CS482:
Radiosity

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(윤성의)

Course URL:
http://sglab.kaist.ac.kr/~sungeui/ICG

Class Objective (Ch. 11)

- **Understand radiosity**
    - **Radiosity equation**
    - **Solving the equation**

History

- Problems with classic ray tracing
  - Not realistic
  - View-dependent

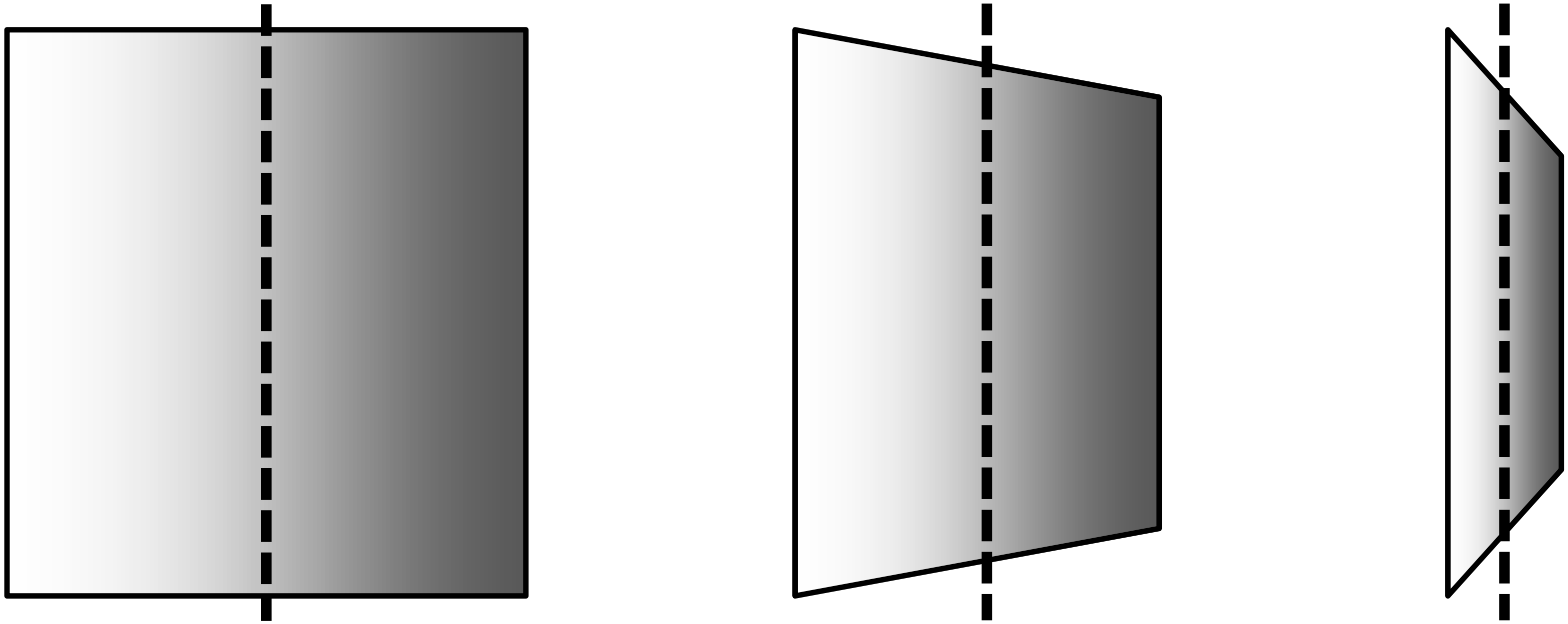
- Radiosity (1984)
  - Global illumination in diffuse scenes

- Monte Carlo ray tracing (1986)
  - Global illumination for any environment

Radiosity

- Physically based method for diffuse environments
  - Support diffuse interactions, color bleeding, indirect lighting and penumbra
  - Account for very high percentage of total energy transfer
  - Finite element method

