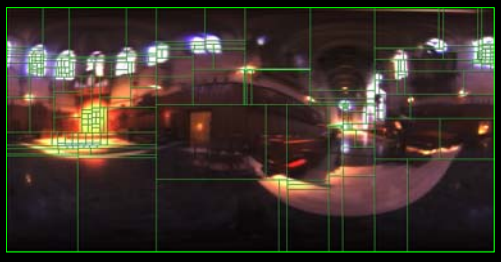
Bidirectional Importance Sampling



C0417 – Advanced Computer Graphics: Photographic Image Synthesis

Abhijeet Ghosh

Lecture 13, Feb.11th 2013

Bidirectional Importance

- $L_r(\omega_r) = \int_\Omega f_r(\omega_i \rightarrow \omega_r) \cos\theta_i L_i(\omega_i) V(\omega_i) d\omega_i$, (1)
- Target distribution *p* for direct illumination:

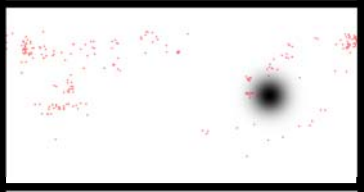
$$p(\omega_i) := \frac{f_r(\omega_i \rightarrow \omega_r) \cos\theta_i L_i(\omega_i)}{\int_\Omega f_r(\omega_i \rightarrow \omega_r) \cos\theta_i L_i(\omega_i)\, d\omega_i} \quad , \quad (2)$$

Bidirectional Importance Sampling

Importance function of Grace Cathedral EM

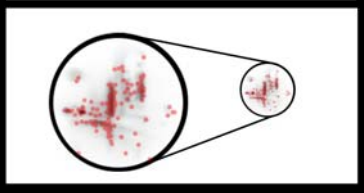
Samples according to BRDF

Samples according to EM



Importance function of Phong BRDF (s = 50)

Burke, Ghosh, and Heidrich EGSR 2005



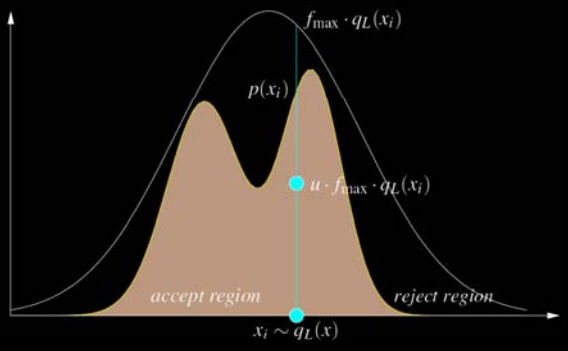
Samples according to bidirectional importance

Realizing Bidirectional Sampling

- 2 step approach
  - generate samples from one distribution
  - adjust samples to be proportional to the product p
- 2 Monte Carlo techniques for redistribution
  - rejection sampling
  - sampling importance re-sampling (SIR)
    - also Talbot et al. 2005

Rejection Sampling

we want to sample the product of



- Accept $\omega_{i,j}$ with probability:

$$\frac{p(\omega_{i,j})}{f_{max} \cdot q_L(\omega_{i,j})} = \frac{f_r(\omega_{i,j} \rightarrow \omega_r) cos\theta_{i,j} \int_\Omega L_i(\omega_i) d\omega_i}{f_{max} \cdot L_{ns}}$$

Sampling Importance Resampling

Stage 1

$\omega_{i,j} \sim f(\omega_{i,j})$	$L(\omega_{i,j})$
$\omega_{i,1}$	$L(\omega_{i,1})$
$\omega_{i,2}$	$L(\omega_{i,2})$
.	.
.	.
.	.
$\omega_{i,M}$	$L(\omega_{i,M})$

Stage 2

$\omega_{i,j} \sim L_M(\omega_{i,j})$
$\omega_{i,1}$
$\omega_{i,2}$
.
.
.
$\omega_{i,N}$

