

DCGI

KATEDRA POČÍTAČOVÉ GRAFIKY A INTERAKCE

Radiosity

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Outline

- Radiosity Methods

- Assumptions
- Basic principle
- Radiosity equation
- Iterative methods
- Meshing
- Instant radiosity

MPG 15.10

Radiosity - Overview

- Global Illumination Computation
- Assumption: **Diffuse surfaces**
- Energy transport
 - Balance of emitted and absorbed energy
 - Origin in heat transfer simulation

Example



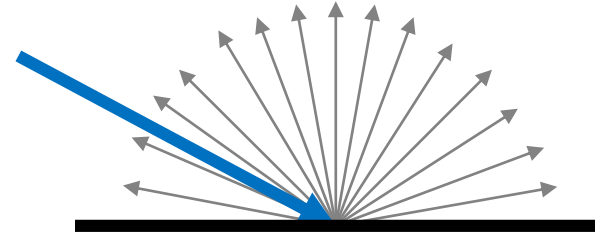
From Cohen, Chen, Wallace and Greenberg 1988

Basic Properties

- Illumination computed for planar patches
 - Finite element method
- View independent solution
 - Long preprocessing (1x)
 - Fast viewing (Nx)
- Good soft shadows, bad sharp shadows
- Cannot simulate specular reflection/refraction

Assumption #1: Diffuse emission and reflection

- Directionally independent radiance
- Diffuse emitter
 - Equal radiance in all directions
- Reflection on a diffuse patch



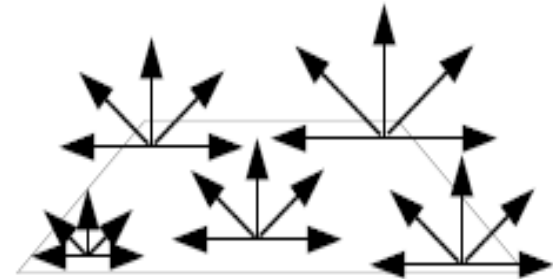
$$B(\mathbf{x}) = \rho_d(\mathbf{x}) * E(\mathbf{x})$$

B ... radiosity [W/m²]

E ... irradiance [W/m²]