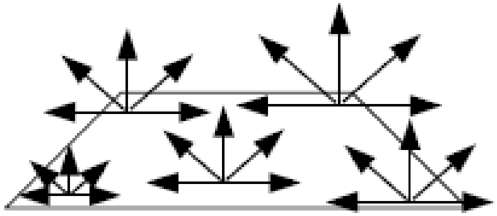
Key Idea #1: Diffuse Only



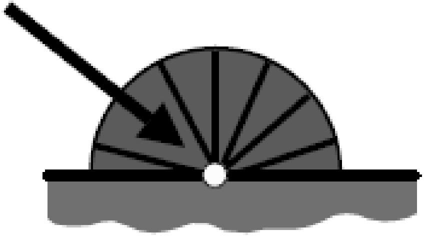
- **Radiance independent of direction**
  - **Surface looks the same from any viewpoint**
  - **No specular reflection**

Diffuse Surfaces

- **Diffuse emitter**
  - $L(x \rightarrow \Theta)$ **= constant over** Θ



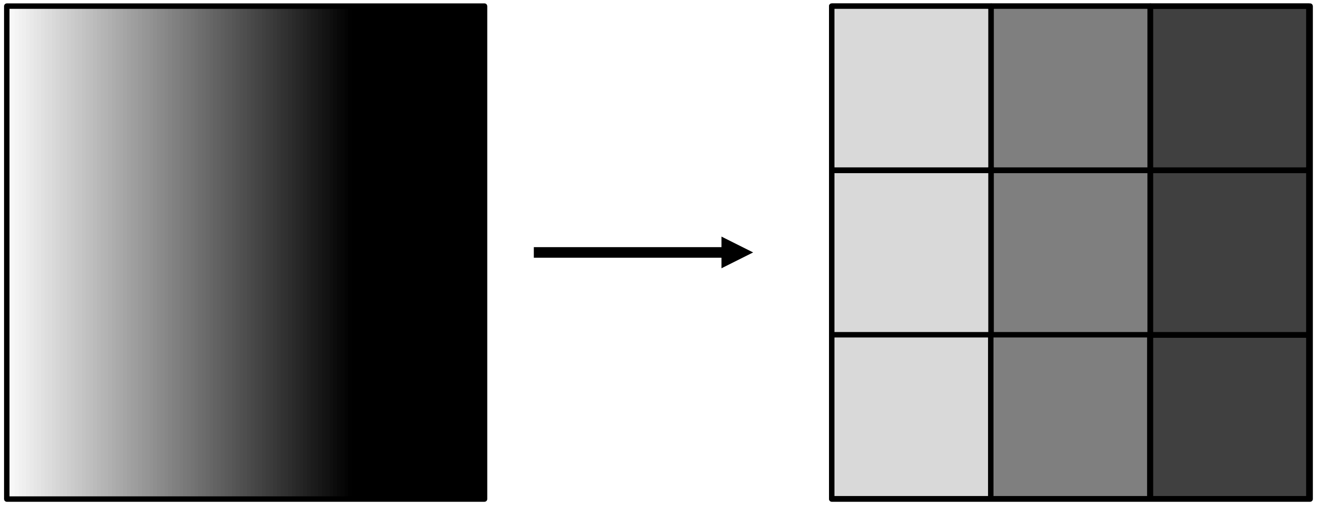
- **Diffuse reflector**
  - **Constant reflectivity**