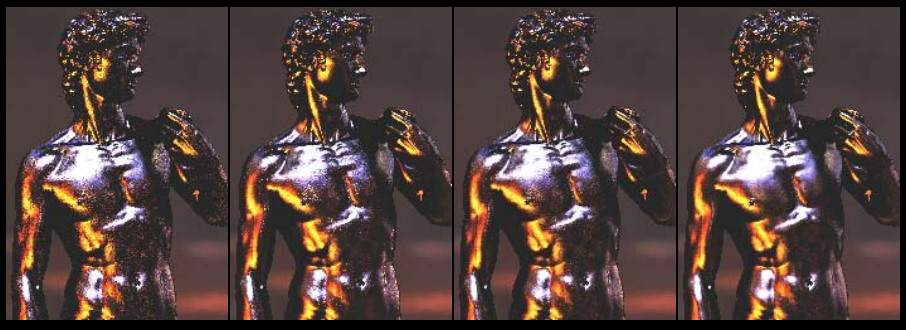
M ≈ 100 · N

generate a lot of samples according to one of your proposed functions e.g. in this case BRDF

we query the intensity of these lights in these directions L()

These

Phong BRDF ($s = 50$, $k_s = 1.0$)



EM
100 samples

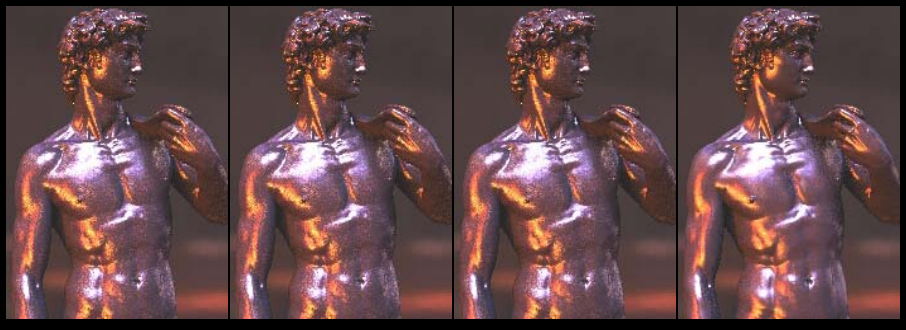
BRDF
75 samples

MIS

SIR
15/800 samples

- Render time 13 seconds for 176 × 248 image
- Visibility traced only for N=15 samples with SIR!

Phong BRDF ($s = 50$, $k_s = 1.0$, $k_d = 0.5$)



EM
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15/800 samples

- Render time 13 seconds for 176 × 248 image

Wavelet Importance Sampling

BRDF Sampling Lighting Sampling Product Sampling

Clarberg, Jarosz, Akenine-Möller, and Jensen. Wavelet Importance Sampling: Efficiently Evaluating Products of Complex Functions. SIGGRAPH 2005.

Wavelet Importance Sampling

BRDF Sampling Lighting Sampling Product Sampling

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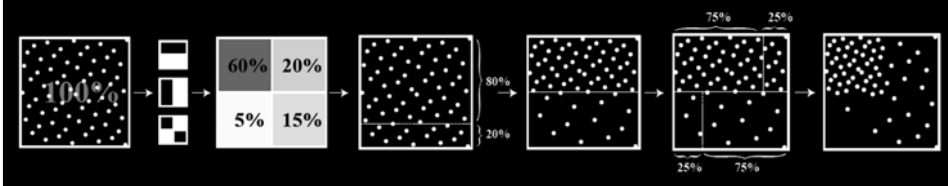
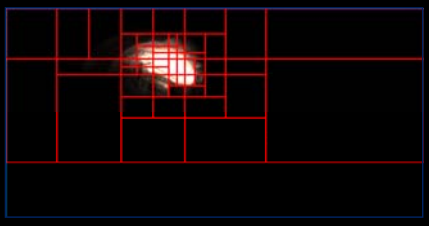


Hierarchical sample warping

Two-Stage Importance Sampling
[Cline et al., EGSR 2006]

Eucalyptus Grove, Diffuse Lobe

Galileo's Tomb, Specular Lobe



"split potential"

$$p_{split}(R) = \sigma_f(R)\, sum(R)\, area(R)$$