**Global Illumination**

Local vs. Global Illumination

Local

- Direct illumination of surfaces by light sources
- e.g. Phong and Cook/Torrance illumination

Global

- all light/surface interactions for entire environment
- Recursive ray tracing and radiosity compute this partially...

**Rendering Equation**

\[ I(x, x') = g(x, x') \left[ c(x, x') + \sum \rho(x', x'', x') I(x', x'') dx'' \right] \]

- \( I \): illumination at first point from second
- \( g \): geometry term for visibility and distance
- \( c \): emitted light from second point to first
- \( \rho \): reflectivity of light from \( x'' \) to \( x \) via \( x' \)
- Note that the equation is recursive

**Ray Tracing**

Modifies reflectivity term

- Computes specular interreflections among surfaces
- Computes diffuse and specular reflections between light sources and surfaces
- Typically integrates using point sampling of direction space

**Radiosity**

Also modifies reflectivity term

- Computes diffuse interreflections among surfaces (light sources not distinguished)
- Integrates by quantizing surface points and summing

**Light Transport Models**

Specular

- Direction dependent
- High frequency

Diffuse

- Direction independent
- Lower frequency

From Watt and Watt, Advanced Animation and Rendering Techniques
Light Transport in Ray Tracing and Radiosity

Ray Tracing
- Handles specular-to-specular and diffuse-to-specular

Radiosity
- Handles diffuse-to-diffuse

Problematic light transport chain

Things easily missed: mirrors

Specular-to-diffuse
- Ray tracing unlikely to discover illumination reflected off mirror onto table

From Watt and Watt, Advanced Animation and Rendering Techniques

Things easily missed: caustics

Reflection and refraction by curved surfaces causes intense focusing of light

From Watt and Watt, Advanced Animation and Rendering Techniques

Backward ray tracing

Trace lots of rays from light sources to see where they go
- Store illumination maps with diffuse surfaces
- Easier to “follow the light” than to “find the light”
- Gets expensive! (in the general case)

Can be made efficient for special cases

Path Tracing

Similar to distribution ray tracing
Applies Monte Carlo sampling to estimate integral
Traces a single path for each eye ray (only a single ray spawned at each surface intersection)
Two-Pass Radiosity/Ray Tracing

First pass: radiosity
• Compute extended form factors and diffuse illumination

Second pass: ray tracing
• Perform standard ray tracing
• Diffuse component of illumination radiosity solution rather than just local illumination

Note: still doesn’t handle light reflected specularly and later diffusely

Two-Pass Examples

From Foley, van Dam, et al., Computer Graphics: Principles and Practice