From kavita's slides

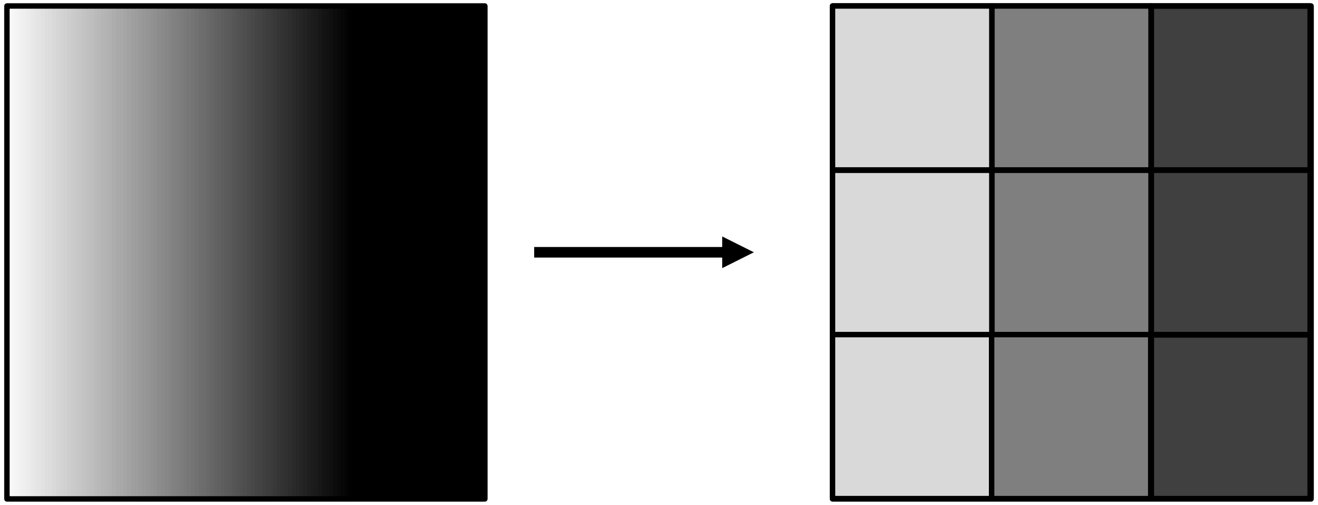
Key Idea #2: Constant Polygons

- Radiosity is an approximation
  - Due to discretization of scene into patches



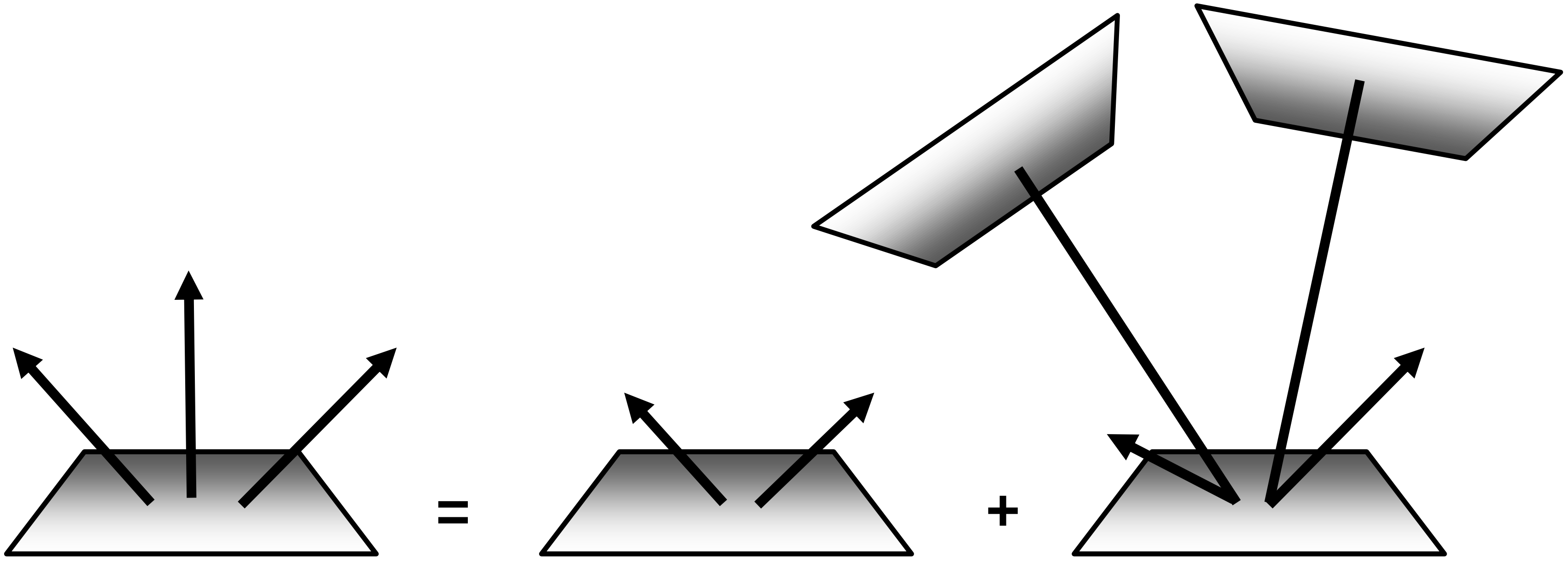
  - Subdivide scene into small polygons

Constant Radiance Approximation



- **Radiance is constant over a surface element**
  - **L(x) = constant over x**

Radiosity Equation



Radiosity

Self-emitted radiosity

Reflected radiosity

$$\boldsymbol{Radiosity_i = Radiosity_{self,i} + \sum_{j=1}^{N} a_{j\to i}\, Radiosity_j}$$

