

Global Illumination

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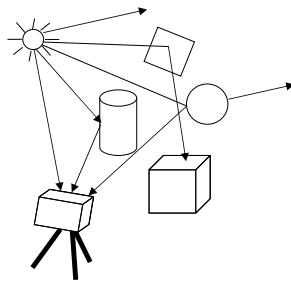
Global Illumination

- Shading is conducted by considering the interaction between all objects in the environment.
- More accurate rendering with more cost.
- Often done in off-line.
- Two main approaches:
 - Ray Tracing
 - Radiosity

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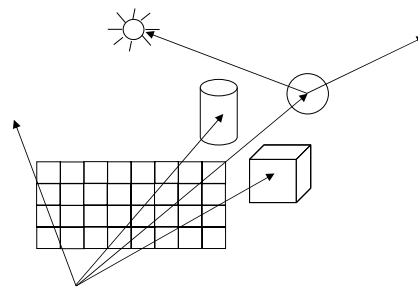
Ray Tracing



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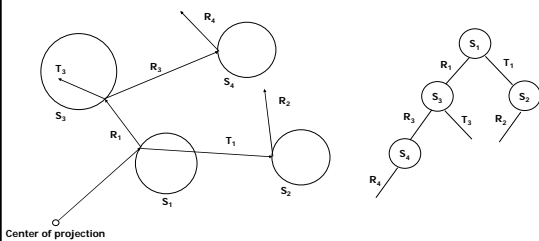
Ray Tracing



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Ray Tracing Tree



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Ray Tracing

- The intensity assigned to a pixel is then determined by accumulating the intensity contributions, starting at the bottom (terminal nodes) of its ray-tracing tree.
- Surface intensity from each node in the tree is attenuated by the distance from the "parent" surface (next node up the tree) and added to the intensity of the parent surface. Pixel intensity is then the sum of the attenuated intensities at the root node of the ray tree.

<http://www.siggraph.org/education/materials/HyperGraph/raytrace/rtrace0.htm>

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Radiosity

- Ray tracing is best suited for modeling specular reflection.
- Radiosity is better for inter-object reflections.

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Radiosity

- Assume the conservation of light energy in a closed environment.
- Based on thermal-engineering models for the emission and reflection of radiation, all surfaces can emit light, and all light sources have area.
- Radiosity is the rate at which energy leaves a surface, i.e. the sum of rates at which the surface emits energy and reflects or transmits it from that surface.
- Determine all the light interactions in a view-dependent way first, then conduct visible-surface determination and interpolative (Gouraud) shading.

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Radiosity Equation

- Break up the environment into a finite number of n discrete patches, each of which is assumed to be of finite size, emitting and reflecting light uniformly over its entire area. Then, for each surface i ,

$$B_i = E_i + \rho_i \sum B_j F_{j \rightarrow i} A_j / A_i, 1 \leq j \leq n \quad (1)$$

B_i and B_j are the radiosities (energy/time/area) of patches i and j .

ρ_i is the patch i 's reflectivity.

E_i is the rate at which light is emitted from patch i .

F_j is the form factor, which is the fraction of energy leaving the patch j that arrives at the patch i .

A_i and A_j are the areas of patches i and j .

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Radiosity Equation

$$B_i = E_i + \rho_i \sum B_j F_{j \rightarrow i} A_j / A_i, 1 \leq j \leq n \quad (1)$$

- Equation 1 states that the energy leaving a unit area of surface is the sum of the light emitted plus the light reflected.
- The reflected light is computed by scaling the sum of the incident light by the reflectivity.
- The incident light is in turn the sum of the light leaving each patch in the environment scaled by the fraction of that light reaching a unit area of the receiving patch.
- $B_j F_{j \rightarrow i}$ is the amount of light leaving a unit area of A_j that reaches all of A_i .
- Hence, it is needed to multiply by the area ratio A_j / A_i to determine the light leaving all of that reaches a unit area of A_i .

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Radiosity Equation

- A simple reciprocity relationship holds between form factors in diffuse environments.

$$A_i F_{i \rightarrow j} = A_j F_{j \rightarrow i}$$

- Thus, Equation 1 can be simplified to

$$B_i = E_i + \rho_i \sum B_j F_{j \rightarrow i}, 1 \leq j \leq n$$

- Rearranging terms,

$$B_i - \rho_i \sum B_j F_{j \rightarrow i} = E_i, 1 \leq j \leq n$$

- Therefore, the interaction of light among the patches in the environment can be solved as a set of simultaneous equations.

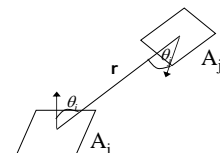
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Form Factor

- Expresses the fraction of the energy leaving one surface and reaching the other (and vice-versa)
- It depends on the distance and orientation of the two surface elements

$$F_{i \rightarrow j} = \frac{1}{A_i} \iint_{A_i A_j} \frac{\cos \theta_i \cos \theta_j}{\pi^2 r^2} H_{ij} dA_j dA_i$$



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