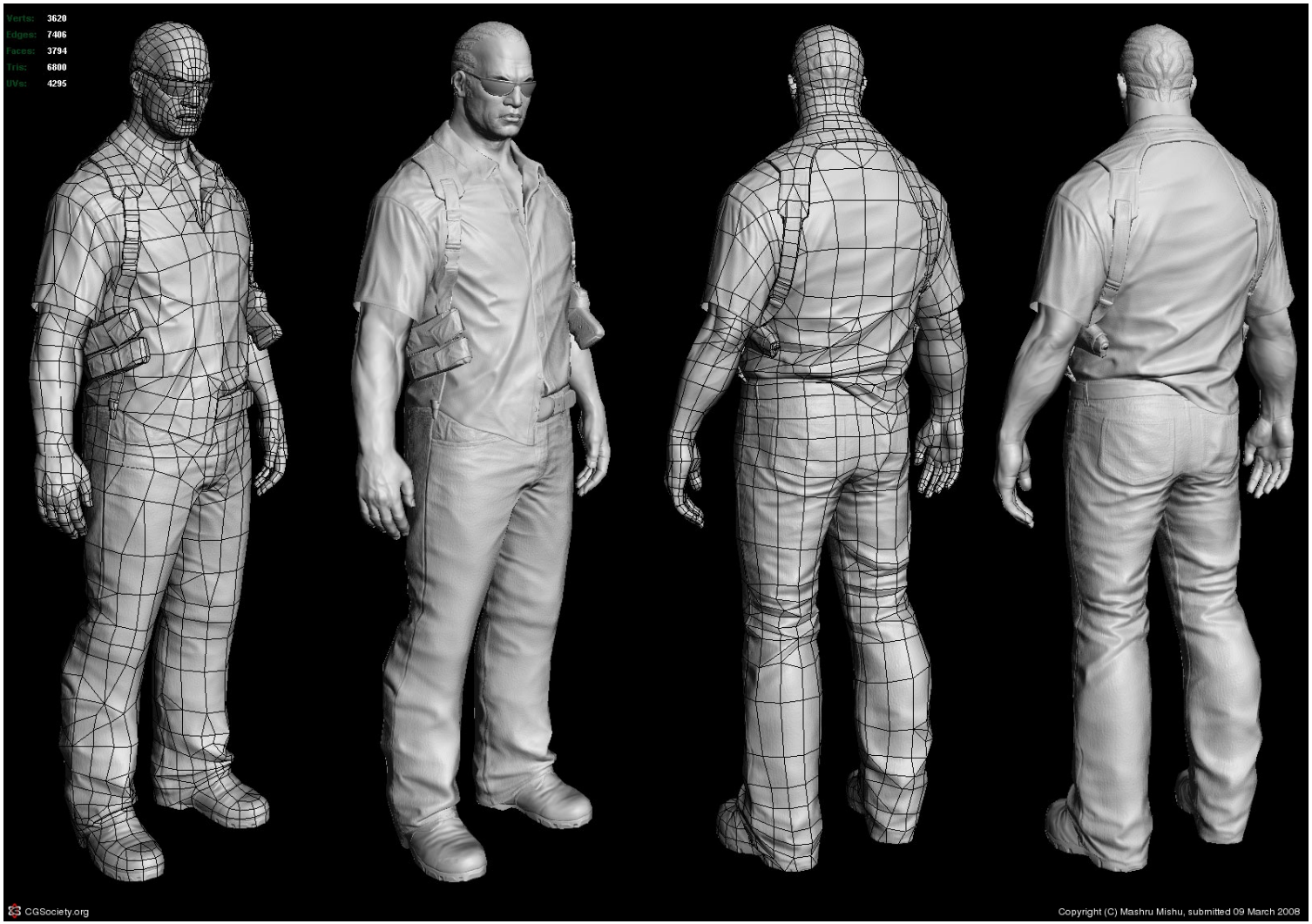


simplified mesh
500 triangles

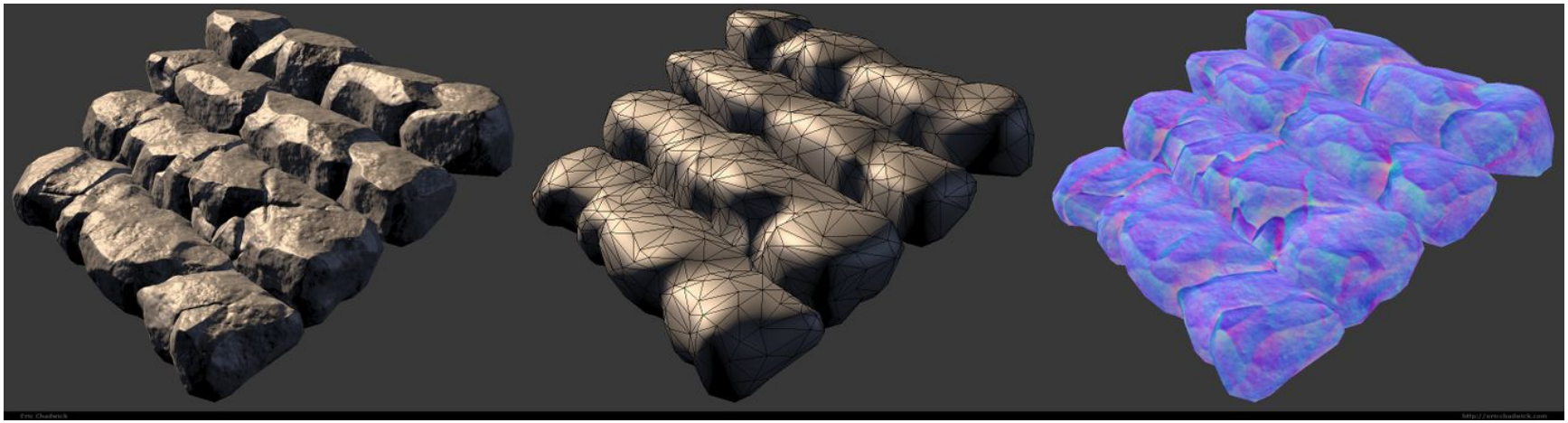


simplified mesh
and normal mapping
500 triangles

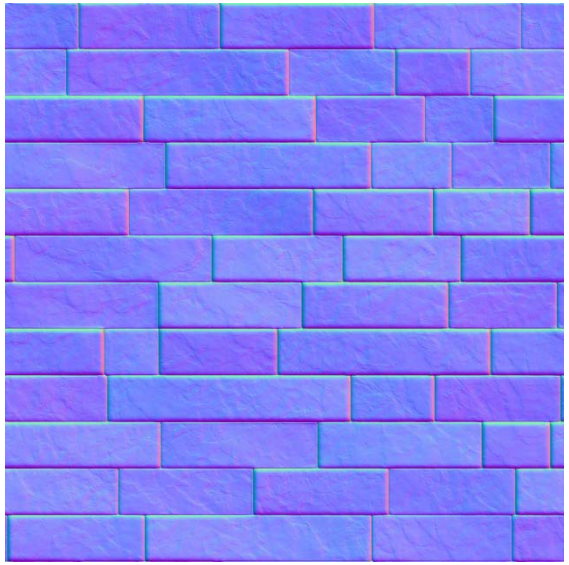
Normal maps – Adding details to surfaces