Radiosity Equations

- Radiosity for each polygon i

$$Radiosity_1 = Radiosity_{self,1} + \sum_{j=1}^{N} a_{j\to 1}\, Radiosity_j$$

$$\vdots$$

$$Radiosity_i = Radiosity_{self,i} + \sum_{j=1}^{N} a_{j\to i}\, Radiosity_j$$

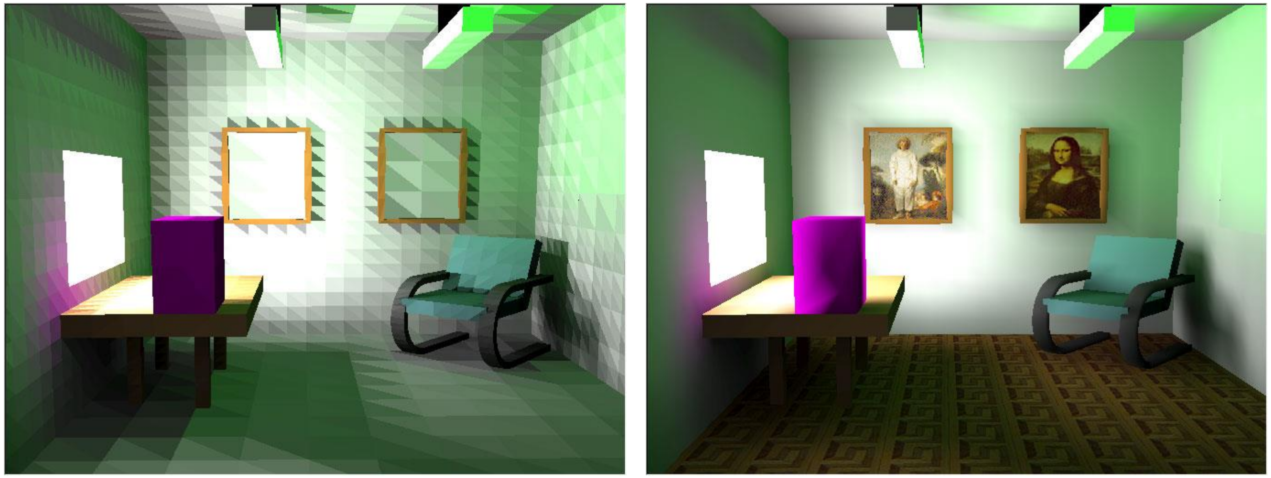
$$\vdots$$

$$Radiosity_N = Radiosity_{self,N} + \sum_{j=1}^{N} a_{j\to N}\, Radiosity_j$$

- N equations and N unknown variables

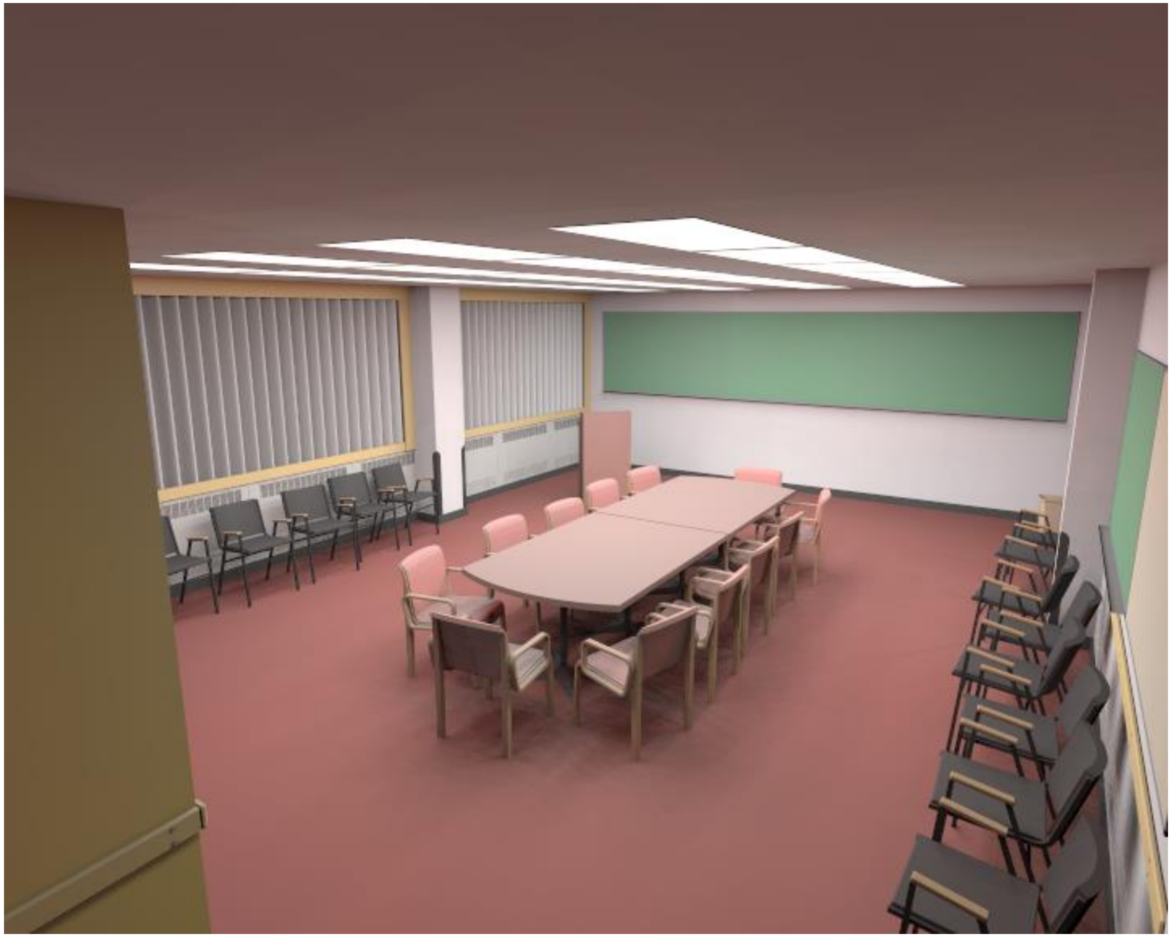
Radiosity Algorithm

