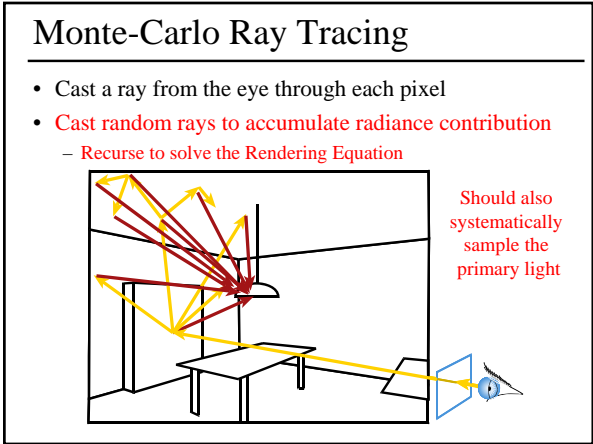
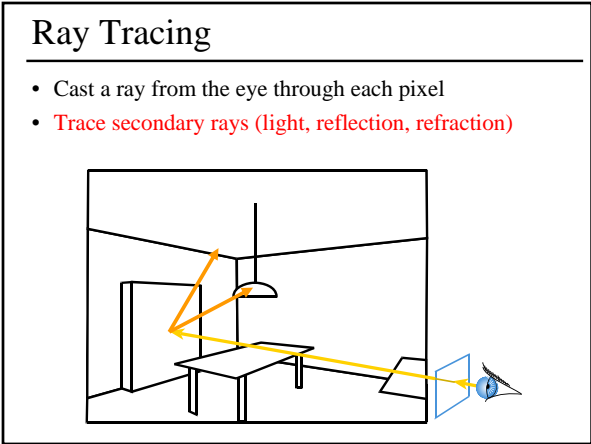
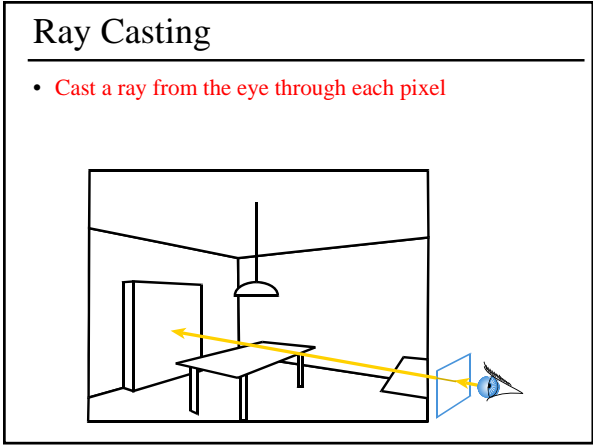


Irradiance Caching & Photon Mapping

Last Time?

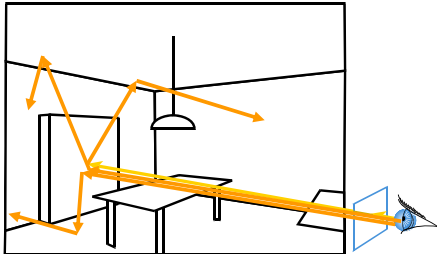
- What is a Pixel?
- Aliasing
- Fourier Analysis
- Sampling & Reconstruction
- Mip maps

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

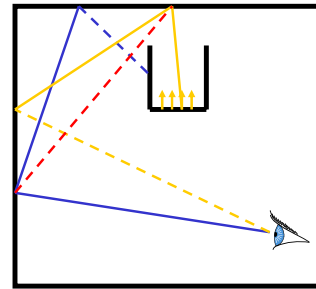


Monte Carlo Path Tracing

- 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

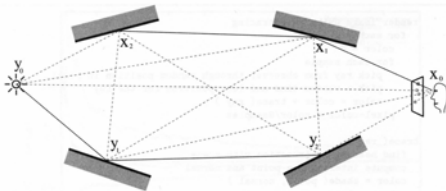
Forward
path tracing

Bi-directional
path tracing

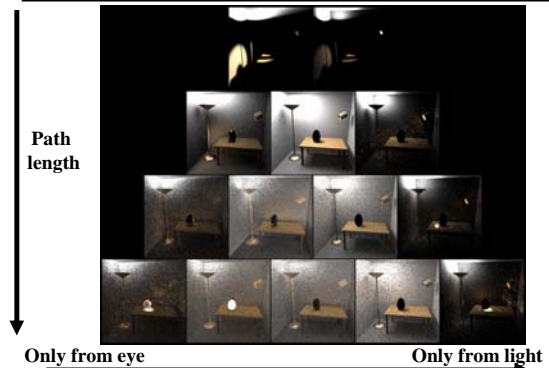
Bi-directional Path Tracing

- Start from both eye and lights
- Create all compound paths
 - Evaluate geometric/visibility term at connecting vertices: $\cos \theta \cos \theta' / r^2$

[Veach & Guibas 94,
Lafortune & Willems 93]



Bi-directional Path Pyramid



Questions?