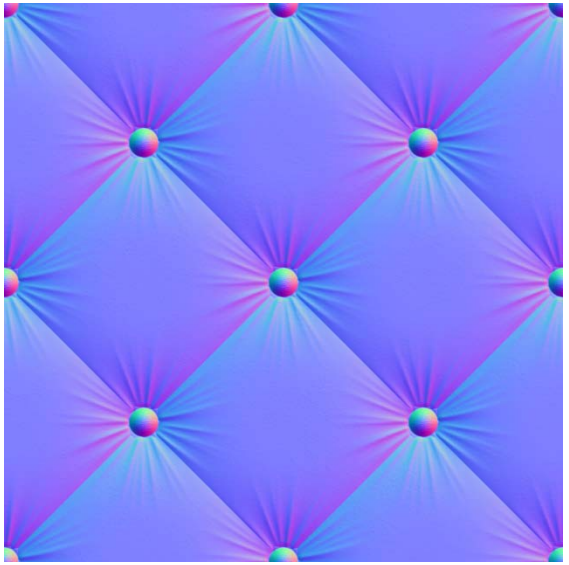


Normal maps – Adding details to surfaces



Normal map examples





Motivation for radiosity normal mapping

Light map only

Motivation for radiosity normal mapping

Irradiance normal mapped

Motivation for radiosity normal mapping

Irradiance normal mapped no texture

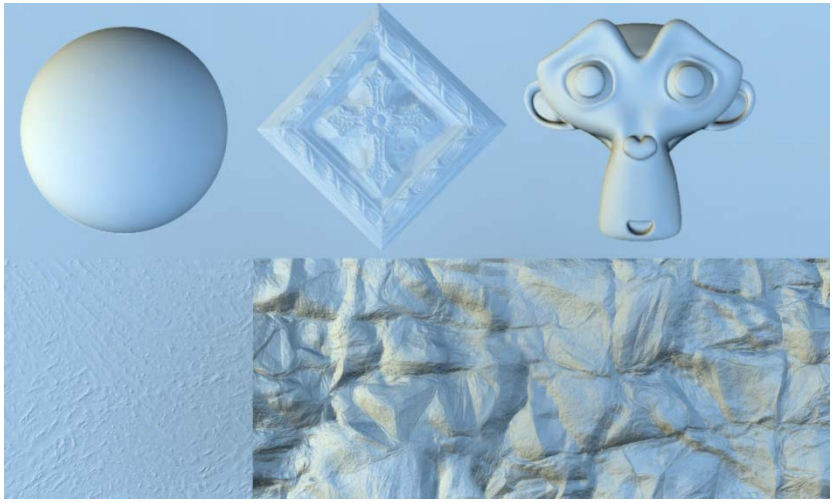
Idea

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

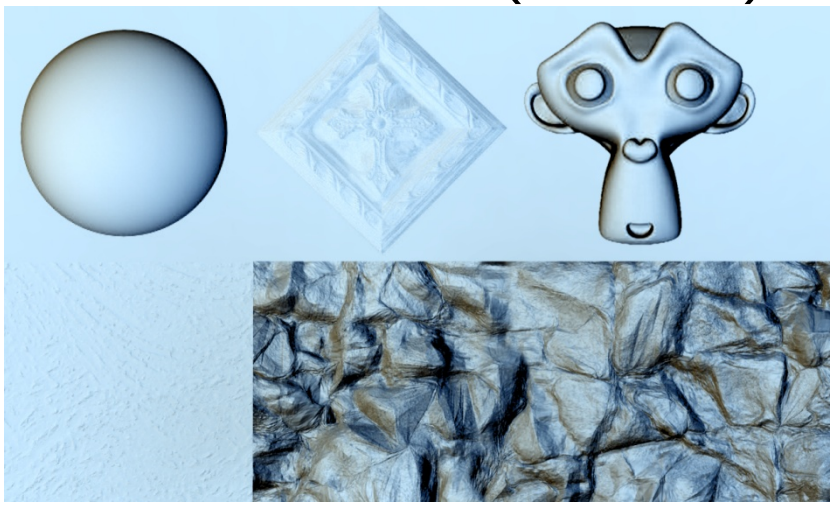
- **Radiosity light map**
  - Directional distribution of incident light for each texel
    - That is, essentially an irradiance EM for each texel
  - Question: how to represent it efficiently
    - Irradiance EM: 9 SH coefficients (i.e. RGB triplets) per texel
    - Half-life 2 basis: 3 coefficients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

