CS580:
Radiosity

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(윤성의)

Course URL:
http://sgvr.kaist.ac.kr/~sungeui/GCG

Schedule

- **Apr. 23, 25: Students Presentation I (2 talks per each class)**
- **Apr. 30, May 2: SP**

- **May 7 May 9 Mid-term project presentation**
- **May 14, 16 Students Presentation I (2 talks per each**

- **May 21 23; reservation (no class for now; I'm attending a conf.)**
- **May 28 30: SP**
- **June 4, 6 Final presentation**
- **June 11, 13 reservation for now (exam period, no class for now)**

Announcements

- Make a project team of 2 or 3 persons for your final project
    - Each student has a clear role
    - Declare the team at the KLMS by Apr-1; you don’t need to define the topic by then
- Each student
    - Present two papers related to the project in each talk slot
    - 25 min for each talk; we will have 10 min Q&A
- Each team
    - Give a mid-term review presentation for the project
    - Give the final project presentation

Deadlines

- **Declare project team members**
  - **By 4/1 at KLMS**
  - **Confirm schedules of paper talks and project talks at 4/2**

- **Declare two papers for student presentations**
  - **by 4/10 at KLMS**
  - **Discuss them at the class of 4/11**

Class Objective (Ch. 11)

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

History

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

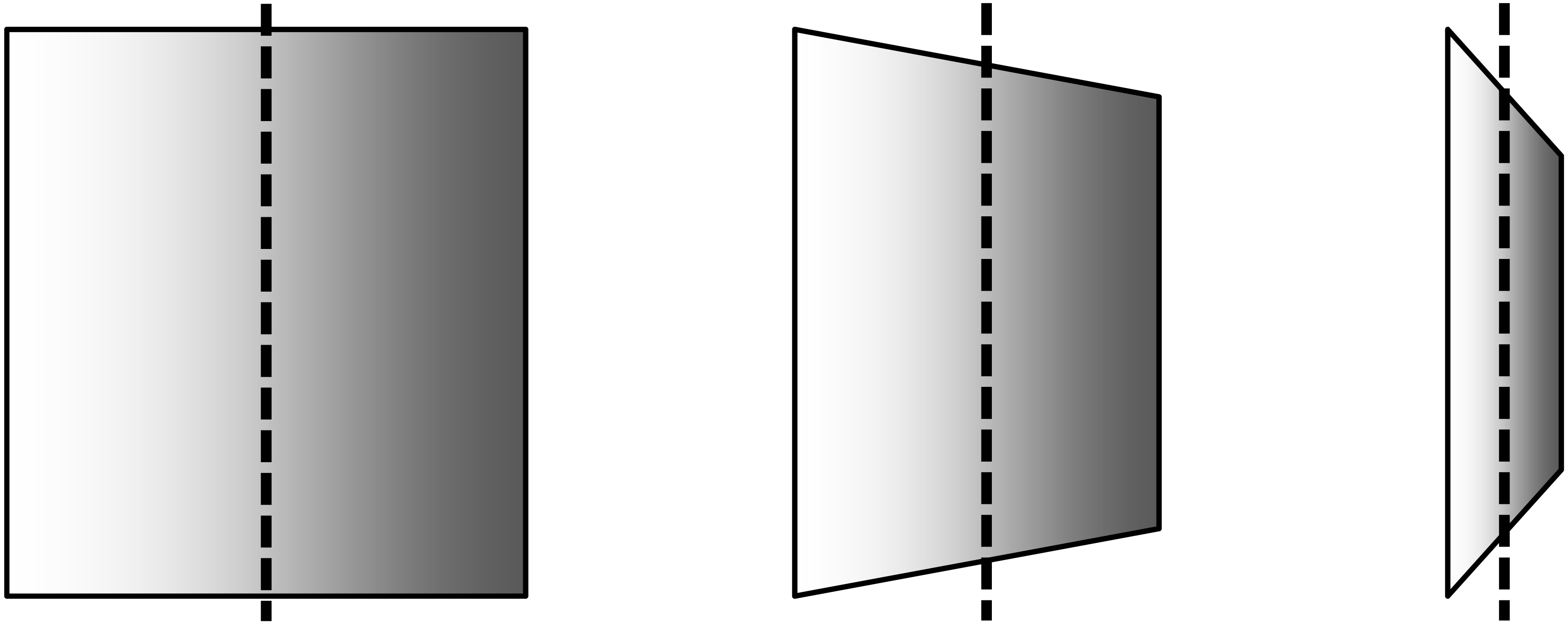
- Radiosity (1984)
  - Global illumination in diffuse scenes

