

Irradiance Caching & Photon Mapping

Last Time?

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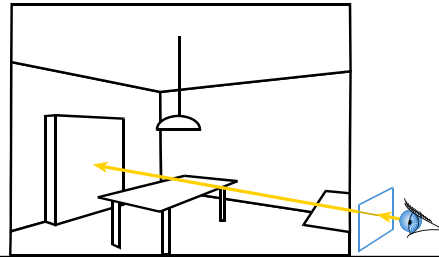
Today

- Monte-Carlo Rendering
- Path Tracing
- Irradiance Caching
- Photon Mapping
- Ray Grammar
- Subsurface Scattering

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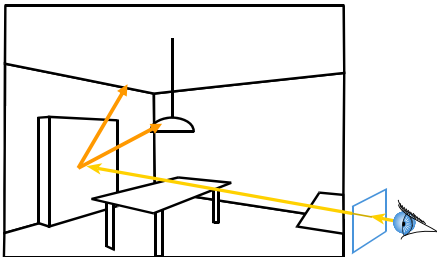
Ray Casting

- Cast a ray from the eye through each pixel



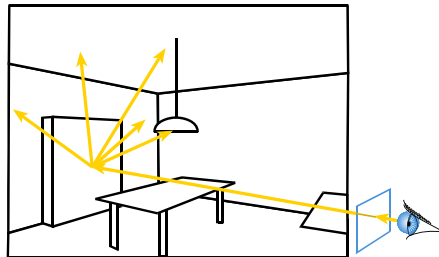
Ray Tracing

- 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 from the visible point
 - Accumulate radiance contribution



Monte-Carlo Ray Tracing

- Cast a ray from the eye through each pixel
- Cast random rays from the visible point
 - Accumulate radiance contribution
- Recurse

Monte-Carlo

- Systematically sample primary light

Importance of sampling the light

	Without explicit light sampling	With explicit light sampling
1 path per pixel		
4 path per pixel		

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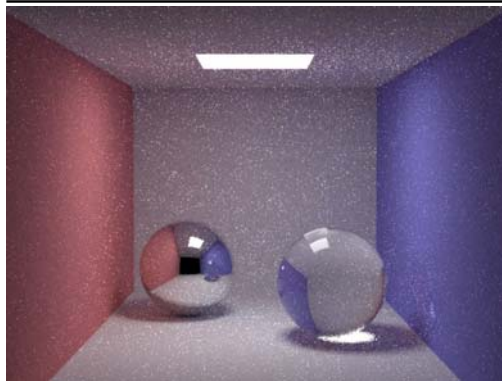
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Monte Carlo Path Tracing

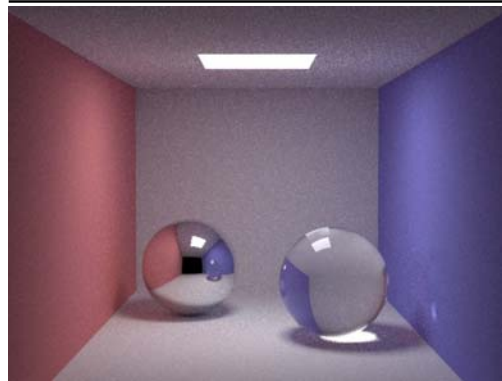
- Trace only one secondary ray per recursion
- But send many primary rays per pixel
 - (performs antialiasing as well)

Results: 10 paths/pixel

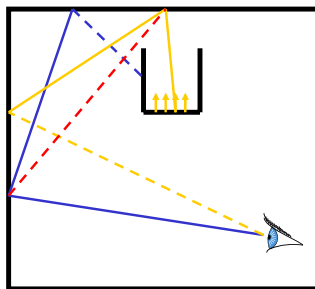
Results: 10 paths/pixel, glossy



Results: 100 paths/pixel, glossy



Challenging Indirect Lighting Scene



Backward path tracing

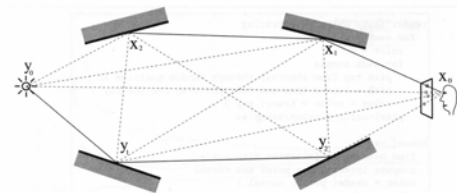
Forward path tracing

Bi-directional path tracing

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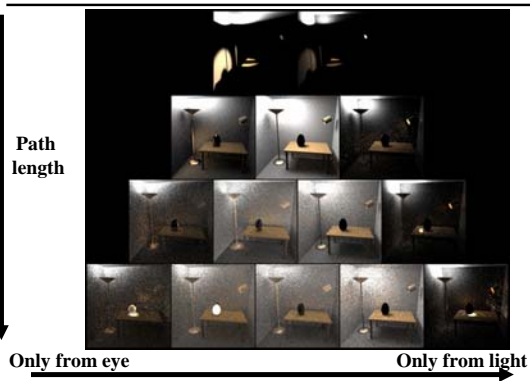
Bi-directional Path Tracing

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



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Bi-directional Path Pyramid



Questions?