- Subdivide the scene in small polygons
- Compute a constant illumination value for each polygon
- Choose a viewpoint and display the visible polygon
  - Keep doing this process



From Donald Fong's slides

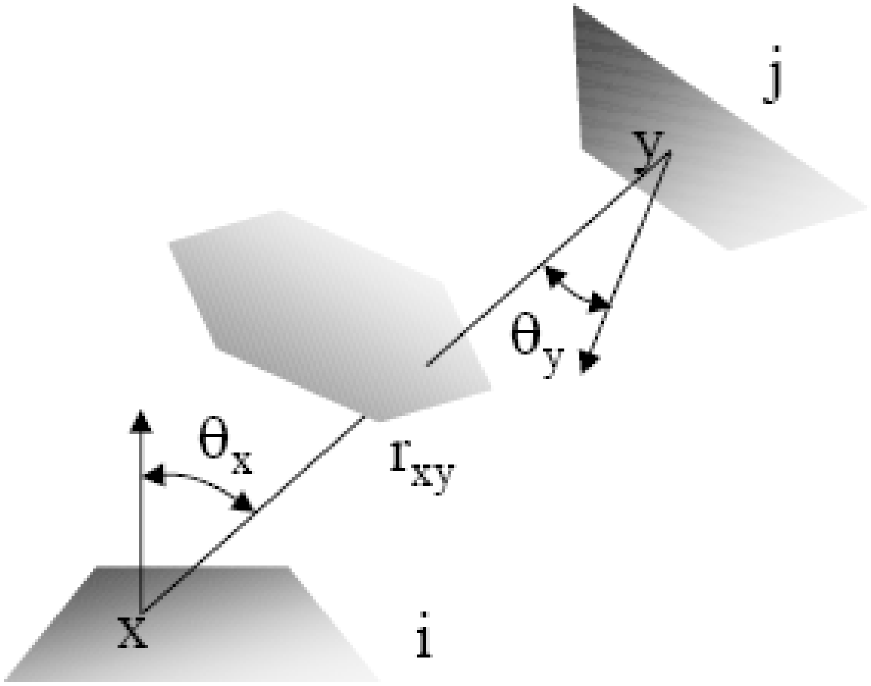
Radiosity Result



Theatre Scene

Compute Form Factors

$$F(j \to i) = \frac{1}{A_j} \int_{A_i} \int_{A_j} \frac{\cos\theta_x \cdot \cos\theta_y}{\pi \cdot r_{xy}^2} \cdot V(x,y) \cdot dA_y \cdot dA_x$$