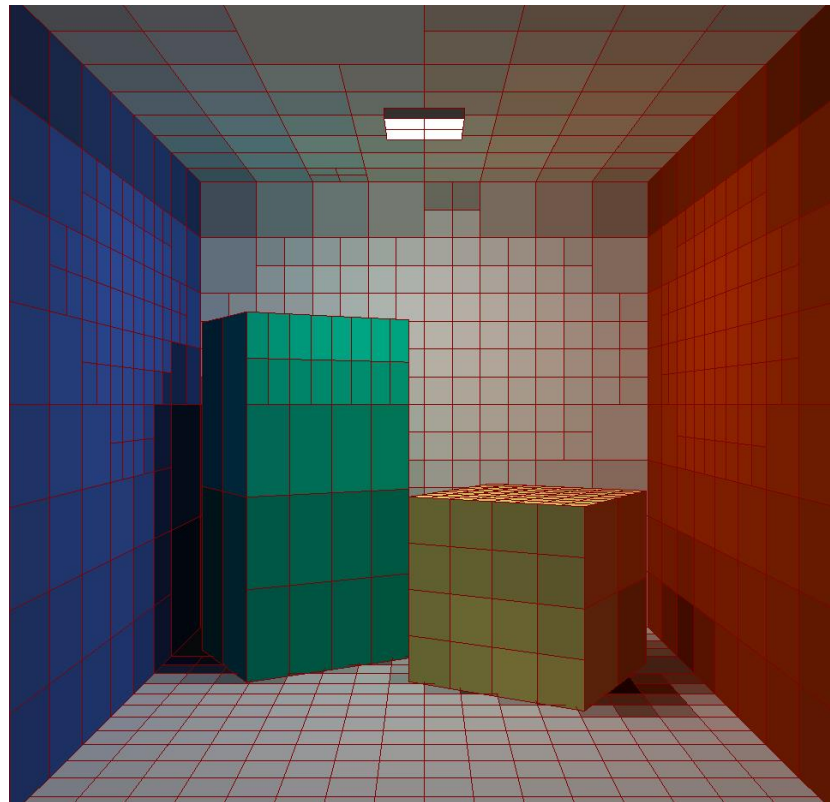
ρ_d ... reflectivity

- View independent solution

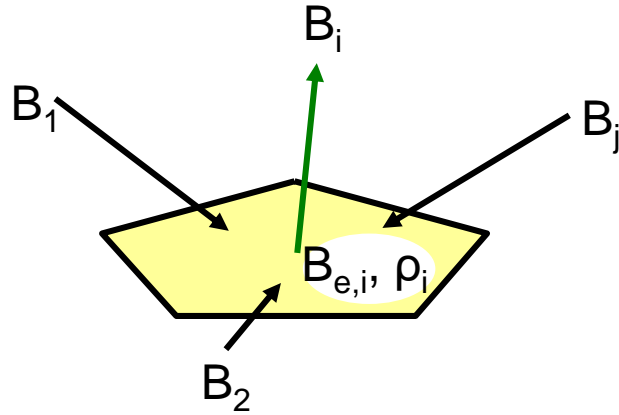


Assumption #2: Constant radiosity on patches

- Scene subdivision to patches
- Piecewise constant approximation of radiosity



Radiosity Equation



$$B_i = B_{e,i} + \rho_i \cdot \sum_{j=1}^N B_j \cdot F_{ij}$$

radiosity B_i
self emission $B_{e,i}$ (E_i)
reflectivity ρ_i
form factor F_{ij}

Form Factor

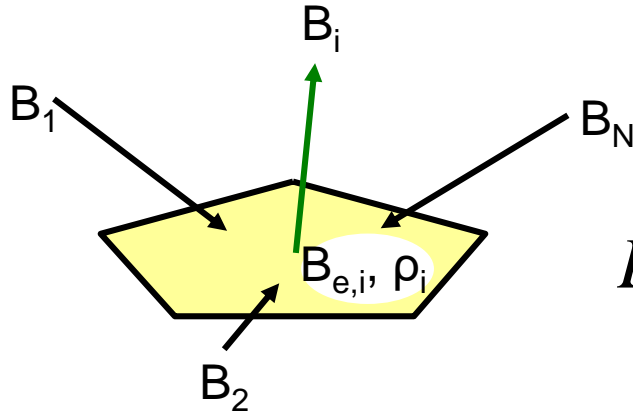
- Form factor F_{ij}
 - Portion of energy from A_i reaching A_j

$$F_{ij} = \frac{1}{A_i} \int_{A_i} \int_{A_j} \frac{v(x_i, x_j) \cos\phi_i \cos\phi_j}{\pi r^2} dA_j dA_i$$

$$A_i F_{ij} = A_j F_{ji}$$

Radiosity Equation

- Leads to system of N equations with unknowns B_i



$$B_i = B_{e,i} + \rho_i \cdot \sum_{j=1}^N B_j \cdot F_{ij}$$

$$A_i B_i = A_i B_{e,i} + \rho_i \cdot \sum_{j=1}^N A_j B_j \cdot F_{ji}$$

Power formulation

Solving Radiosity Equation

- Linear system: N equations with N unknowns (radiosities)

- $B_i \dots$ (unknown)

- $B_{e,i} \dots$ (known)

- $\rho_i \dots$ (known)

- $F_{ij} \dots$ form factors

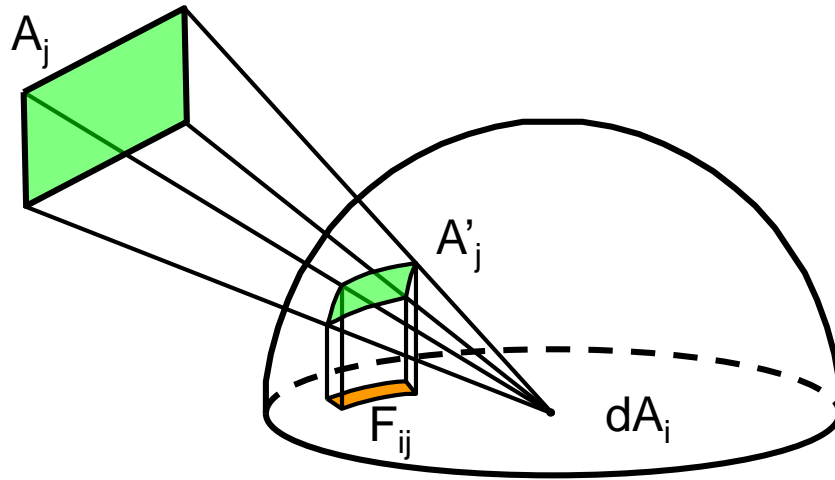
- Have to be computed, known when solving the system