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

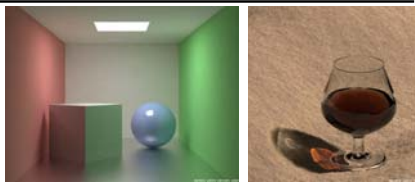


Today

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

Readings for Today:

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

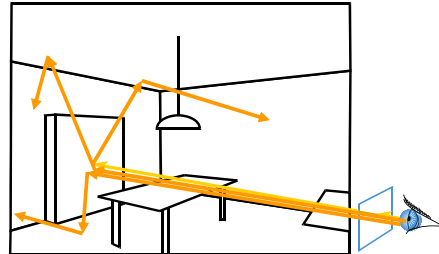


A Ray Tracing Solution for Diffuse Interreflection
Ward et al.
SIGGRAPH 1988

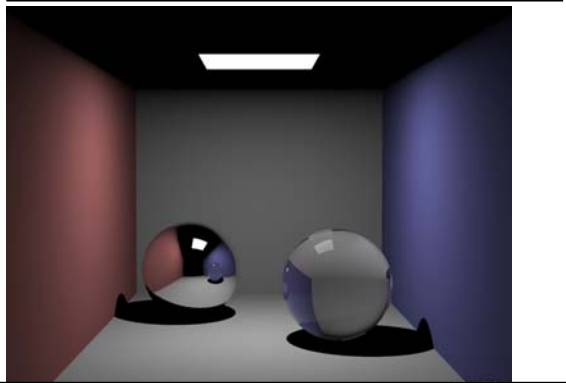


Path Tracing is costly

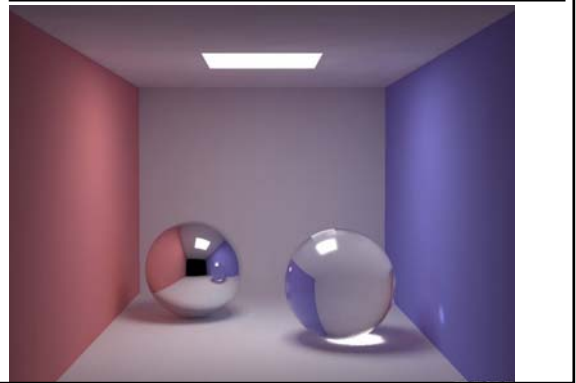
- Needs tons of rays per pixel



Direct Illumination



Global Illumination

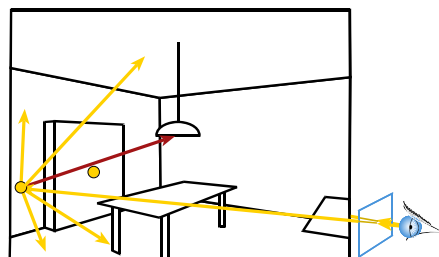


Indirect Illumination: smooth



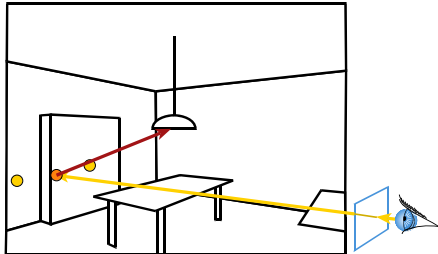
Irradiance Cache

- The indirect illumination is smooth
- Store the indirect illumination

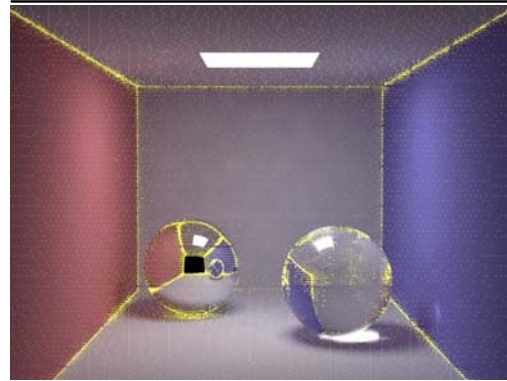


Irradiance Cache

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



Irradiance Cache



Questions?