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Radiosity Equation

- **Radiosity for each polygon *i***

$$B_i = B_{e,i} + \rho_i \sum_j B_j F(i \rightarrow j)$$

- **Linear system**
  - B_i : radiosity of patch i (unknown)
  - $B_{e,i}$: emission of patch i (known)
  - ρ_I : reflectivity of patch i (known)
  - F(i→j): form-factor (coefficients of matrix)

Linear System of Radiosity

Known

Known

$$\begin{bmatrix} 1-\rho_1 F(1\to 1) & -\rho_1 F(1\to 2) & \dots & -\rho_1 F(1\to n) \\ \vdots & \vdots & \ddots & \vdots \\ -\rho_n F(n\to 1) & -\rho_n F(n\to 2) & \dots & 1-\rho_n F(n\to n) \end{bmatrix} \begin{bmatrix} B_1 \\ \vdots \\ B_n \end{bmatrix} = \begin{bmatrix} B_{e,1} \\ \vdots \\ B_{e,n} \end{bmatrix}$$

Unknown

$$\underline{A}X = \underline{B}$$

How to Solve Linear System

- Matrix inversion
  - Takes O(n^3)
- Gather methods
  - Jacobi iteration
  - Gauss-Seidel
- Shooting
  - Southwell iteration

Iterative Approaches

- Jacobi iteration
  - Start with initial guess for energy distribution (light sources)
  - Update radiosity of all patches based on the previous guess

$$B_i = B_{e,i} + \rho_i \sum_j B_j F(i \rightarrow j)$$

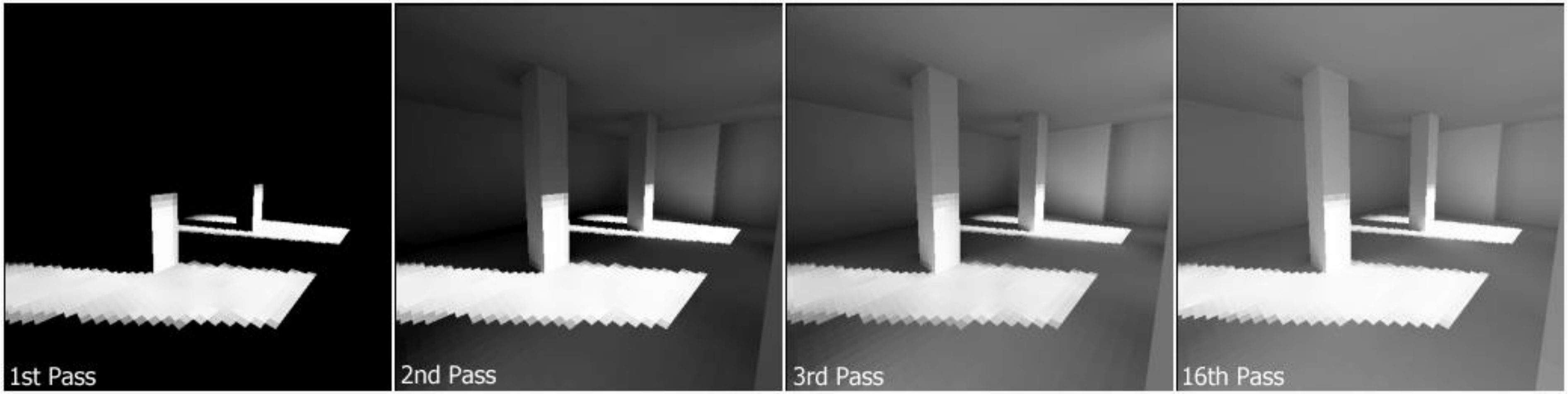
New values

Old values

  - Repeat until converged
- Guass-Seidel iteration
  - New values used immediately