- 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

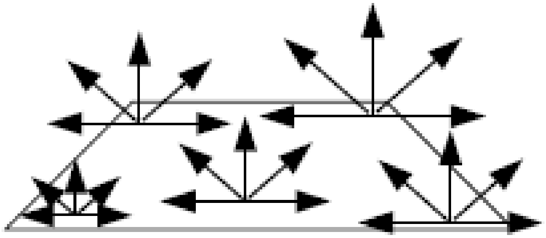
Key Idea #1: Diffuse Only



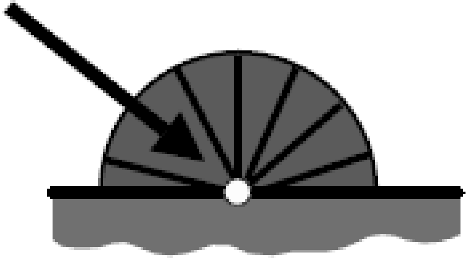
- **Radiance independent of direction**
  - **Surface looks the same from any viewpoint**
  - **No specular reflection**

Diffuse Surfaces

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



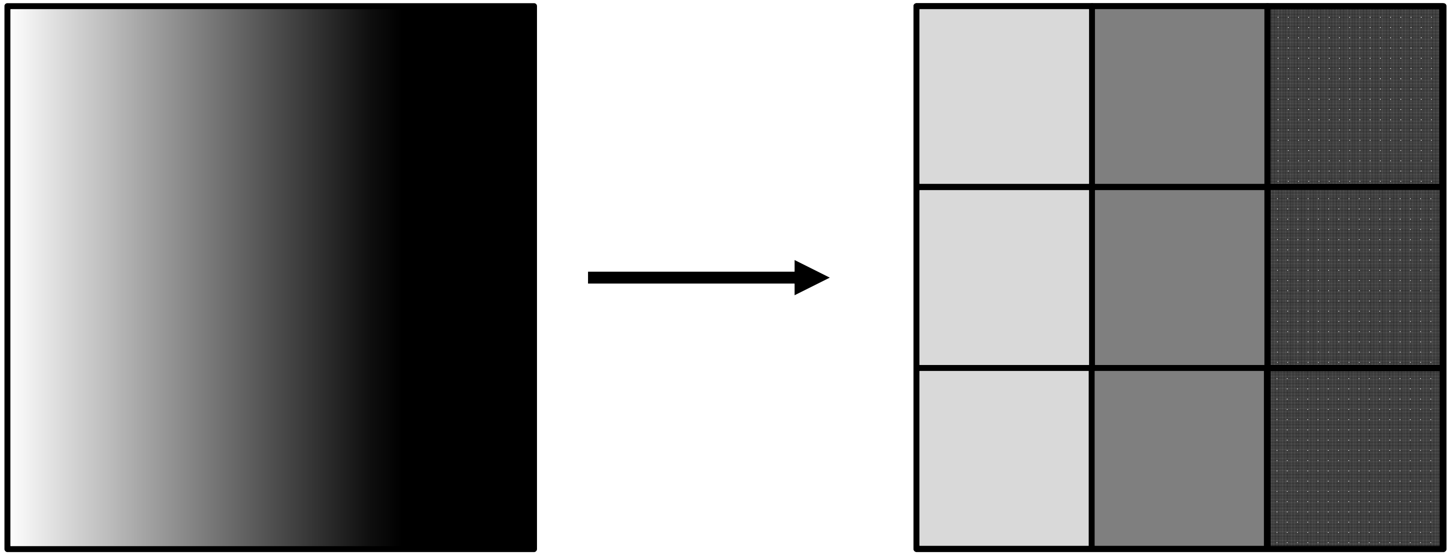
- **Diffuse reflector**
  - **Constant reflectivity**



