Precomputed Radiance Transfer
for Real-Time Rendering in Dynamic, Low-Frequency Lighting Environments

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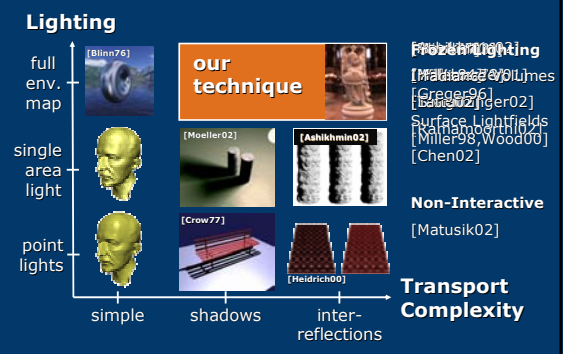
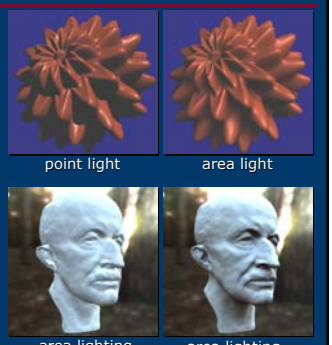
Previous Work – Where We Fit

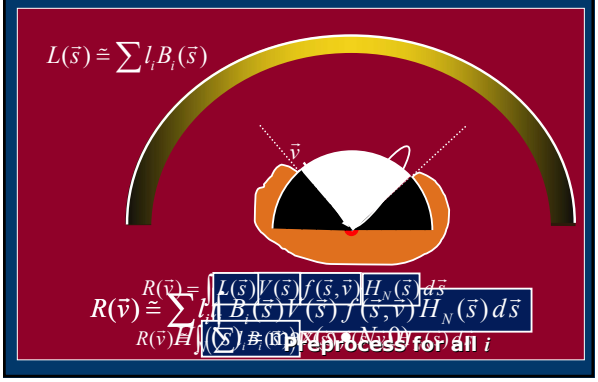


Motivation

- Better light integration and transport
  - dynamic, area lights
  - self-shadowing
  - interreflections
- For diffuse and glossy surfaces
- At real-time rates

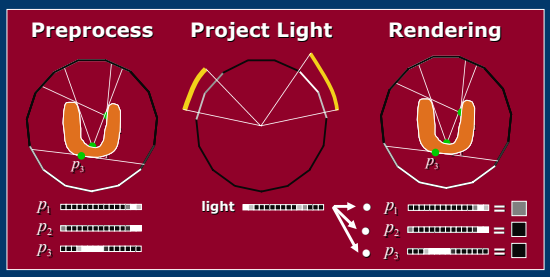


Basic Idea

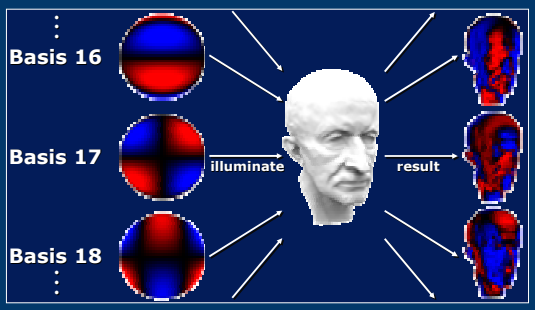


Diffuse Self-Transfer

2D example, piecewise constant basis, shadows only



Precomputation

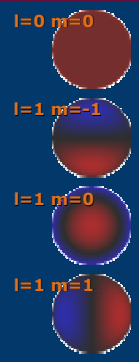


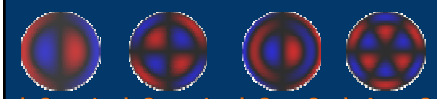
Previous Work – Scene Relighting

- [Dorsey91] opera lighting design
  adjusts intensity of fixed light sources
- [Nimeroff94] natural environments
  uses steerable functions for general skylight illumination
- [Teo97] efficient linear re-rendering
  generalizes to non-infinite sources, PCA to reduce basis
- [Debevec00] reflectance field of a face
  uses directional light basis for relighting faces
- [Dobashi95] lighting design
  uses SH basis for point light intensity distribution