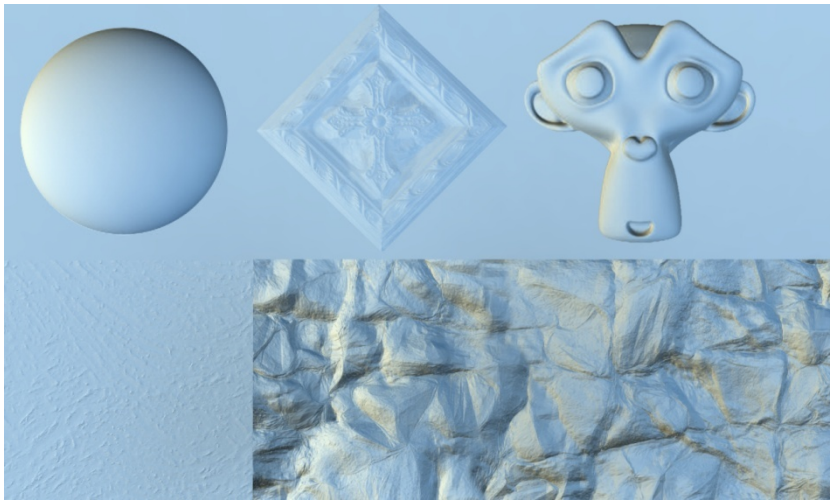
Bases Comparison: 3/6/9 Coefficients

Ground truth

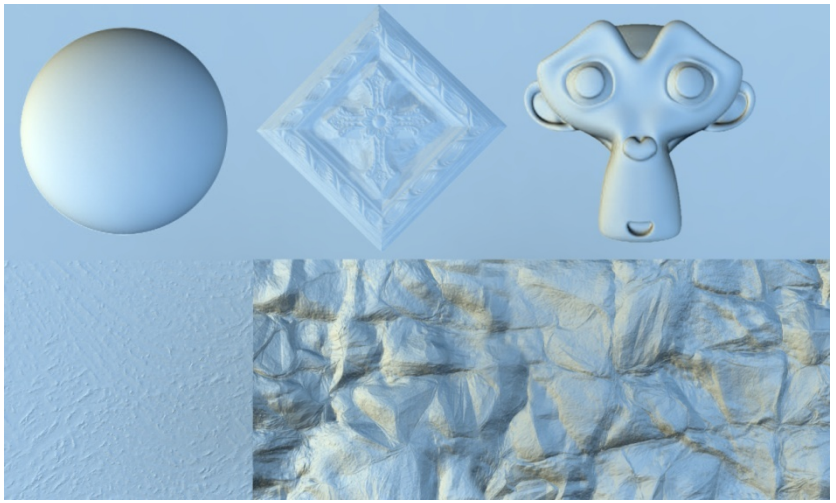


Half-Life 2 basis (3 coeffs)





H_6 (6 coefficients)



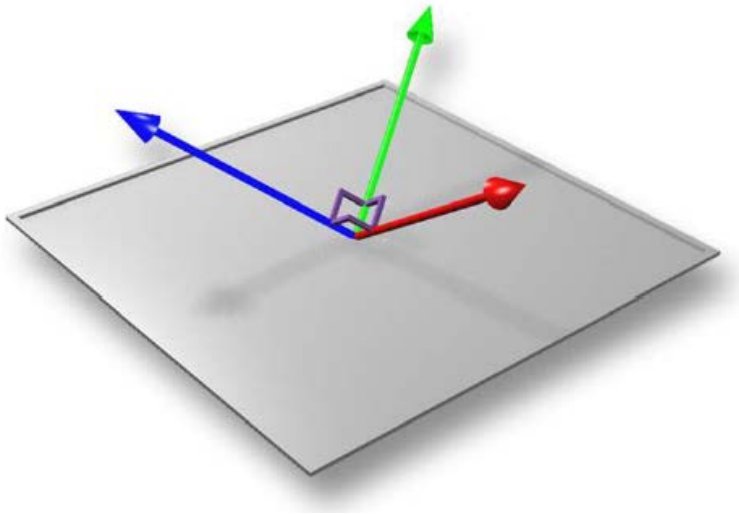
SH 3 bands (9 coefficients)