$$B_i = B_{e,i} + \rho_i \sum_{j=1}^N B_j F_{ij}$$

$$\begin{bmatrix} 1 - \rho_1 F_{1 \rightarrow 1} & -\rho_1 F_{1 \rightarrow 2} & \dots & -\rho_1 F_{1 \rightarrow n} \\ -\rho_2 F_{2 \rightarrow 1} & 1 - \rho_2 F_{2 \rightarrow 2} & \dots & -\rho_2 F_{2 \rightarrow n} \\ \dots & \dots & \dots & \dots \\ -\rho_n F_{n \rightarrow 1} & 1 - \rho_n F_{n \rightarrow 2} & \dots & 1 - \rho_n F_{n \rightarrow n} \end{bmatrix} \begin{bmatrix} B_1 \\ B_2 \\ \dots \\ B_n \end{bmatrix} = \begin{bmatrix} B_{e,1} \\ B_{e,2} \\ \dots \\ B_{e,n} \end{bmatrix}$$

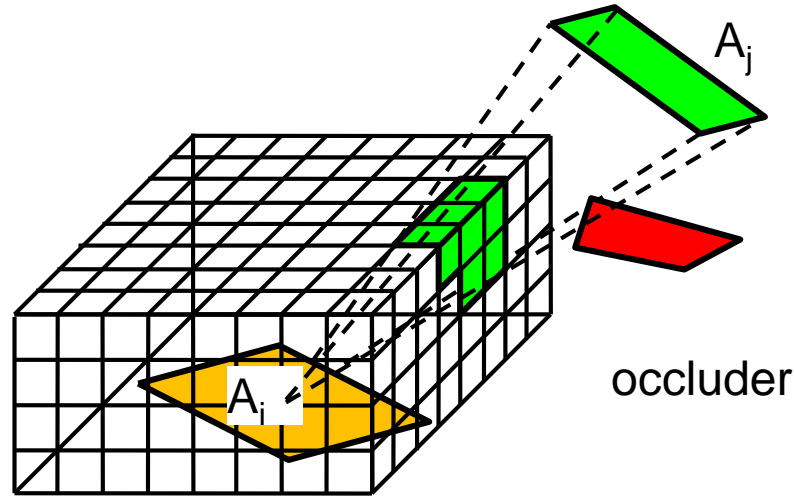
Configuration Factor F_{ij}

- Part of energy emitted by patch **i** to patch **j**
or
- How patch **i** sees patch **j** (Nusselt analogy)

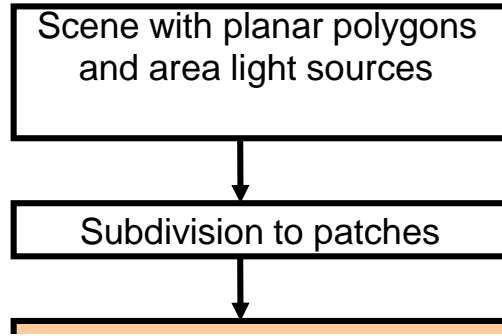


Computing F_{ij} using Hemicube

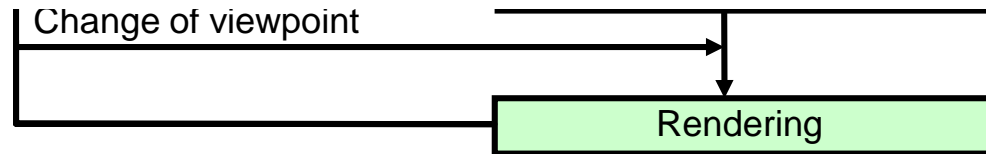
- Hemicube instead of Hemisphere
- Configuration factors from patch projections
 - Cell weights (δ factors)
 - z-buffer



