Efficient computation of global illumination for image synthesis

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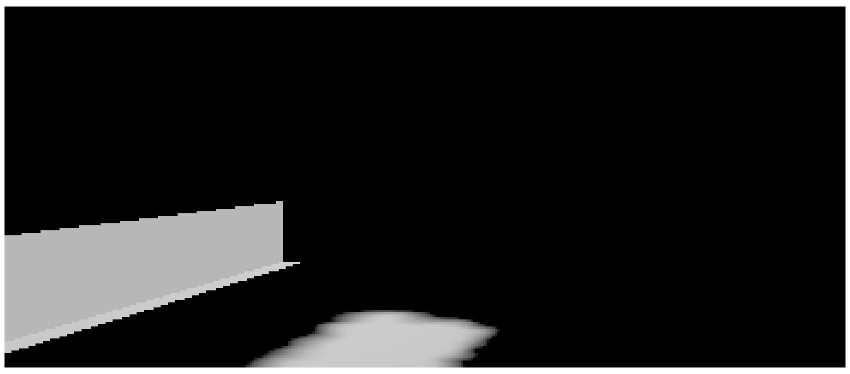
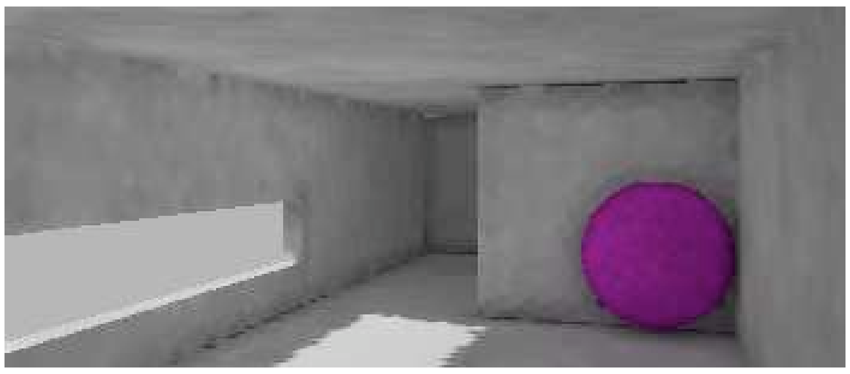
Goal: Image Synthesis with Radiosity

Direct Illumination



Radiosity (Radial basis)

Radiosity (Shepard basis)



Rendering equation

$$L = E + \mathcal{R}L$$

L (unknown) radiance function

E spontaneous emission function

$\mathcal{R}$ light transfer operator

$$(\mathcal{R}L)(p,q) = \int_{\mathcal{C}} \rho(\dot{p},\dot{q})L(\dot{p},\dot{q})G(\dot{p},\dot{q},\vec{p})V(\dot{p},\dot{q})d\dot{q}$$

ρ reflectance factor

G form factor

V visibility factor

Solving the rendering equation

General solution

$$L = (\mathcal{I} - \mathcal{R})^{-1}E$$

$$(\mathcal{I} - \mathcal{R})^{-1} = (\mathcal{I} + \mathcal{R} + \mathcal{R}^2 + \mathcal{R}^3 + \cdots)$$

Discretizing the rendering equation

$$\lambda = \epsilon + R\lambda$$

λ, ϵ = coefficients of L, E

R = radiance transfer matrix.

$$R_{jk} = G(\dot{p}_k, \dot{p}_j, \vec{p}_j)\,\rho(p_j)\,V(\dot{p}_k, \dot{p}_j)$$

Iterative solution

$\lambda \leftarrow (0, 0, \ldots 0)$; repeat $\lambda \leftarrow \epsilon + R\lambda$ until convergence

Finite Elements for Radiosity

Site: a pair $p = (\dot{p}, \vec{p})$

$\dot{p}$ = point on the scene's surface

$\vec{p}$ = unit normal vector

Finite Element Basis

$\phi_1, \phi_2, \ldots, \phi_n$

$\phi_i : sites \to \Re$, with small support

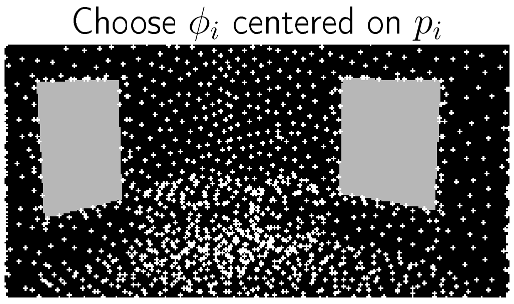
Finite Element Approximation

$B(p) \approx \sum_{i=1}^{n} \beta_i \phi_i(p)$

Point-based Finite Elements

Choose $p_1, p_2, \ldots, p_n$

Choose ϕ_i centered on p_i



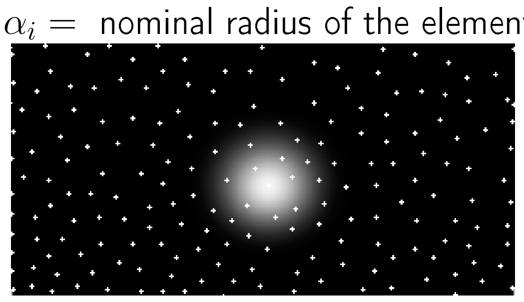
Finite Element Types

Radial Basis

$\phi_i(p) = \Phi\left(\|p, p_i\| / \alpha_i\right)$

$\|p, q\|$ = distance between p and q

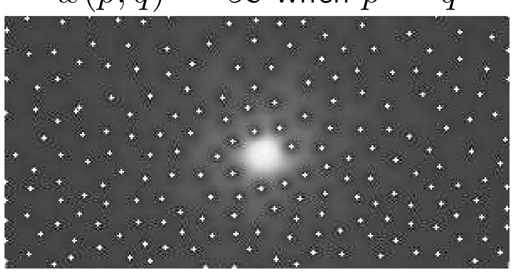
α_i = nominal radius of the element



Shepard Basis

$$\phi_i(p) = \frac{w(p, p_i)}{\sum_{j=1}^{n} w(p, p_j)}$$

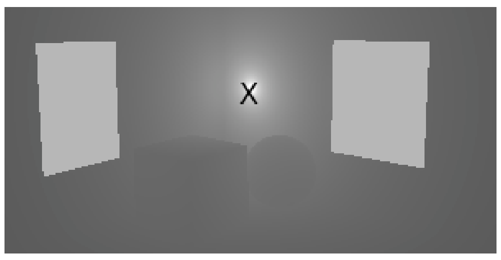
$w(p, q) \to \infty$ when $p \to q$



Site distance functions

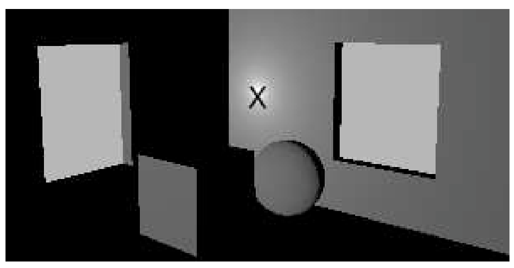
Euclidean distance

$\|p, q\| = |\dot{p} - \dot{q}|$



Normal-sensitive distance

$$\|p, q\| = \frac{|\dot{p} - \dot{q}|}{\max\{0, \vec{p} \cdot \vec{q}\}}$$



Support: CNPq, Unicamp.