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

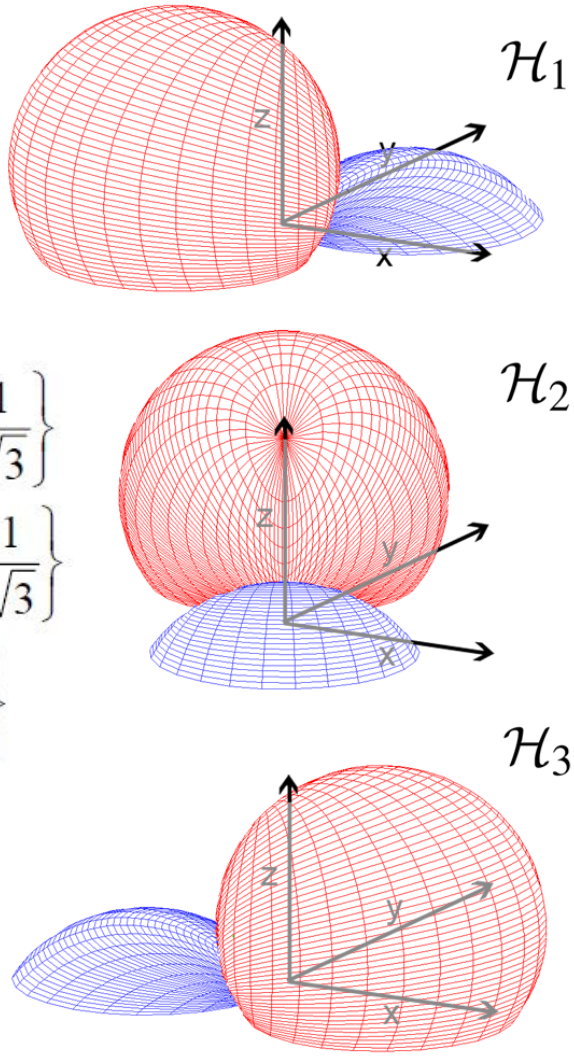
- Cosine lobes around three orthogonal directions



$$\left\{-\frac{1}{\sqrt{6}},\frac{1}{\sqrt{2}},\frac{1}{\sqrt{3}}\right\}$$

$$\left\{-\frac{1}{\sqrt{6}},-\frac{1}{\sqrt{2}},\frac{1}{\sqrt{3}}\right\}$$

$$\left\{\sqrt{\frac{2}{3}},0,\frac{1}{\sqrt{3}}\right\}$$



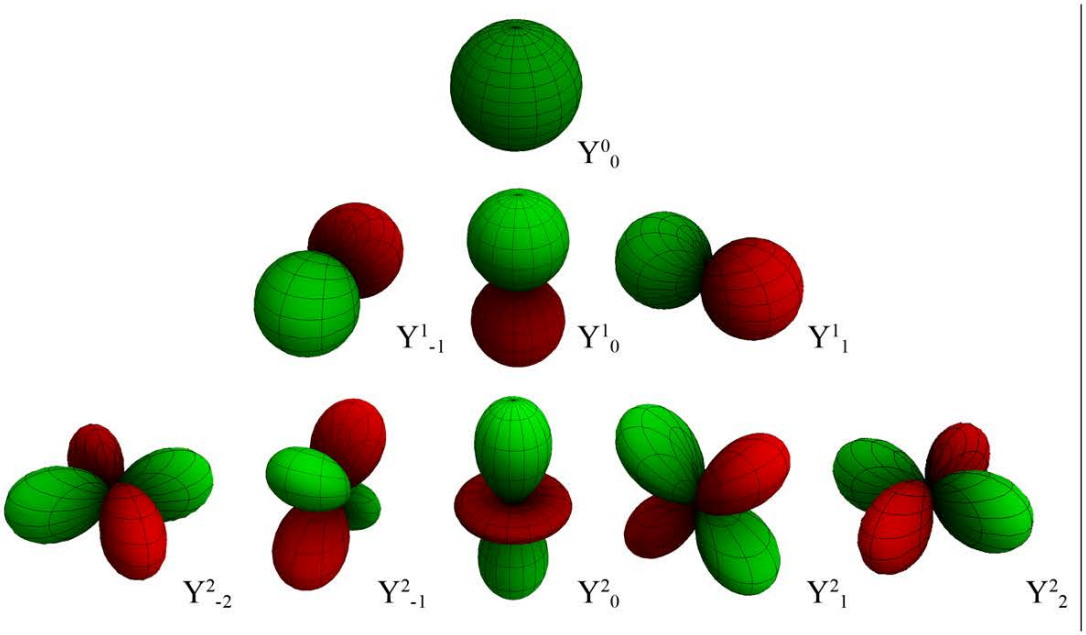
Radiosity Normal Mapping with Half-Life 2 basis