Classical Computation Scheme



replaced by explicitly iterative methods

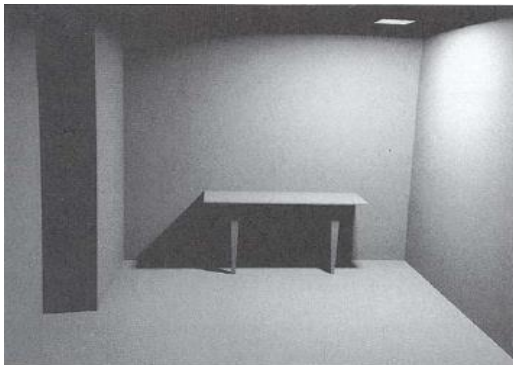


Iterative Methods

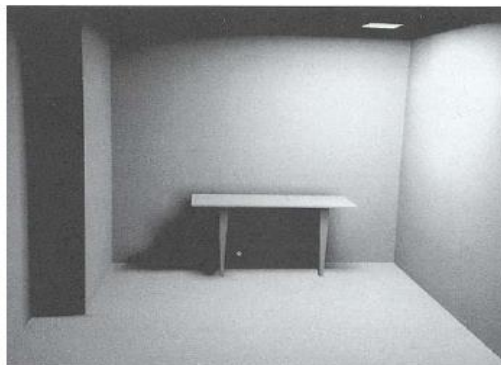
- Progressive radiosity
 - Southwell iteration: shooting energy from brightest patches
- Hierarchical radiosity
 - Patches in a hierarchy
 - Energy transfer between hierarchy nodes
- Stochastic radiosity (Monte-Carlo)
 - Using rays to stochastically distribute energy
 - Diffuse ray reflection
 - Register #hits per patch
 - No form-factor computation needed!

