Precomputed Light Transport

Indirect Lighting

- Many indirect lighting effects are subtle, yet crucial for visual realism. Examples are:
  - Soft shadow
  - Ambient occlusion

Ambient Occlusion

- Ambient light is a very crude approximation to indirect reflections of surrounding objects.
- What if a point can't see much of its surrounding?

From: Janne Kontkanen & Samuli Laine
ACM I3D 2005

Soft Shadow from Environment Lighting

Sen, Cammarano, Hanrahan, 2003

Shadows from point-lights (shadow maps, volumes)

Sloan, Kautz, Snyder 2002

Shadows from smooth lighting (precomputed radiance transfer)

Beyond Monte Carlo Path Tracing?

- Are global illumination solvers always time consuming?
- What if the scene and the lights are static ? ➔ Radiosity (view can changes!)
- What if only the scene is static?

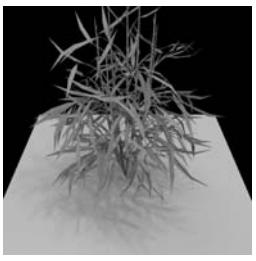
Precomputed Light Transport

- Three important papers to start with:
  - "Precomputed Radiance Transfer for Real-Time Rendering in Dynamic, Low-Frequency Lighting Environments" Sloan et al., SIGGRAPH 2002
  - "All-Frequency Shadows Using Non-linear Wavelet Lighting Approximation" Ng et al., SIGGRAPH 2003.
  - "Triple Product Wavelet Integrals for All-Frequency Relighting" Ng et al. SIGGRAPH 2004

The following 8 slides are from Ren Ng's SIGGRAPH 2003 presentation

Relighting as Matrix-Vector Multiply

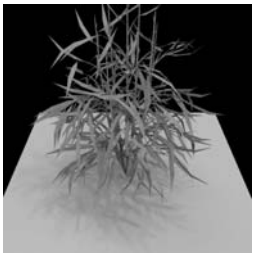
$$\begin{bmatrix} P_1 \\ P_2 \\ P_3 \\ \vdots \\ P_N \end{bmatrix}$$



$$= \begin{bmatrix} T_{11} & T_{12} & \cdots & T_{1M} \\ T_{21} & T_{22} & \cdots & T_{2M} \\ T_{31} & T_{32} & \cdots & T_{3M} \\ \vdots & \vdots & \ddots & \vdots \\ T_{N1} & T_{N2} & \cdots & T_{NM} \end{bmatrix} \begin{bmatrix} L_1 \\ L_2 \\ \vdots \\ L_N \end{bmatrix}$$

Relighting as Matrix-Vector Multiply

$$\begin{bmatrix} P_1 \\ P_2 \\ P_3 \\ \vdots \\ P_N \end{bmatrix}$$



- Output Image (Pixel Vector)

- Input Lighting (Cubemap Vector)

- Transport Matrix

Ray-Tracing Matrix Columns

$$\begin{bmatrix} T_{11} & T_{12} & \cdots & T_{1M} \\ T_{21} & T_{22} & \cdots & T_{2M} \\ T_{31} & T_{32} & \cdots & T_{3M} \\ \vdots & \vdots & \ddots & \vdots \\ T_{N1} & T_{N2} & \cdots & T_{NM} \end{bmatrix}$$

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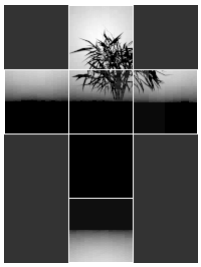
Light-Transport Matrix Rows

$$\begin{bmatrix} T_{11} & T_{12} & \cdots & T_{1M} \\ T_{21} & T_{22} & \cdots & T_{2M} \\ T_{31} & T_{32} & \cdots & T_{3M} \\ \vdots & \vdots & \ddots & \vdots \\ T_{N1} & T_{N2} & \cdots & T_{NM} \end{bmatrix}$$



Light-Transport Matrix Rows

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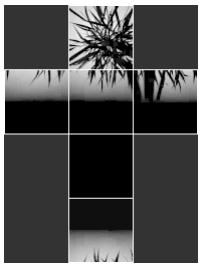


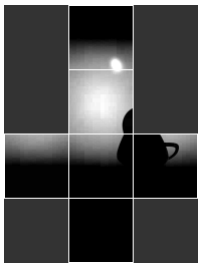
Light-Transport Matrix Rows

$$\begin{bmatrix} T_{11} & T_{12} & \cdots & T_{1M} \\ T_{21} & T_{22} & \cdots & T_{2M} \\ T_{31} & T_{32} & \cdots & T_{3M} \\ \vdots & \vdots & \ddots & \vdots \\ T_{N1} & T_{N2} & \cdots & T_{NM} \end{bmatrix}$$

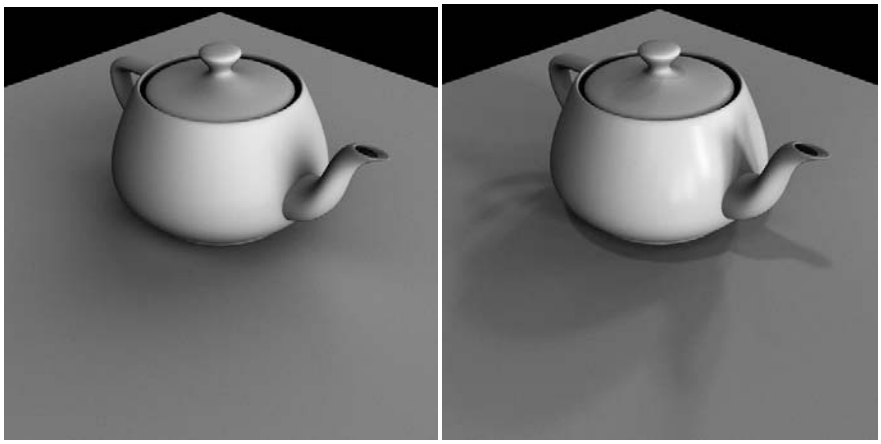
Rasterizing Matrix Rows

Pre-computing rows

- Rasterize visibility hemicubes with graphics hardware
- Read back pixels and weight by reflection function