- **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 the transformed vector

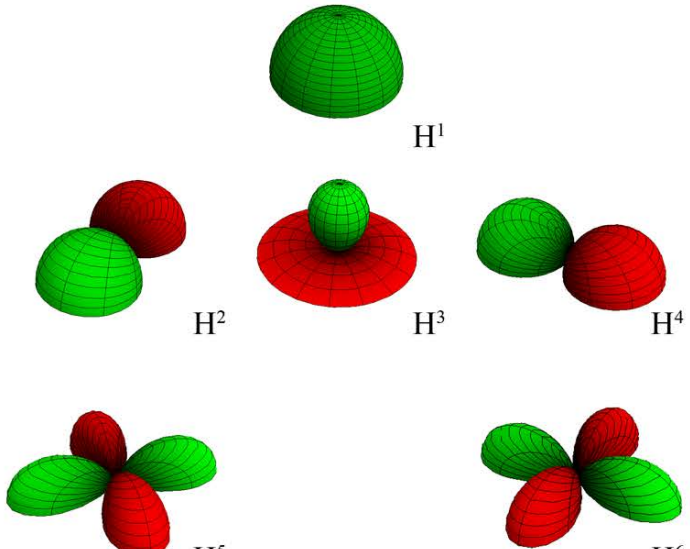
```
lightmapColor[0] * dot( bumpBasis[0], normal )+
lightmapColor[1] * dot( bumpBasis[1], normal )+
lightmapColor[2] * dot( bumpBasis[2], normal )
```

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/



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



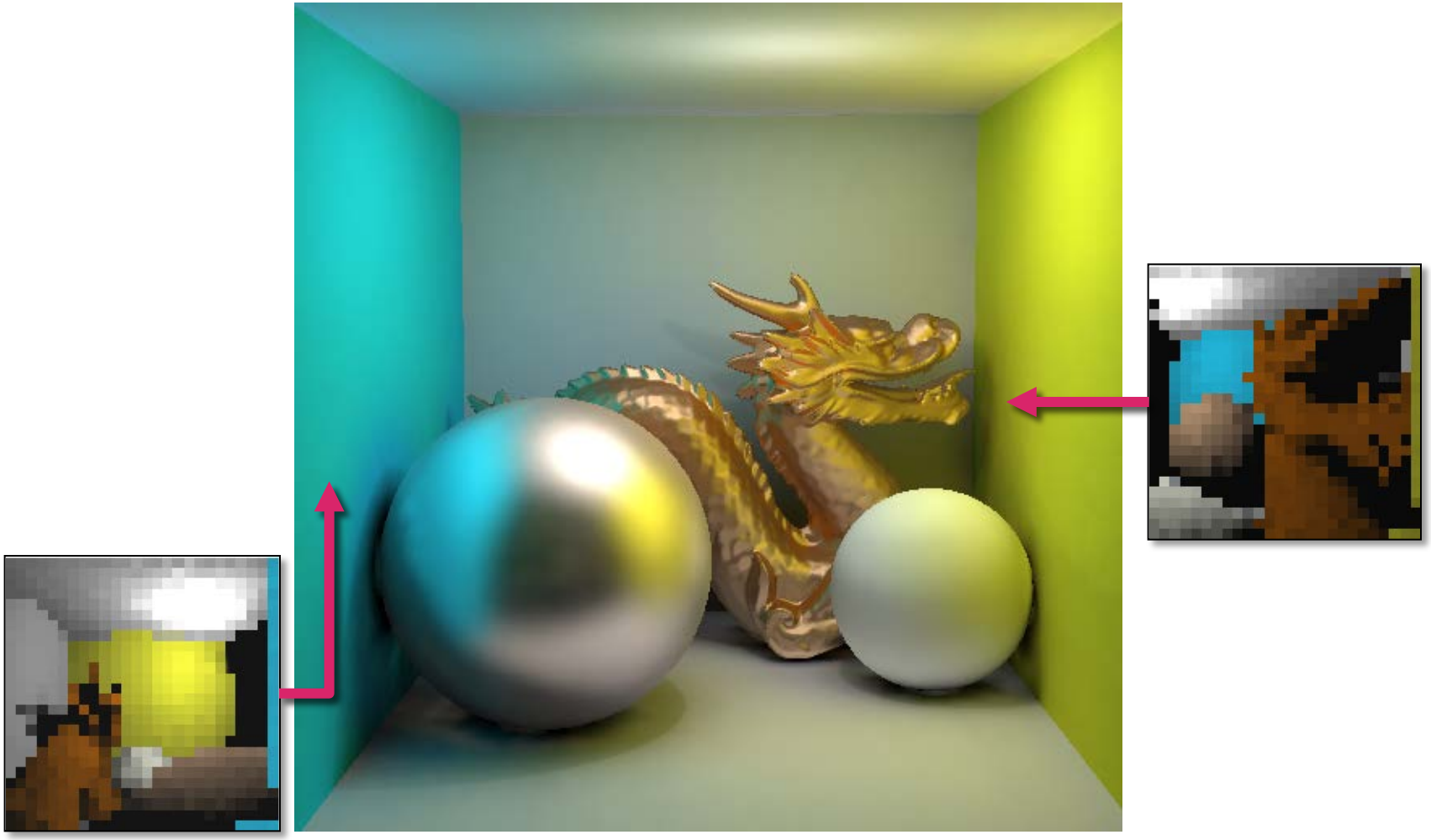
H6-basis
(proposed by Habel)