Meshing

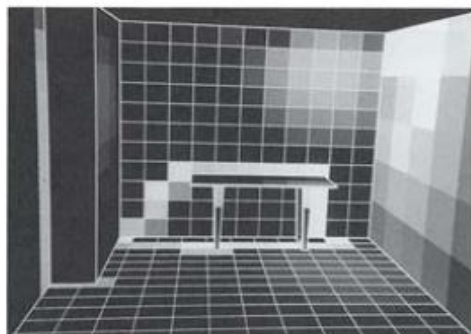
Reference solution



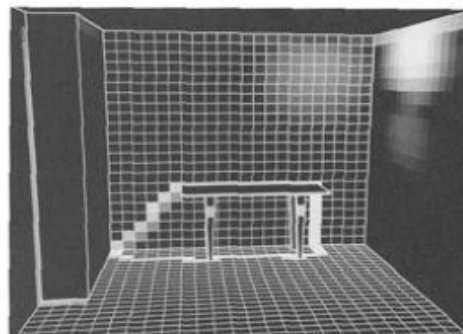
Uniform subdivision



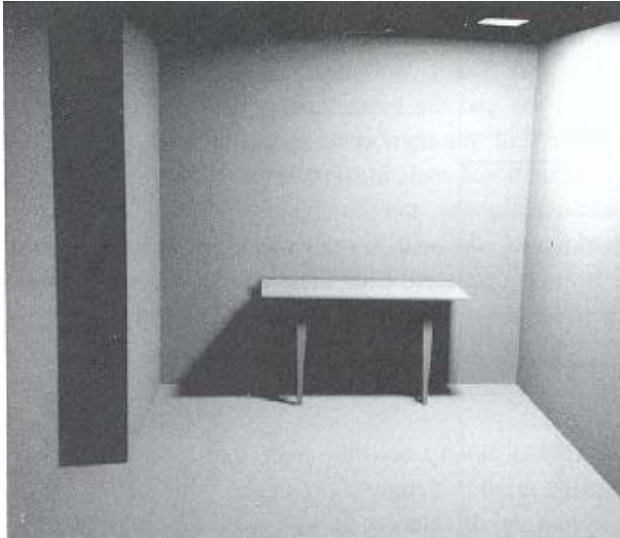
coarse



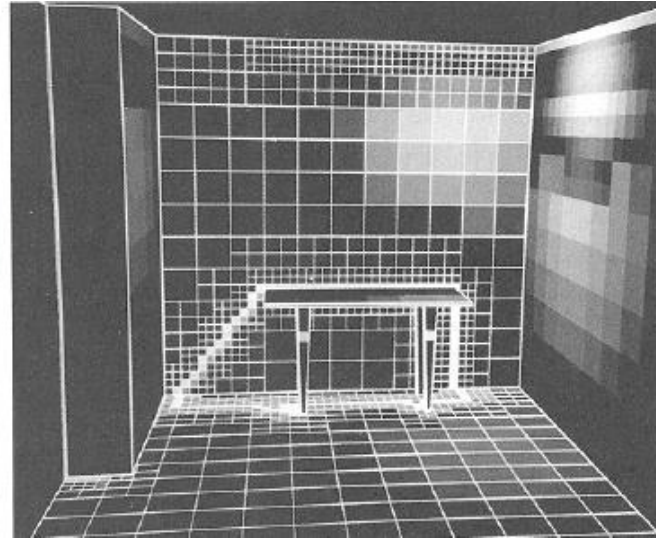
fine



Adaptive Subdivision



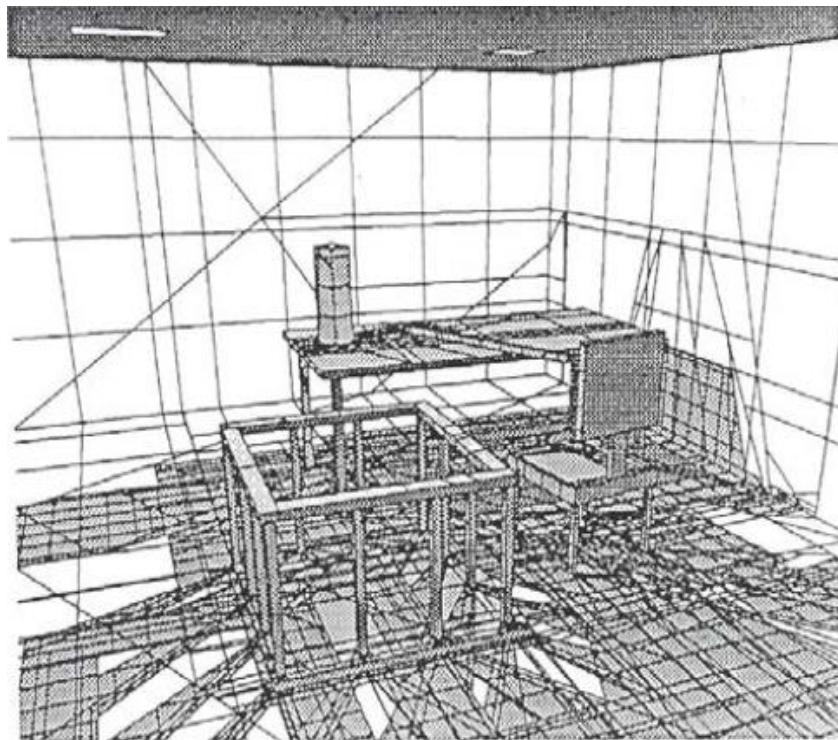
solution



adaptive subdivision

Discontinuity Meshing

- Subdivision along illumination discontinuities



From Campbell et al.

