Irradiance Caching & Photon Mapping

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

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

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)

Bi-directional Path Tracing
- Start from both eye and lights
- Create all compound paths
  - Evaluate geometric/visibility term at connecting vertices: \( \cos \theta \cos \theta' / r^2 \)

Challenging Indirect Lighting Scene
- Backward path tracing
- Forward path tracing
- Bi-directional path tracing

Bi-directional Path Pyramid
- Path length
  - Only from eye
  - Only from light

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

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
Today

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

Reading for Today:


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 |

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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

Advanced Global Illumination

Reading for Friday 4/4:


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