

Irradiance Caching & Photon Mapping

Last Time?

- What is a Pixel?
- Aliasing
- Fourier Analysis
- Sampling & Reconstruction
- Mip maps

- ## Today
- Ray Tracing Review
 - Irradiance Caching
 - Photon Mapping
 - Ray Grammar

Ray Casting

- Cast a ray from the eye through each pixel

Ray Tracing

- Cast a ray from the eye through each pixel
- Trace secondary rays (light, reflection, refraction)

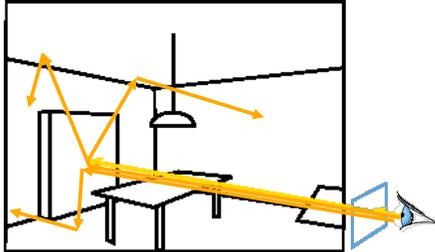
Monte-Carlo Ray Tracing

- Cast a ray from the eye through each pixel
- Cast random rays to accumulate radiance contribution
 - Recurse to solve the Rendering Equation

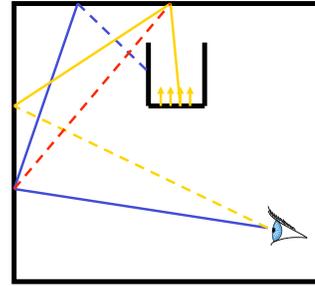
Should also systematically sample the primary light

Monte Carlo Path Tracing

- Trace only one secondary ray per recursion
- But send many primary rays per pixel (performs antialiasing as well)



Challenging Indirect Lighting Scene



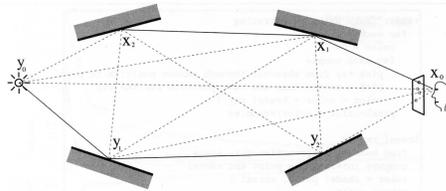
Backward path tracing

Forward path tracing

Bi-directional path tracing

Bi-directional Path Tracing

- Start from both eye and lights [Veach & Guibas 94, Lafortune & Willems 93]
- Create all compound paths
 - Evaluate geometric/visibility term at connecting vertices: $\cos \theta \cos \theta' / r^2$



Bi-directional Path Pyramid



Questions?

- Why do we need "good" random numbers?
 - With a fixed random sequence, we see the structure in the error

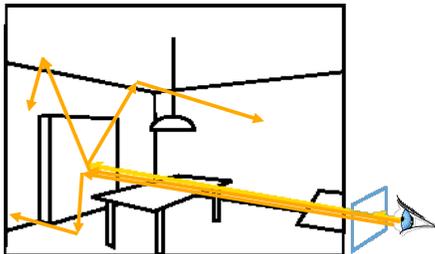


Today

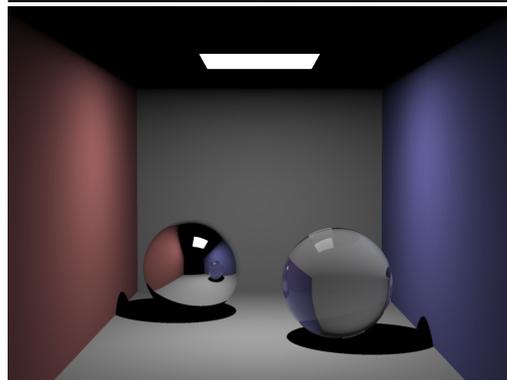
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Path Tracing is costly