Progress of Update Steps

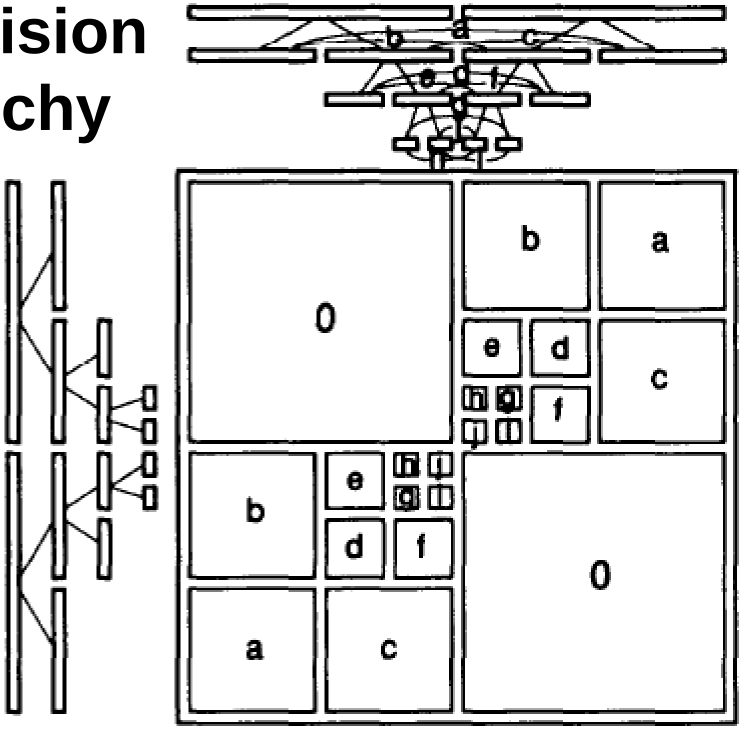
- **Update step supports the light bounce**



Multi-Resolution Approach

- A Rapid Hierarchical Radiosity Algorithm, Hanrahan, et al, SIGGRAPH 1991

Subdivision hierarchy



Block diagram of the form factor matrix

- Refine triangles only if doing so improves the foam factor accuracy above a threshold

Hybrid and Multipass Methods

- Ray tracing
  - Good for specular and refractive indirect illumination
  - View-dependent

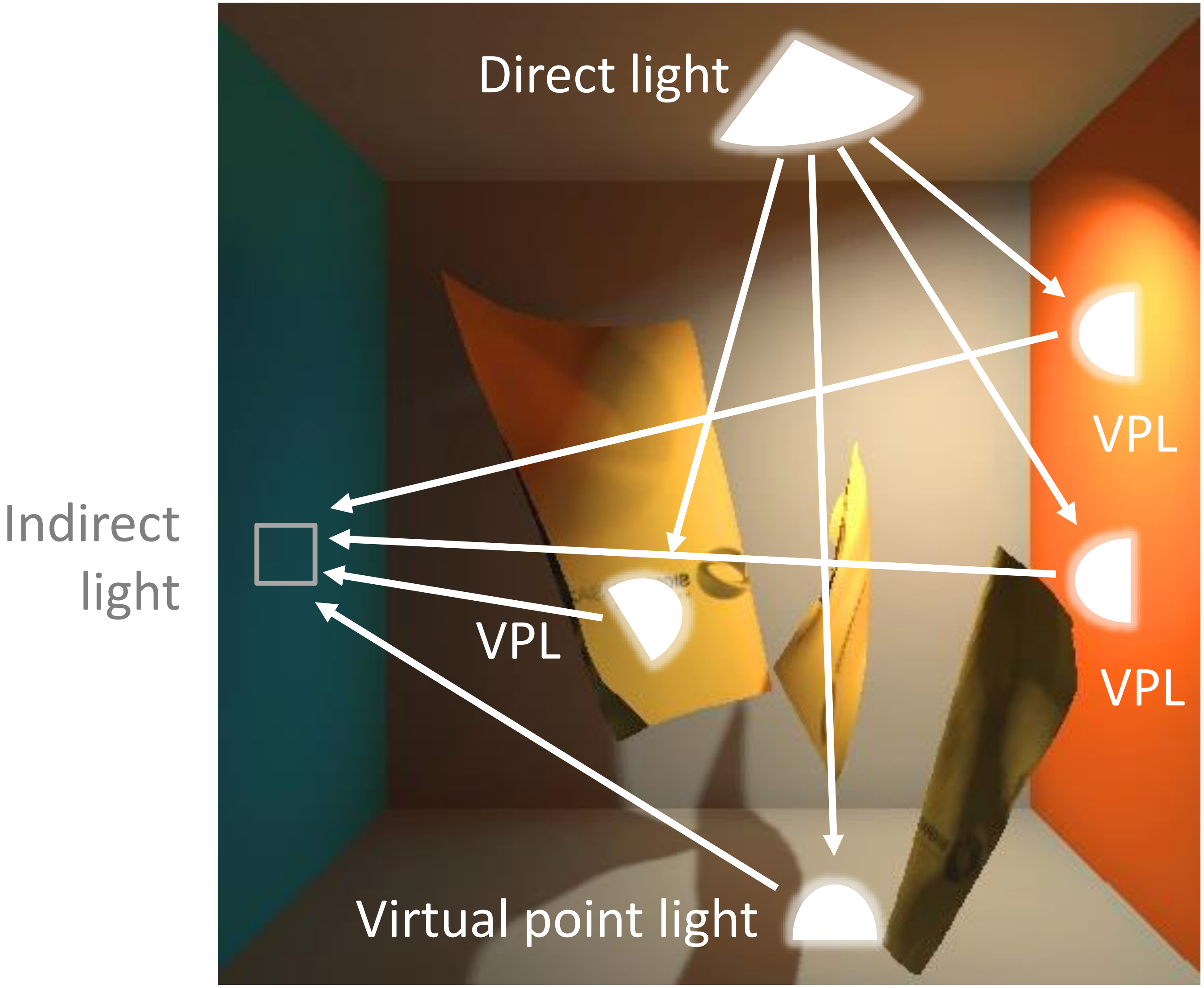
- Radiosity
  - Good for diffuse
  - Allows interactive rendering
  - Does not scale well for massive models