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



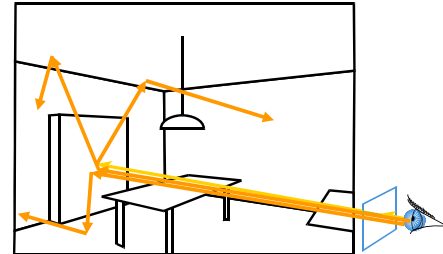
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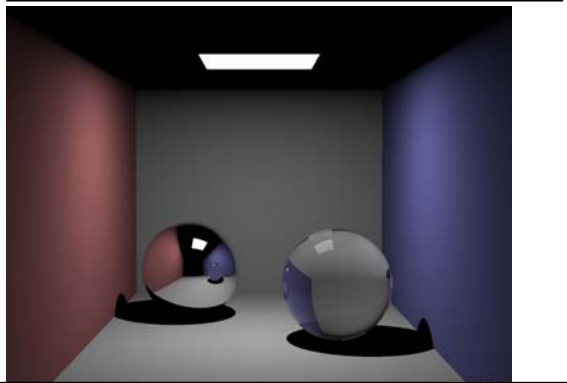
Path Tracing is costly

- Needs tons of rays per pixel

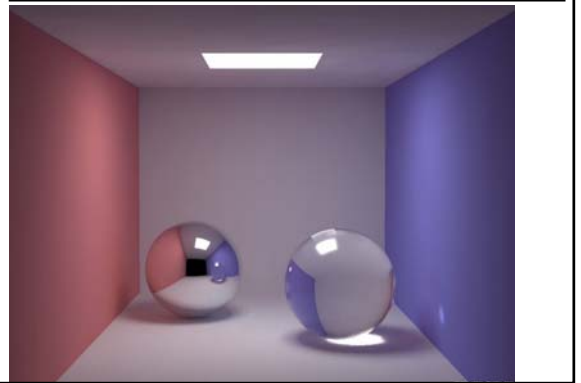


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Direct Illumination



Global Illumination

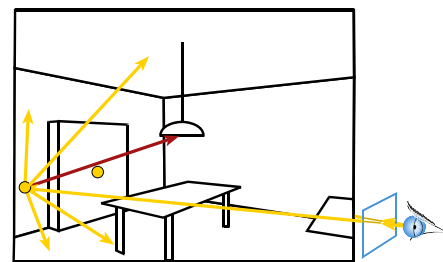


Indirect Illumination: smooth



Irradiance Cache

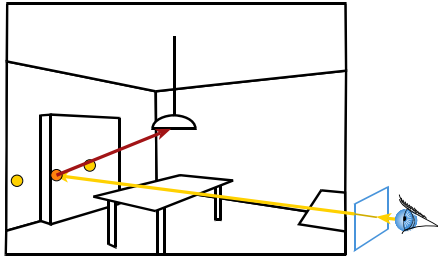
- The indirect illumination is smooth
- Store the indirect illumination



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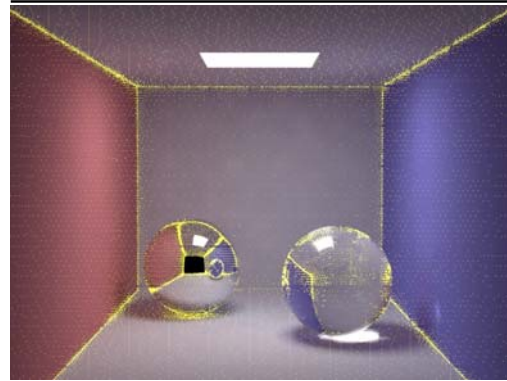
Irradiance Cache

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



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Irradiance Cache



Questions?