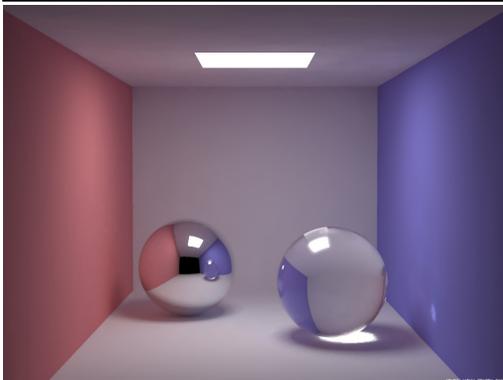
- Needs tons of rays per pixel



Direct Illumination



Global Illumination

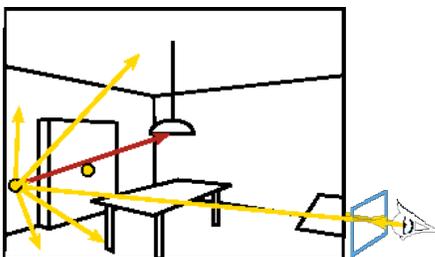


Indirect Illumination: smooth



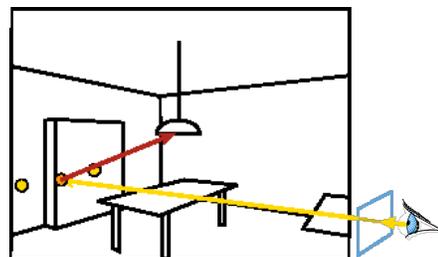
Irradiance Cache

- The indirect illumination is smooth
- Store the indirect illumination

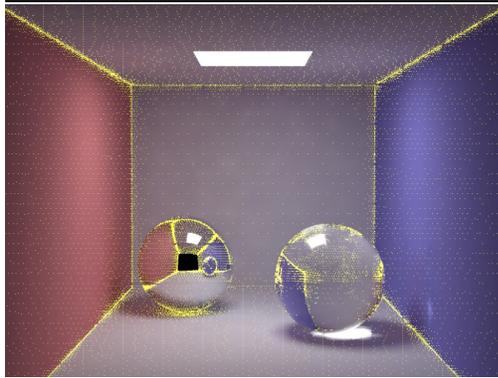


Irradiance Cache

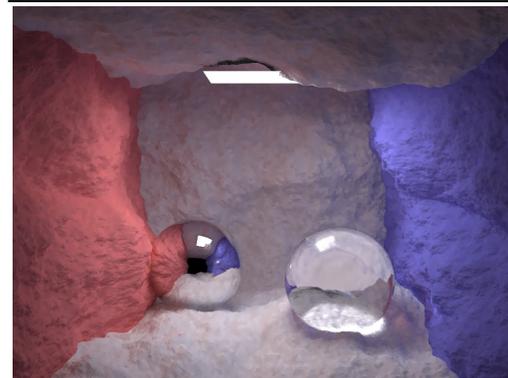
- Interpolate nearby cached values
- But do full calculation for direct lighting



Irradiance Cache



Questions?



Today

- Ray Tracing Review
- Irradiance Caching
- **Photon Mapping**
- Ray Grammar

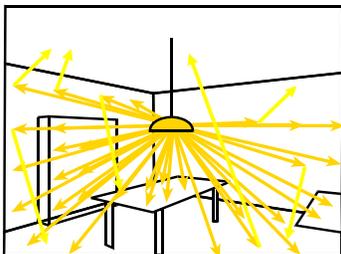
Reading for Today:

- *Global Illumination using Photon Maps*,
Henrik Wann Jensen, *Rendering Techniques 1996*



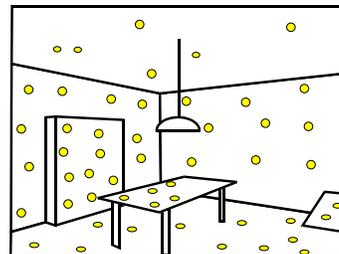
Photon Mapping

- Preprocess: cast rays from light sources
 - independent of viewpoint



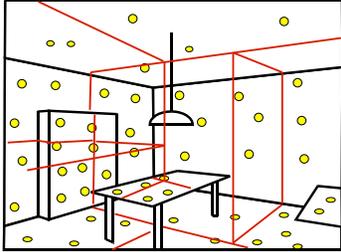
Photon Mapping

- Store photons
 - position + light power + incoming direction



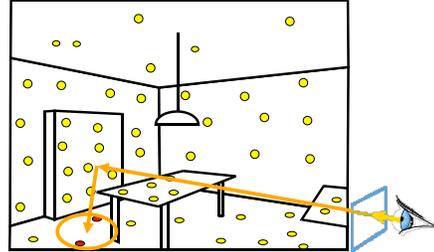
Photon Map

- Efficiently store photons for fast access
- Use hierarchical spatial structure (kd-tree)