- Hybrid methods
  - Combine both of them in a way

Instant Radiosity

- Use the concept of radiosity
- Map its functions to those of classic rendering pipeline
  - Utilize fast GPU
- Additional concepts
  - Virtual point lights
  - Shadow maps

Instant Radiosity



Class Objectives were:

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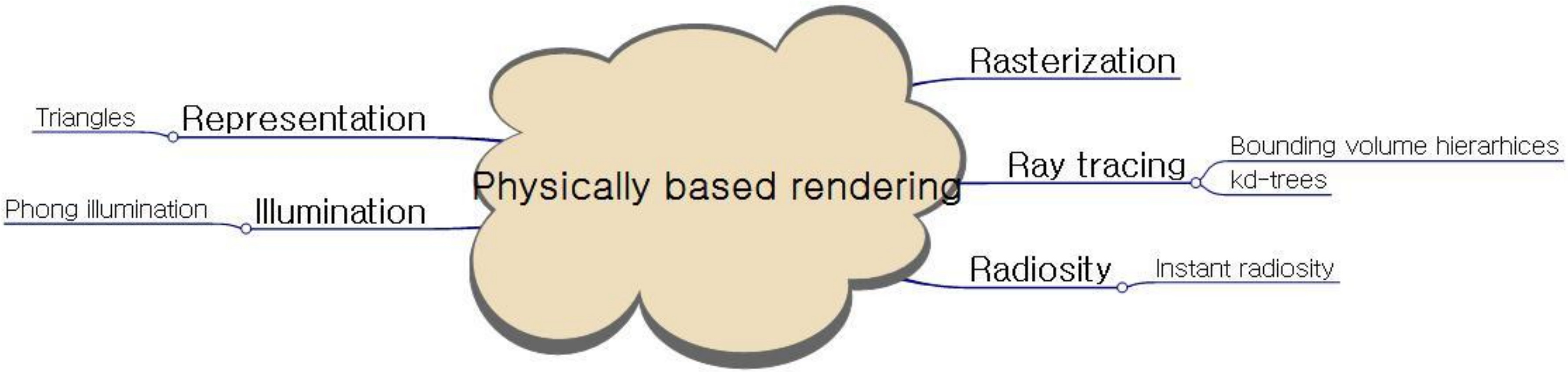

Homework

- **Go over the next lecture slides before the class**
- **Watch 2 paper videos and submit your summaries every Mon. class**
  - **Just one paragraph for each summary**

Example:

Title: XXX XXXX XXXX

Abstract: this video is about accelerating the performance of ray tracing. To achieve its goal, they design a new technique for reordering rays, since by doing so, they can improve the ray coherence and thus improve the overall performance.

Next Time

- **Radiometry and rendering equation**