



Global Illumination

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Course 600.456: Rendering Techniques, Professor: Jonathan Cohen



Local vs. Global Illumination

Local

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

Global

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



Rendering Equation

$$I(x, x') = g(x, x') \left[\varepsilon(x, x') + \int_S \rho(x, x', x'') I(x', x'') dx'' \right]$$

I: illumination at first point from second

g: geometry term for visibility and distance

ε: emitted light from second point to first

ρ: 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

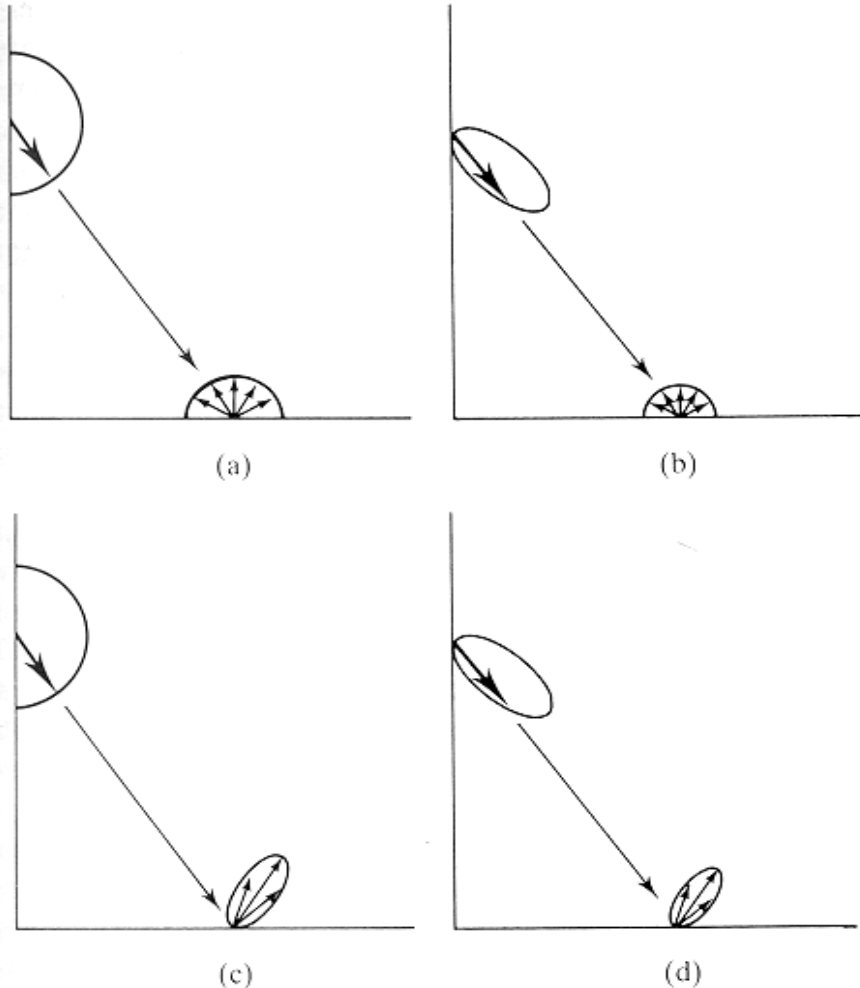
Specular

- 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

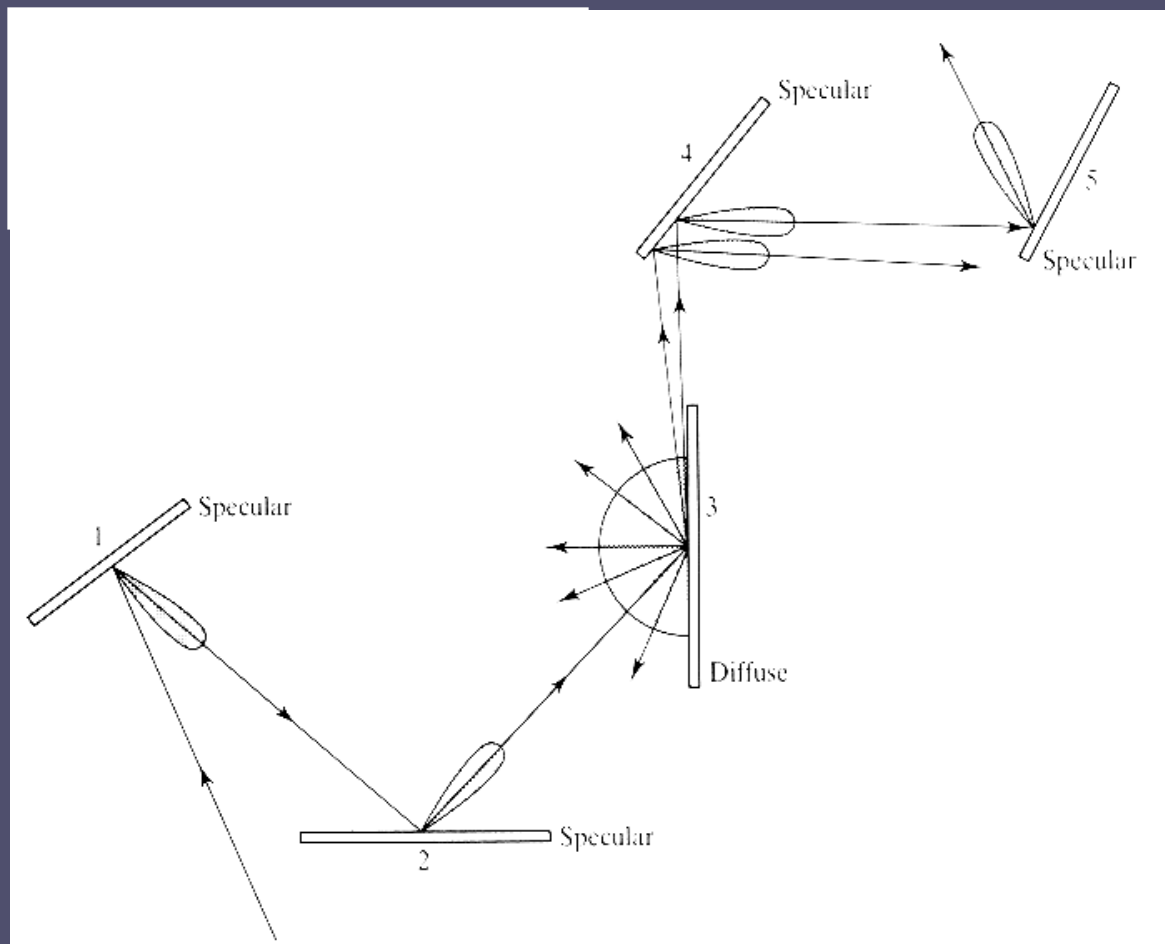
- Handles specular-to-specular and diffuse-to-specular

