Illumination effects

- **Caustics:**
  - refraction or reflection causes light to be “collected” in some regions.
- **Specular-> diffuse transfer**
  - source reflected in a mirror
- **Can’t render this by tracing rays from the eye - how do they know how to get back to the source?**
- Instead, trace rays from the light to the first diffuse surface
  - leave a note that illumination has arrived - an illumination map, or photon map
  - now retrieve this note by tracing eye rays
- **Issues**
  - efficiency (why trace rays to things that might be invisible?)
  - aliasing (rays are spread out by, say, curved mirrors)
Refraction caustic

Henrik Jensen, http://www.gk.dtu.dk/~hwj
Reflection caustic

Henrik Jensen, http://www.gk.dtu.dk/~hwj
Refraction caustics

Henrik Jensen, http://www.gk.dtu.dk/~hwj
from
A Realistic Camera Model for Computer Graphics
Craig Kolb, Don Mitchell, and Pat Hanrahan
Computer Graphics (Proceedings of SIGGRAPH '95), ACM SIGGRAPH 34995, pp
from
A Realistic Camera Model for Computer Graphics
Craig Kolb, Don Mitchell, and Pat Hanrahan
Radiosity

Ray-traced Cornell box, due to Henrik Jensen, http://www.gk.dtu.dk/~hwj

Radiosity, Cornell box, due to Henrik Jensen, http://www.gk.dtu.dk/~hwj, rendered
Radiosity

Want to capture the basic effect that surfaces illuminate each other.

Again, following every piece of light from a diffuse reflector is impractical--but combinations of brute force and clever hacks can be done.

Another approach: Radiosity methods.
Radiosity (see book §14.9)

Think of the “world” as a bunch of patches. Some are sources, (and reflect), some just reflect. Each sends light towards all the others.

Consider one color band at a time (some of the computation is shared among bands).

Each surface, $i$, *radiates* reflected light, $B_i$

Each surface, *emits* light $E_i$ (if it is not a source, this is 0).

Denote the albedo of surface $i$ as $\rho_i$
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Radiosity equation

\[ B_i = E_i + \rho_i \sum F_{j \rightarrow i} B_i \frac{A_j}{A_i} \]

The form factor \( F_{j \rightarrow i} \)

is the fraction of light leaving \( dA_i \) arriving at \( dA_j \) taking into account orientation and obstructions
Useful relation

\[ A_i F_{i \rightarrow j} = A_j F_{j \rightarrow i} \]

The equation now becomes

\[ B_i = E_i + \rho_i \sum F_{i \rightarrow j} B_i \]

Rearrange to get

\[ B_i - \rho_i \sum F_{i \rightarrow j} B_i = E_i \]
In matrix form

\[
\begin{bmatrix}
1 - \rho_1 F_{1\rightarrow1} & -\rho_1 F_{1\rightarrow2} & \cdots & -\rho_1 F_{1\rightarrow n} & B_1 \\
-\rho_2 F_{2\rightarrow1} & 1 - \rho_2 F_{2\rightarrow2} & \cdots & -\rho_2 F_{2\rightarrow n} & B_2 \\
-\rho_n F_{n\rightarrow1} & -\rho_n F_{n\rightarrow2} & \cdots & 1 - \rho_n F_{n\rightarrow n} & B_n \\
\end{bmatrix}
= 
\begin{bmatrix}
E_1 \\
E_2 \\
E_n \\
\end{bmatrix}
\]
The fun part: Computing the $F_{i \rightarrow j}$

Without obstruction \[ dF_{d_j \rightarrow d_i} = \frac{\cos \theta_i \cos \theta_j}{r^2} dA_j \]
See book for “hemi-cube method” of computing and storing the form factors

Big picture

  Can reduce calculations by projecting onto hemisphere or, even better, hemi-cube

  While storing the form factors, can do a z-buffer type visibility analysis.
Previous equation is in terms of energy received

Can also do energy emitted

\[ B_j \text{ due to } B_i \text{ is } p_j B_i F_{j \rightarrow i} \]

Rewrite as

\[ B_j \text{ due to } B_i \text{ is } p_j B_i F_{i \rightarrow j} \frac{A_i}{A_j} \]