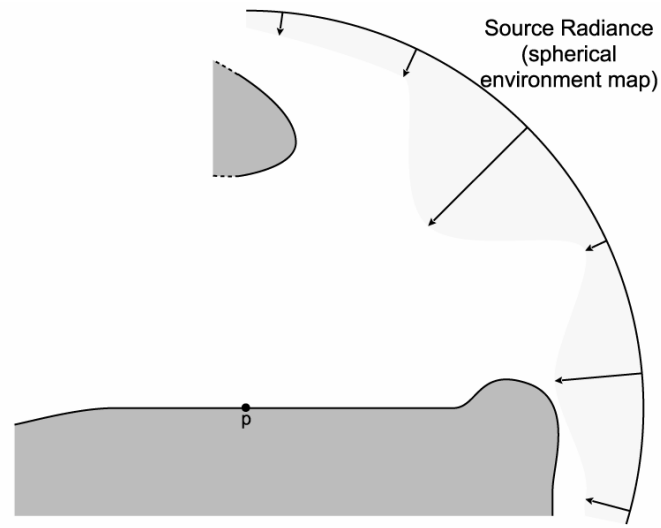
Low-Frequency vs. All-Frequency



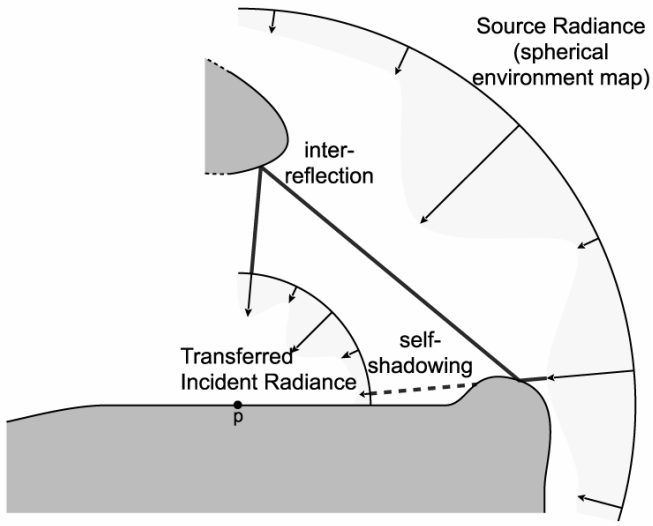
Teapot in Grace Cathedral

The following slides are from Peter-Pike Sloan's presentation at MSRA

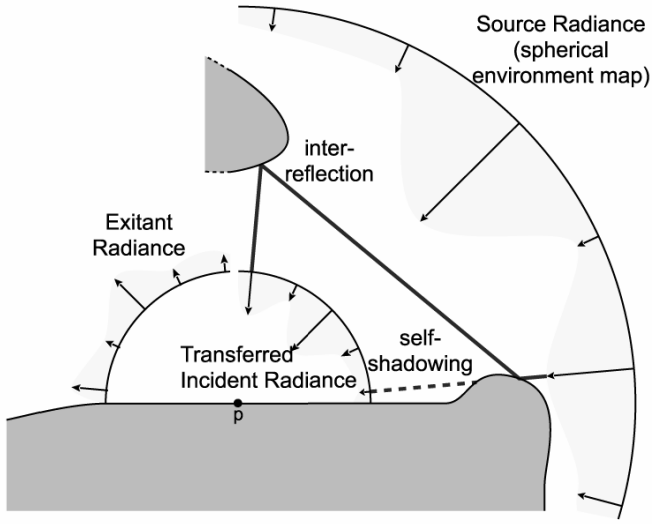
Terminology



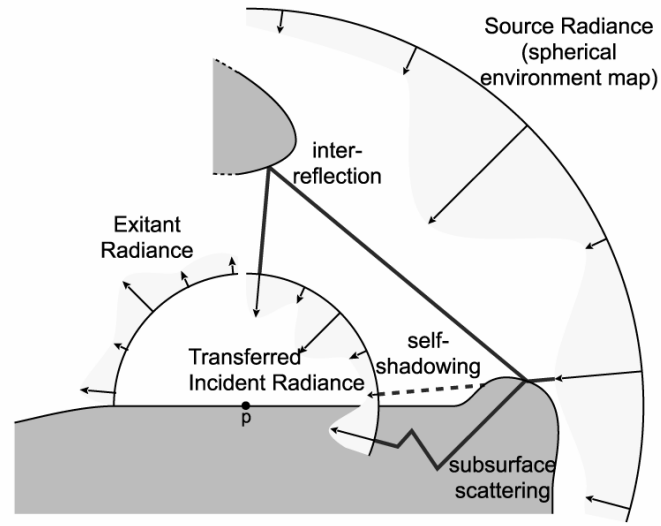
Terminology



Terminology



Terminology



Related Work

Sloan et al. 2002

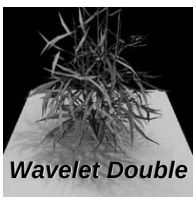
Kautz et al. 2002

Sloan et al. 2003

Sloan et al. 2005

Sloan et al. 2005

Green et al. 2006



Ng et al. 2003

Ng et al. 2004

Wang et al. 2006

Wang et al. 2005