Radiosity

- Handles diffuse-to-diffuse



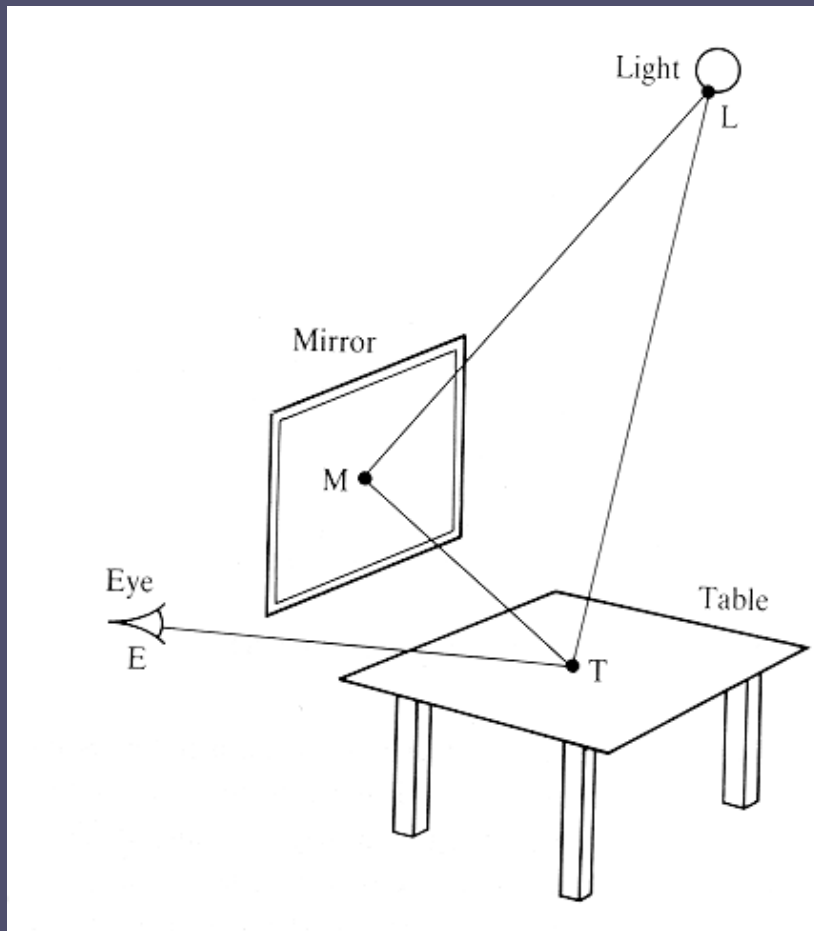
Problematic light transport chain



From Watt and Watt,
*Advanced Animation and
Rendering Techniques*



Things easily missed: mirrors



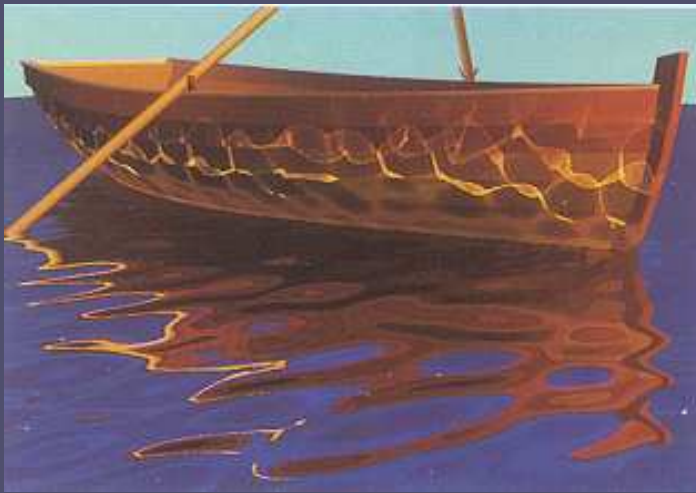
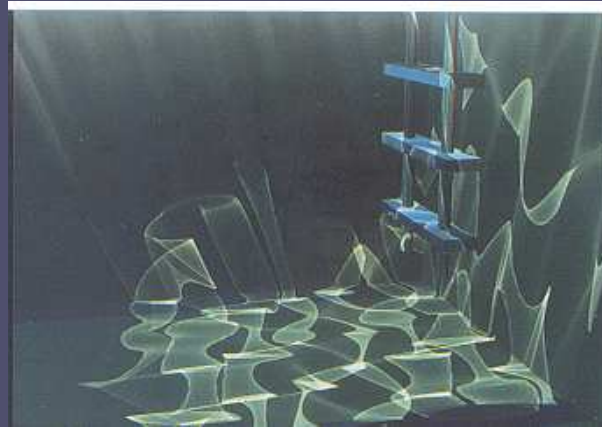
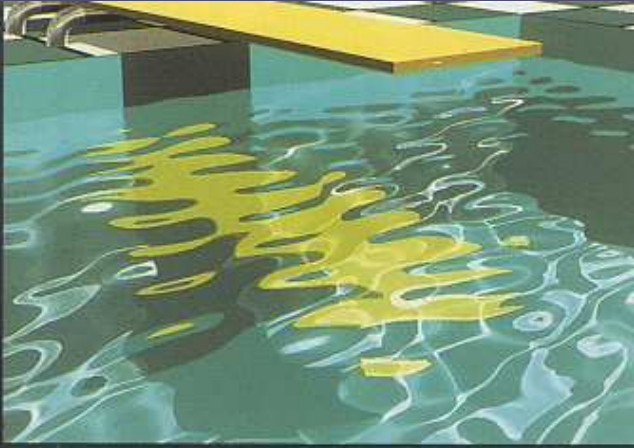
Specular-to-diffuse