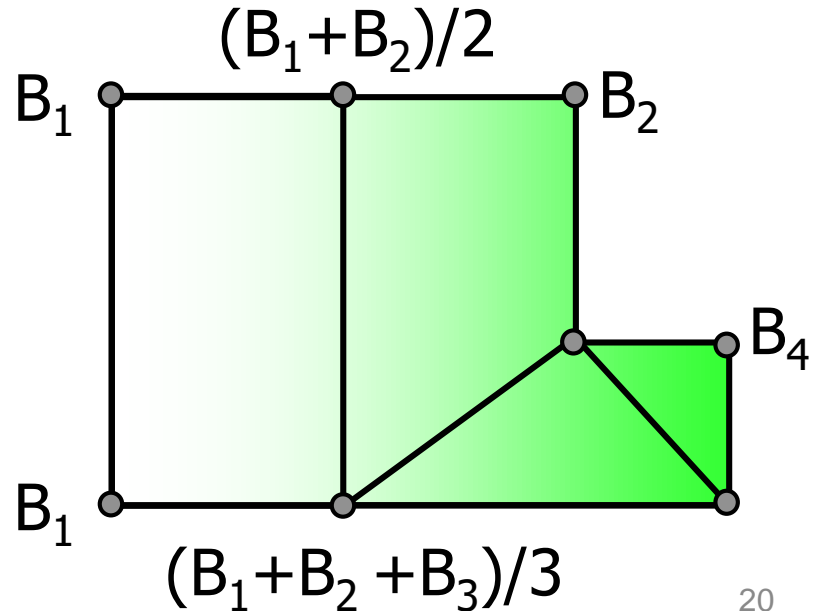
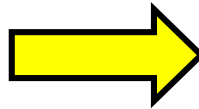
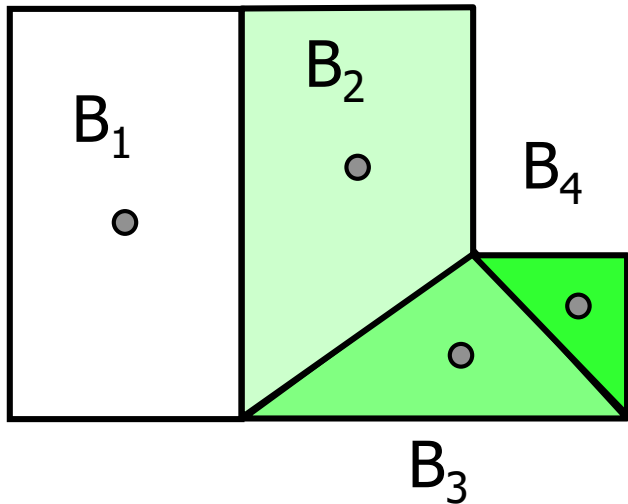
Discontinuity Meshing - Example



From Lischinski, Tampieri, Greenberg 1992

Radiosity and Shading

- Radiosity determines patch color at patch center
- For Gouraud shading values at vertices needed



Instant Radiosity

- Use many virtual point lights (VPLs)

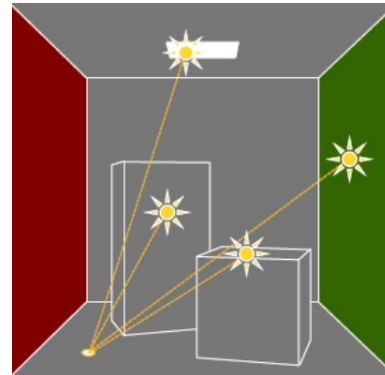
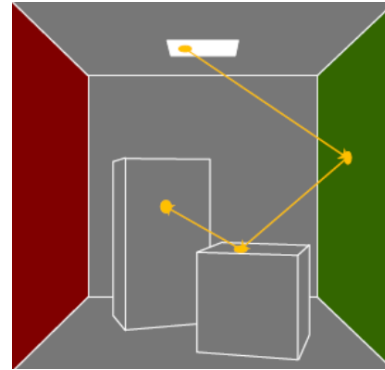
- No explicit meshing needed