Real-time dynamic GI: Point-based Global Illumination

Point-based global illumination

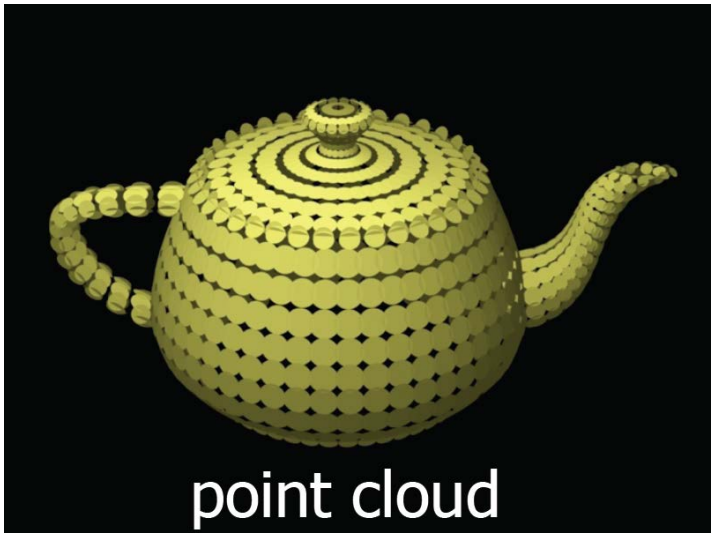
- Slides only
  - http://cgg.mff.cuni.cz/~jaroslav/gicourse2010/giai2010-05-michael_bunnell-slides.pdf
- Annotated slides
  - http://cgg.mff.cuni.cz/~jaroslav/gicourse2010/giai2010-05-michael_bunnell-notes.pdf