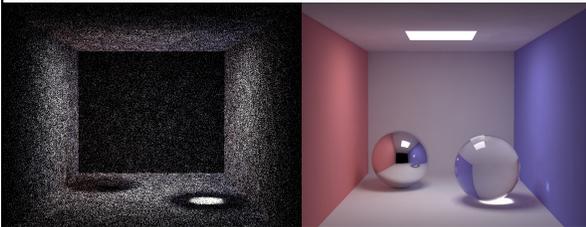


Rendering with Photon Map

- Cast primary rays
- For secondary rays
 - reconstruct irradiance using k closest photons
- Combine with irradiance caching and other techniques

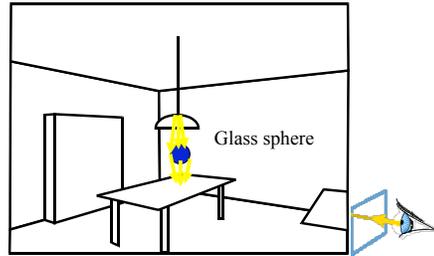


Photon Map Results



Photon Mapping - Caustics

- Special photon map for specular reflection and refraction



Comparison

Path Tracing
1000 paths/pixel

Photon mapping



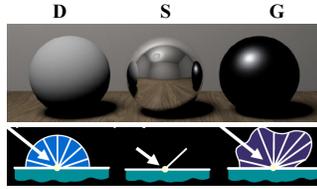
Today

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Ray Grammar

- Classify local interaction:

E = eye
 L = light
 S = perfect specular reflection or refraction
 G = glossy scattering
 D = diffuse scattering

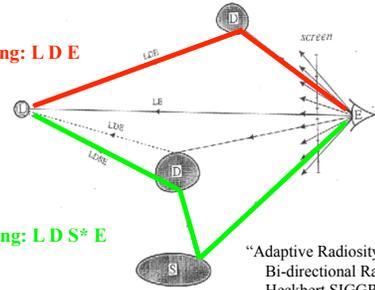


From Dutre et al.'s slides

Classic Ray Casting/Tracing

Ray casting: **L D E**

Ray tracing: **L D S* E**

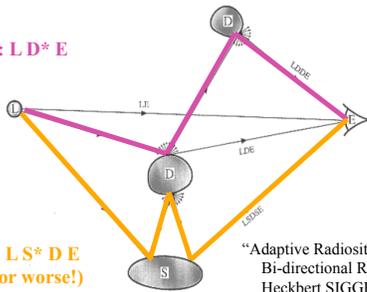


"Adaptive Radiosity Textures for Bi-directional Ray Tracing" Heckbert SIGGRAPH 1990

Photon Tracing

Radiosity: **L D* E**

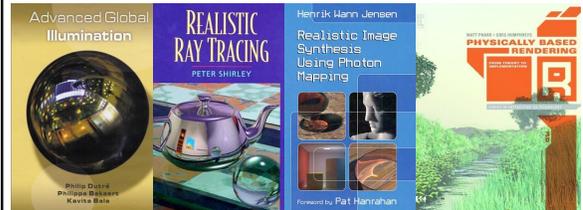
Caustics: **L S* D E**
 (or worse!)



"Adaptive Radiosity Textures for Bi-directional Ray Tracing" Heckbert SIGGRAPH 1990

Advanced Rendering References

- Eric Veach's PhD dissertation http://graphics.stanford.edu/papers/veach_thesis/



Reading for Friday 4/4:

- "A Practical Model for Subsurface Light Transport", Jensen, Marschner, Levoy, & Hanrahan, SIGGRAPH 2001



- Post a comment or question on the LMS discussion by 10am on Tuesday 1/29