Monte Carlo IV:
The Rendering Equation (Continued)
Overview

• Irradiance caching
  • Another biased MC method
• Metropolis sampling
  • Generating samples from arbitrary functions
• Metropolis light transport
Irradiance Caching

• Separate out indirect illumination from direct

• Assumptions:
  • It changes relatively slowly
  • Directional distribution is relatively unimportant

• Approach:
  • Compute indirect illumination at sparse set of points, interpolate it to use at nearby points

• Advantages:
  • Low memory, efficient,...
Irradiance Caching

• Definition of irradiance

\[ E(x) = \int_{\Omega} L_i(x, \omega) \cos \theta_i d\omega \]

• Estimate this integral with standard MC techniques
Irradiance Caching

- Estimate irradiance from nearby samples
- For Lambertian surface,
  \[ f_r(\omega_i \rightarrow \omega_o) = c \]
- Rendering equation:
  \[
  L(x, \omega) = L_e(x, \omega) + \int_{\Omega} f(\omega_i \rightarrow \omega) L_i(x, \omega_i) \cos \theta_i \, d\omega_i \\
  = L_e(x, \omega) + c \times E(x)
  \]
Irradiance Caching

• What if surface isn’t Lambertian?
• Two possible approaches:
  • Use irradiance estimate for Lambertian component of BSDF, handle the rest with different technique
  • Assume that incident radiance is same from all directions

\[ L(x, \omega) = \frac{E(x)}{\pi} \]

• Error depends on specularity of BRDF, variation in illumination...
Irradiance Caching

• When is re-use error prone?
  • Sample is from far away
  • N is substantially different
  • Nearby objects

• Better interpolation
  • Ward & Heckbert: Irradiance gradients

• Other compact representations of incident radiance?
  • If more directional variation can be preserved, can be applied to directionally-varying BRDFs
Examples

- Under-sampled irradiance caching vs under-sampled path tracing

![Example Image 1](image1)

![Example Image 2](image2)