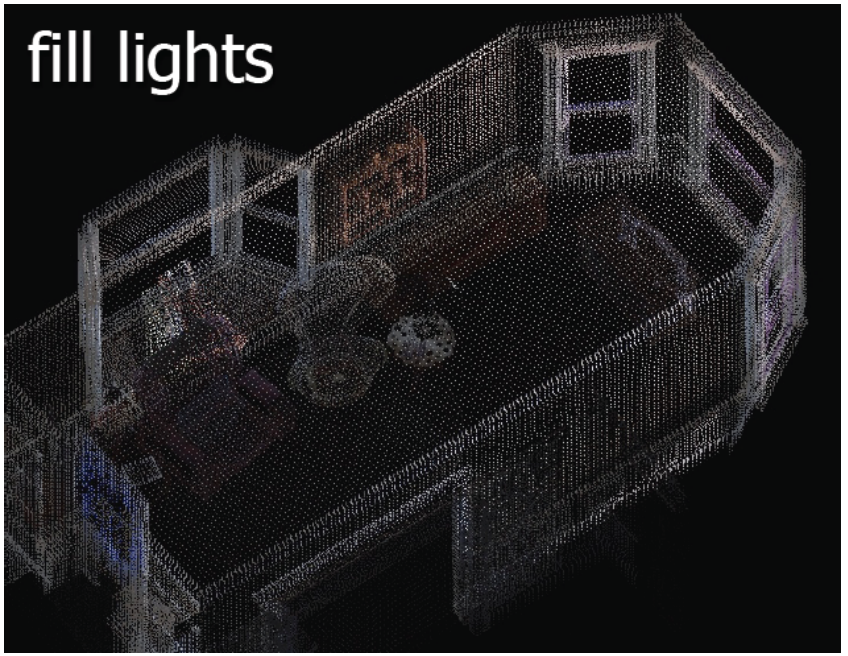
Point-based global illumination



Slide credit: Tobias Ritschel

Point-based global illumination

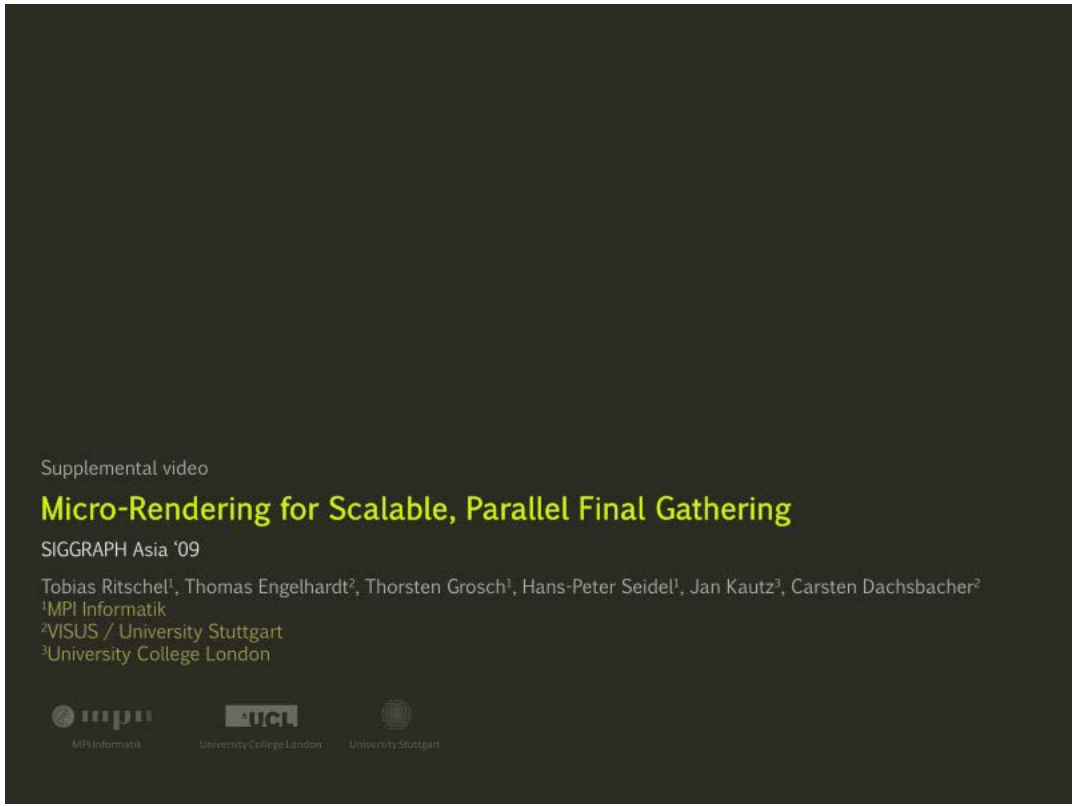




Slide credit: Per Christensen

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
  - See also: http://cgg.mff.cuni.cz/~jaroslav/gicourse2010/giai2010-05-michael_bunnell-notes.pdf

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

- **Real-time implementation** (CUDA)
  - T. Ritschel et al, “Micro-rendering for scalable, parallel final gathering”, SIGGRAPH Asia 2009

Real-time dynamic GI: Light-propagation volumes

Light Propagation Volumes

Advanced Unreal Engine 4.9

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

On this page:

Light propagation volumes

- Anton Kaplanyan's slides form the 2010 course "Global illumination across industries"
  - http://cgg.mff.cuni.cz/~jaroslav/gicourse2010/giai2010-07-anton_kaplanyan.pptx

THANK YOU!

Questions?

Computer
Graphics
Charles
University

[cgg.mff.cuni.cz/~jaroslav]