- 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

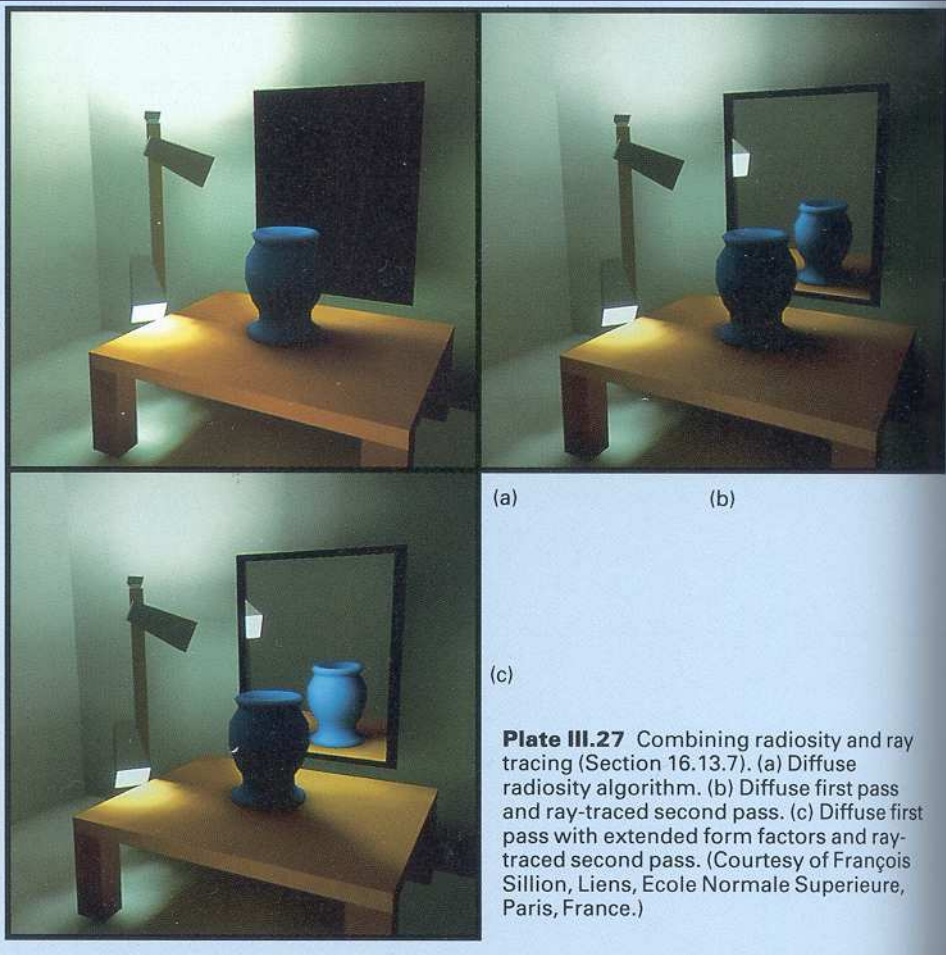
Second pass: ray tracing

- 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*