Photon Mapping
Global Illumination

- How to solve Rendering Equation
- Area energy sampling
  - Finite Element, Radiosity
- Point sampling methods
  - Ray tracing
  - Path tracing with Monte-Carlo method
  - Bidirectional path tracing
    - Tracing paths starting from both the eye and the light sources (Veach Ph.D thesis)
    - Final estimate computed as a sum of weighted averages of different paths
Photon Mapping Motivation

- An efficient algorithm for global illumination
- Handle any type of geometry and any type of BRDFs
Photon Mapping Overview

- Global illumination model
- Every surface will have an extra texture associated with it, called a photon map
- Can be seen as a cache of the light paths in bidirectional path tracing
- Relatively low memory consumption
- One biased Monte-Carlo algorithm
Photon Mapping Overview

- Photon mapping is a two stage process
  - Simulating the movement of photons from light sources and recording their interactions with each surface
  - During rendering, using the photon density around a point on a surface to determine its radiance

- All the stages can be performed on hardware
Photon Emission

- A large number of photons emitted from a light source
- Each photon transports a fraction of the light source power
- For a light source, generate photons with Monte-Carlo sampling
Photon Scattering

- After emission, photons are traced exactly the same way as ray tracing.
- When hitting an object, a photon is:
  - Reflected
  - Transmitted (refracted)
  - Absorbed
- Decided probabilistically based on the material parameters of surface.
Photon Storing

- Photon map – global data structure
- Decoupled from the geometry model
  - Do not associate photons with geometry
  - Use a separate structure
- Photons generated during tracing, it is a static data structure when rendering
- Data structure requirements
  - Fast to locate neighbors in 3D data sets
  - Compact since it will use millions of photons
Photon Map

- Uniform 3D grid
  - Easy to generate and find neighbors
  - Not efficient, waste memory

- Non-uniform structure
  - K-d tree
  - Voronoi diagram

- For GPU acceleration
  - Tree is not a good method
  - Need particular treatment
Illumination Estimate

- A photon hitting a region indicates that the region receives direct or indirect illumination from the light source.
- Need to compute photons density for a region.
- Integrating around a position with BRDF distributions
  - Monte-Carlo methods
- Can be imagined as expanding a sphere around the point until it contains n photons.
Rendering with photon map

- Using ray tracer
- Use the estimated illumination for diffusion
- Standard ray tracing for specular materials
- Or use more complex integration
Images by Per H. Christensen
Images by Jensen

- The Museum. Resolution 1280x960. Rendering time 56 min
A glossy floor. Resolution 2560x1920. Rendering time 50 min.
• Only diffuse surfaces. Resolution 1280x960. Rendering time 10 min.
• Only diffuse surfaces. Resolution 1280x960. Rendering time 60 min
• With a significantly optimized Monte Carlo ray tracing scheme, RADIANCE
Refs


• Webpage: Jensen [Global Illumination Using Photon Maps](#) and his numerous papers