Basis Functions

- We use ***Spherical Harmonics***
- SH have nice properties:
  - simple projection/reconstruction
  - rotationally invariant (no aliasing)
  - simple rotation
  - simple convolution
  - few basis functions ⇒ low freqs



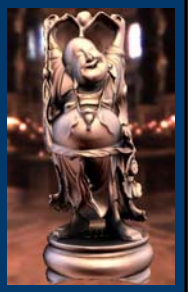


Diffuse Transfer Results

No Shadows/Inter | Shadows | Shadows+Inter

Glossy Self-Transfer

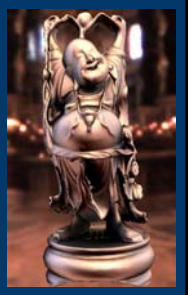
- exiting radiance is view-dependent
  depends on BRDF (we use Phong)



$$R(\vec{v}) = \int L(\vec{s})\, V(\vec{s})\, f(\vec{s},\vec{v})\, H_N(\vec{s})\, d\vec{s}$$

Glossy Self-Transfer

- exiting radiance is view-dependent
  depends on BRDF (we use Phong)
- represent ***transferred incident*** radiance, not exiting
  accounts for shadows, interreflections
- allows run-time BRDF changes



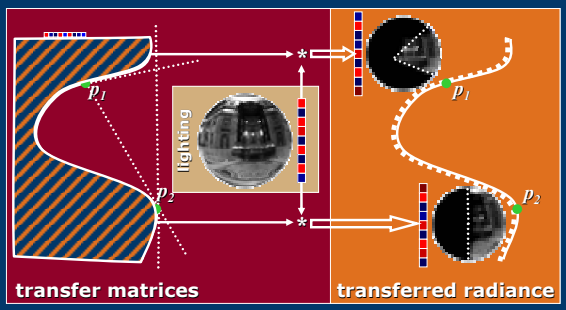
$$R(\vec{v}) = \int L(\vec{s})\, V(\vec{s})\, f(\vec{s},\vec{v})\, H_N(\vec{s})\, d\vec{s}$$

$$L^{tran}(\vec{s}) = M\ L(\vec{s})$$

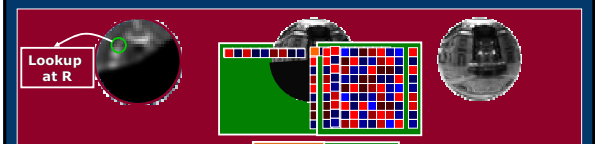
$$R(\vec{v}) = \int L^{tran}(\vec{s})\, f(\vec{s},\vec{v})\, H_N(\vec{s})\, d\vec{s}$$

Transfer Matrix

Precompute how global lighting ⇒ transferred lighting



Glossy Rendering



$$r_{pv} = b_{pv}^{T} M_{p} l$$

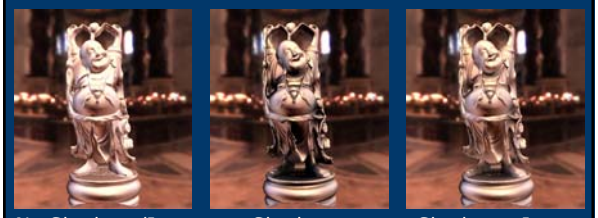
Integrates incident radiance against BRDF in direction v (lighting Env in SH transformed into radiance)

Transfer matrix (maps radiance to transferred radiance)

Freeze the light (vector)

Phong: Convolve light and evaluate in reflection direction, R

Glossy Transfer Results



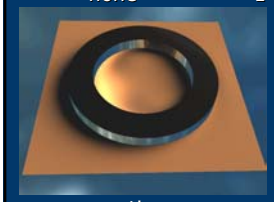
No Shadows/Inter | Shadows | Shadows+Inter

- Glossy object, 50K mesh
- Runs at 3.6/16/125fps on 2.2Ghz P4, ATI Radeon 8500

Interreflections and Caustics

interreflections

none | 1 bounce | 2 bounces



caustics

Transport Paths

LP

LGP

$L(D|G)^{*}P$

$LS^{*}(S^{*}(D|G))^{*}P$

Runtime is independent of transport complexity