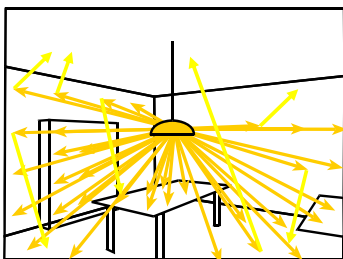


Today

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

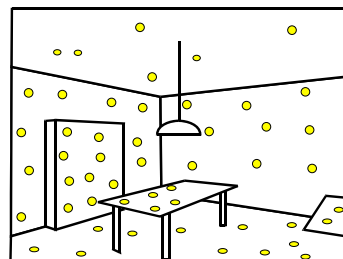
Photon Mapping

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



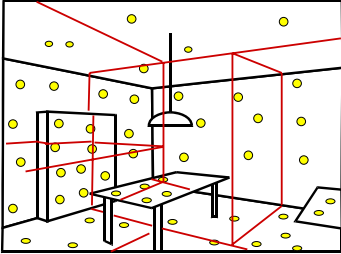
Photon Mapping

- Store photons
 - position + light power + incoming direction



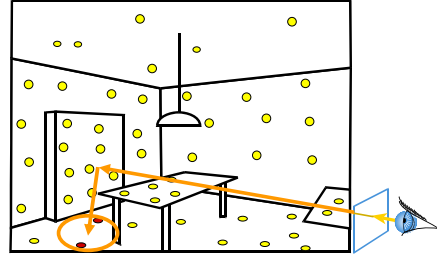
Photon Map

- 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

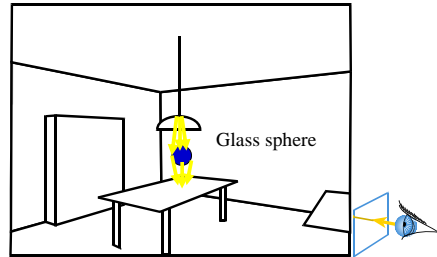


Photon Map Results



Photon Mapping - Caustics

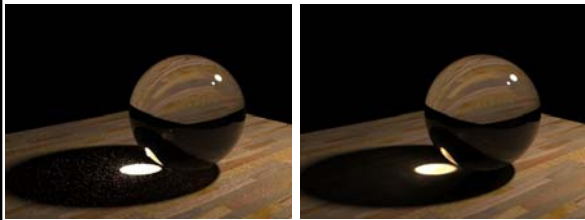
- Special photon map for specular reflection and refraction



Comparison

Path Tracing
1000 paths/pixel

Photon mapping



Today

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

Ray Grammar

- Classify local interaction:

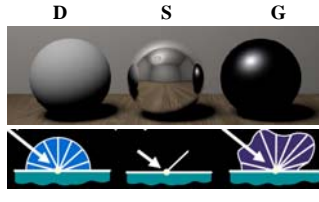
E = eye

L = light

S = perfect specular reflection or refraction

G = glossy scattering

D = diffuse scattering

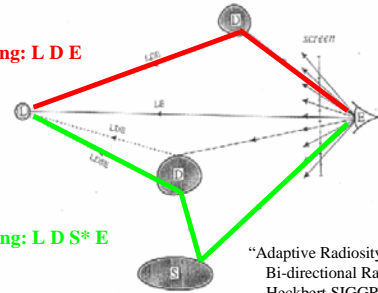


From Dutre et al.'s slides

Classic Ray Casting/Tracing

Ray casting: L D E

Ray tracing: L D S* E

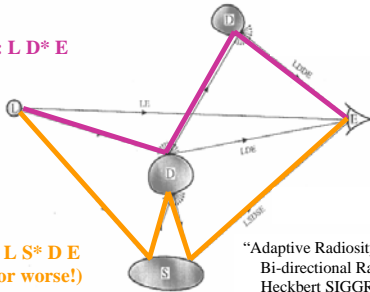


"Adaptive Radiosity Textures for Bi-directional Ray Tracing"
Heckbert SIGGRAPH 1990

Photon Tracing

Radiosity: L D* E

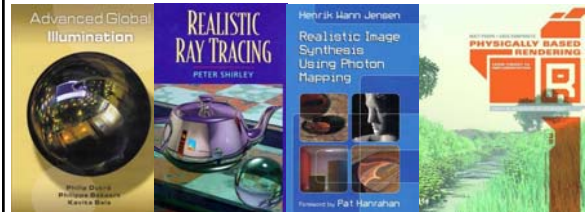
Caustics: L S* D E
(or worse!)



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

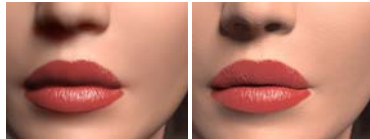
Advanced Rendering References

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



Reading for Tuesday(4/3):

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



Readings for Friday(4/6):



Animation of Plant Development
Prusinkiewicz et al., SIGGRAPH 1993



Feature-Based Cellular Texturing for Architectural Models
Legakis et al. SIGGRAPH 2001