1. Create VPLs

- Shoot photons
- Random walk

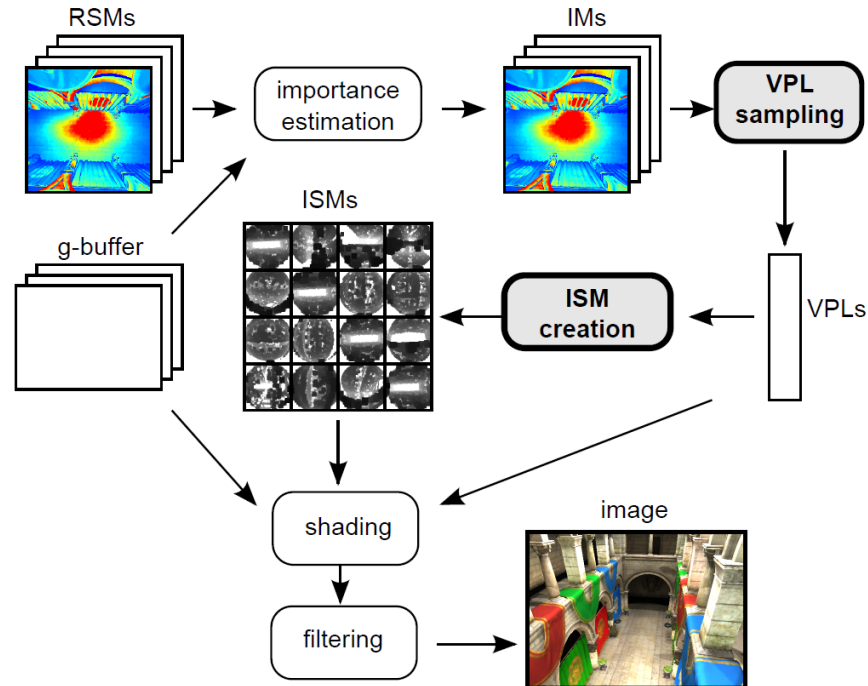
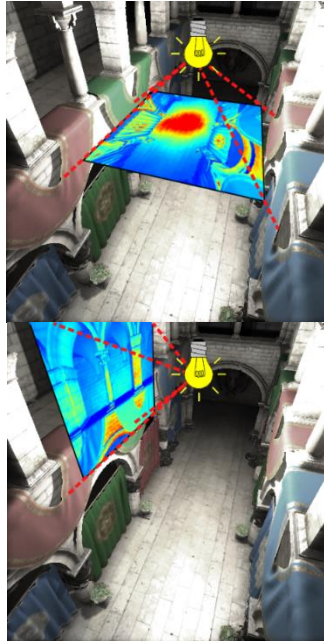
2. Render

- For each VPL
- Render with shadows



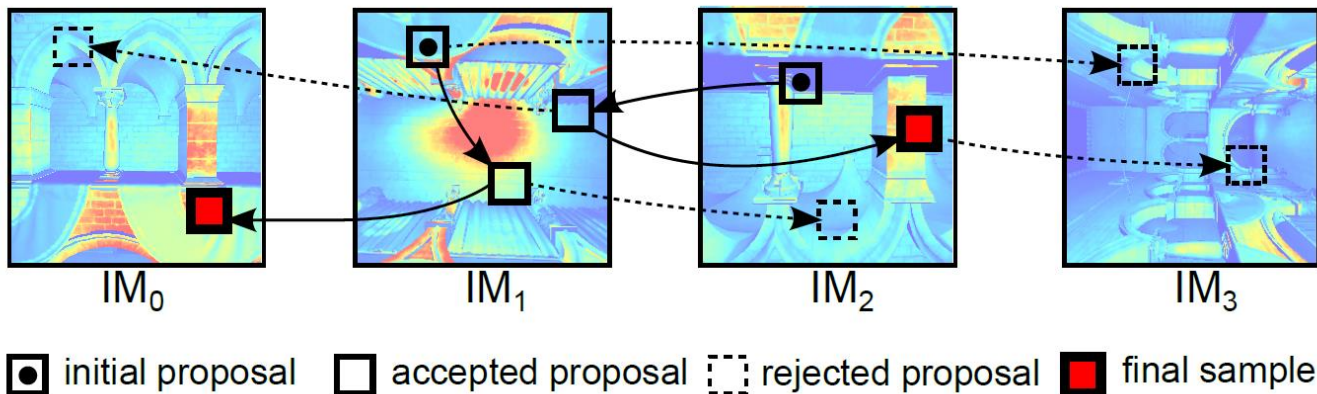
Temporally Coherent VPL Sampling

- Global illumination using instant radiosity (many VPLs)
- Improve stability of adaptive VPL sampling