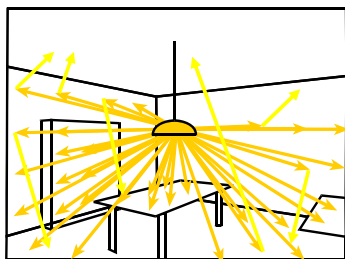
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- **Photon Mapping**
- Ray Grammar
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Photon Mapping

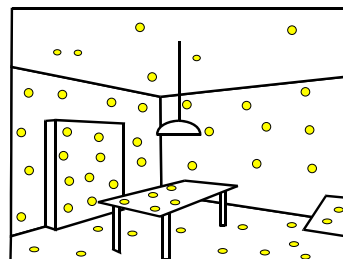
- Preprocess: cast rays from light sources
 - independent of viewpoint



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Photon Mapping

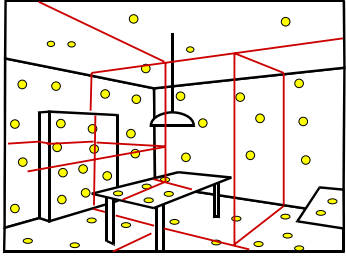
- Store photons
 - position + light power + incoming direction



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Photon Map

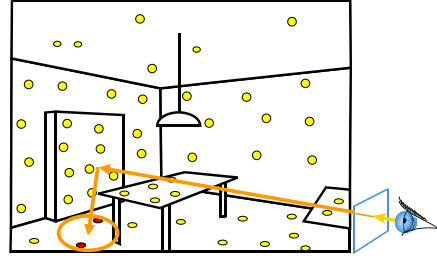
- Efficiently store photons for fast access
- Use hierarchical spatial structure (kd-tree)



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Rendering with Photon Map

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



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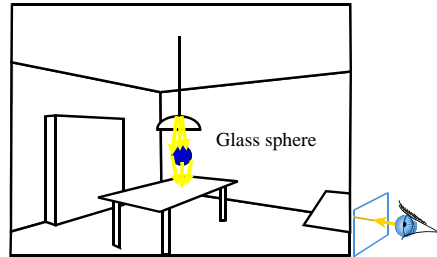
Photon Map Results



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Photon Mapping - Caustics

- Special photon map for specular reflection and refraction

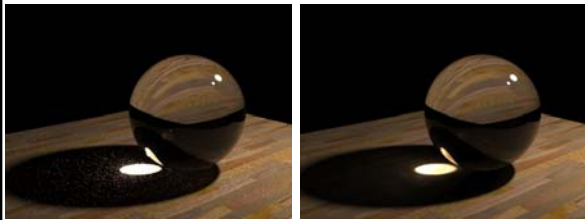


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Comparison

Path Tracing
1000 paths/pixel

Photon mapping



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Ray Grammar

- Classify local interaction:

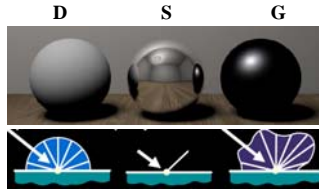
E = eye

L = light

S = perfect specular reflection or refraction

G = glossy scattering

D = diffuse scattering



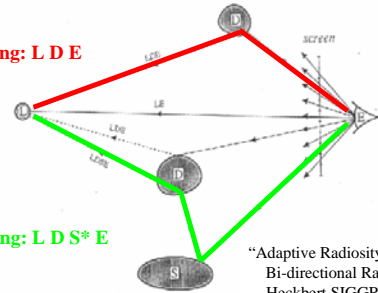
From Dutre et al.'s slides

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Classic Ray Casting/Tracing

Ray casting: $L D E$

Ray tracing: $L D S^* E$



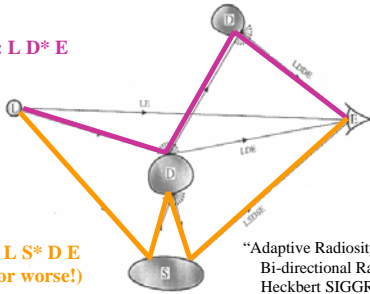
"Adaptive Radiosity Textures for Bi-directional Ray Tracing"
Heckbert SIGGRAPH 1990

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Photon Tracing

Radiosity: $L D^* E$

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



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

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Today

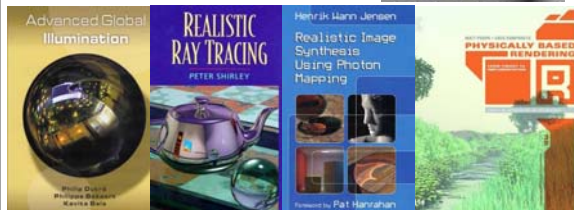
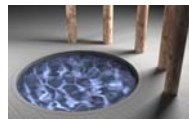
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– Next Time!

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References

- Eric Veach's PhD dissertation

http://graphics.stanford.edu/papers/veach_thesis/



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