Speeding up the radiosity rendering algorithm using the kernel-independent FMM

Ross Adelman

12/13/2011
Radiosity

Color, $\rho$

- Incoming, $I$
- Reflected, $S$
- Emitted, $E$

\[ R_i = E_i + S_i \]
\[ R_i = E_i + \rho_i I_i \]
\[ R_i = E_i + \rho_i \sum_{j=1}^{N} F_{ji} R_j \]
Radiosity kernel

\[
R_i = E_i + \rho_i \sum_{j=1}^{N} F_{ji} R_j
\]

\[
F_{ji} = - \frac{1}{A_i} \int_{A_i} \int_{A_j} \frac{\left( \mathbf{n}_i \cdot (\mathbf{r}_i - \mathbf{r}_j) \right) \left( \mathbf{n}_j \cdot (\mathbf{r}_i - \mathbf{r}_j) \right)}{\pi |\mathbf{r}_i - \mathbf{r}_j|^4} dA_j dA_i
\]

In my implementation, I approximate this by

\[
F_{ji} = - \frac{A_j}{M} \sum_{k=1}^{M} \frac{\left( \mathbf{n}_i \cdot (\mathbf{c}_i - \mathbf{r}_k) \right) \left( \mathbf{n}_j \cdot (\mathbf{c}_i - \mathbf{r}_k) \right)}{\pi |\mathbf{c}_i - \mathbf{r}_k|^4}
\]
Divide the scene up into boxes
Divide the scene up into boxes
S-expansions -- proxy surface
S-expansions -- proxy surface
S-expansions -- proxy surface
S-expansions -- proxy surface
S-expansions -- check surface
S-expansions -- check surface
R-expansions -- proxy surface
R-expansions -- check surface
Interesting artifacts
Interesting artifacts
Solving for the radiosity values on the proxy triangles

Form factors between proxy and check triangles

\[ Fx = b \]

Radiosity values on check triangles due to actual sources

Unknown radiosity values on proxy triangles

To solve this, I use dgels() from AMD's ACML library, which is a LAPACK implementation.
Time/error analysis for scene A
Time/error analysis for scene A

Comparison of the direct, pre-FMM, and SLFMM methods

Error of the pre-FMM and SLFMM methods
Time/error analysis for scene B
Time/error analysis for scene B

Comparison of the direct, pre-FMM, and SLFMM methods

Error of the pre-FMM and SLFMM methods
What about mean absolute error?
Histogram of error in scene B

Pre-FMM using S-expansions for N = 70077
Histogram of error in scene B

Pre-FMM using R-expansions for N = 70077

Frequency

Absolute error
Histogram of error in scene B

SLFMM for $N = 70077$

Frequency

Absolute error
Questions?