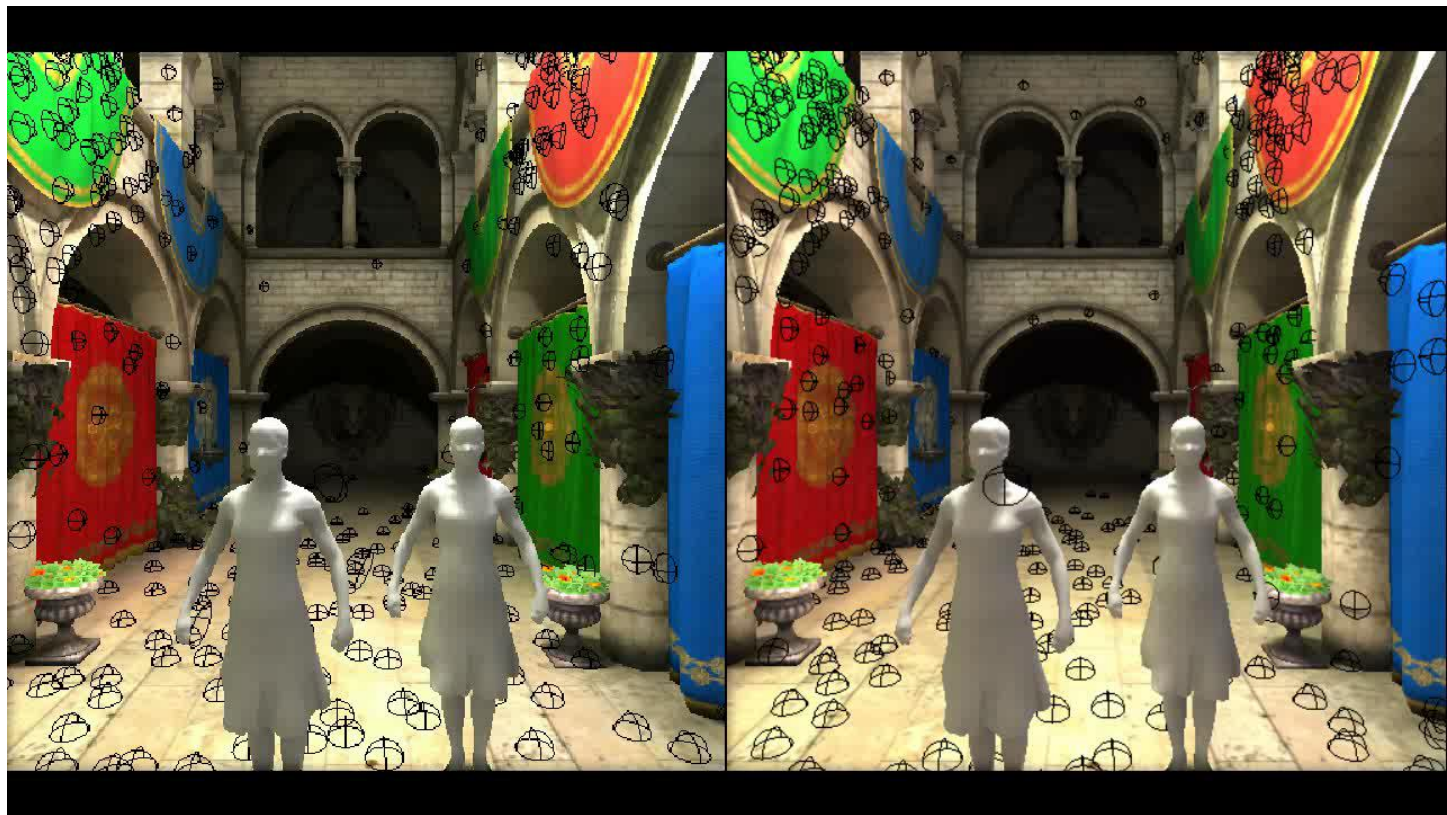
Temporally Coherent VPLs

- Metropolis-Hastings sampling
- Independent Markov chain



[Temporally Coherent Adaptive Sampling for Imperfect Shadow Maps (2013)]

Temporally Coherent VPLs



CDF sampling

Our method

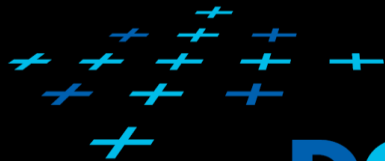
Radiosity - DEMO

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Questions?