From kavita's slides

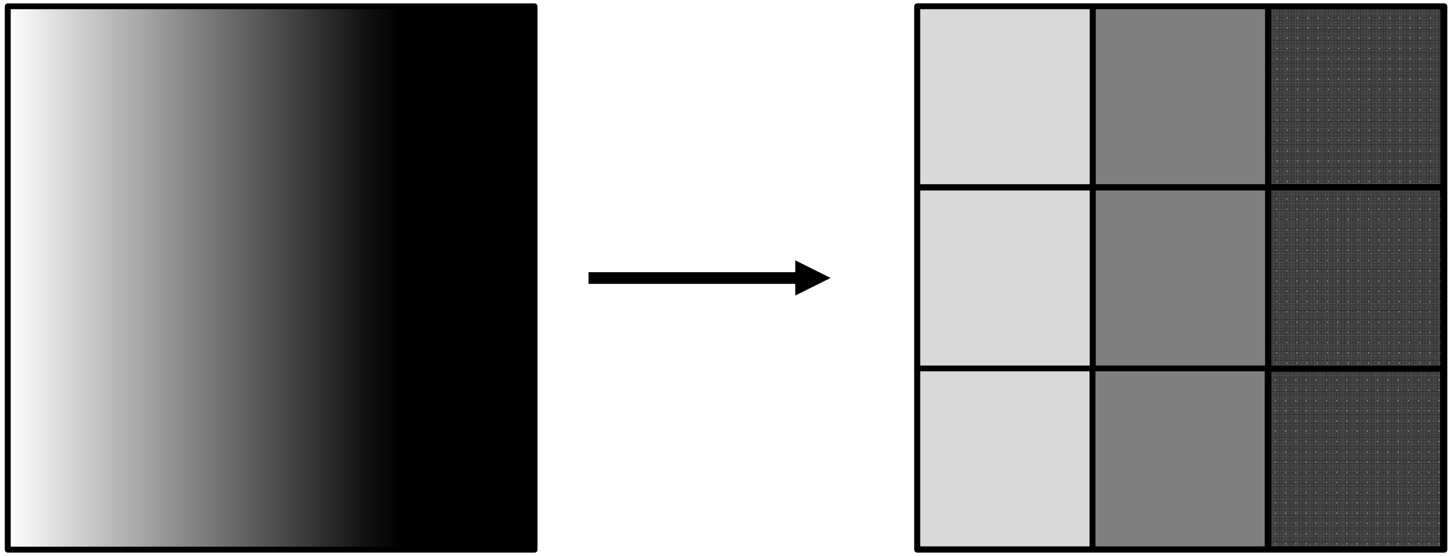
Key Idea #2: Constant Polygons

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



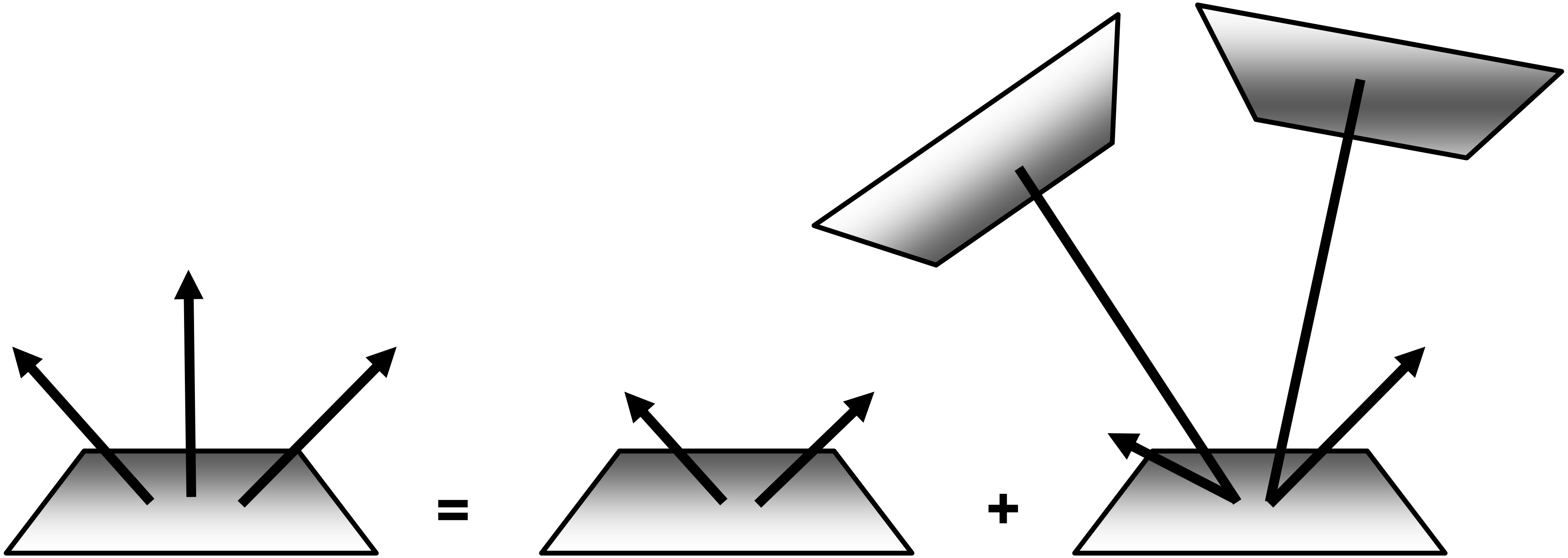
  - **Subdivide scene into small polygons**

Constant Radiance Approximation



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

Radiosity Equation



Radiosity = **Self-emitted radiosity** + **Reflected radiosity**

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

Radiosity Equations

- **Radiosity for each polygon i**

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

$$\vdots$$

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

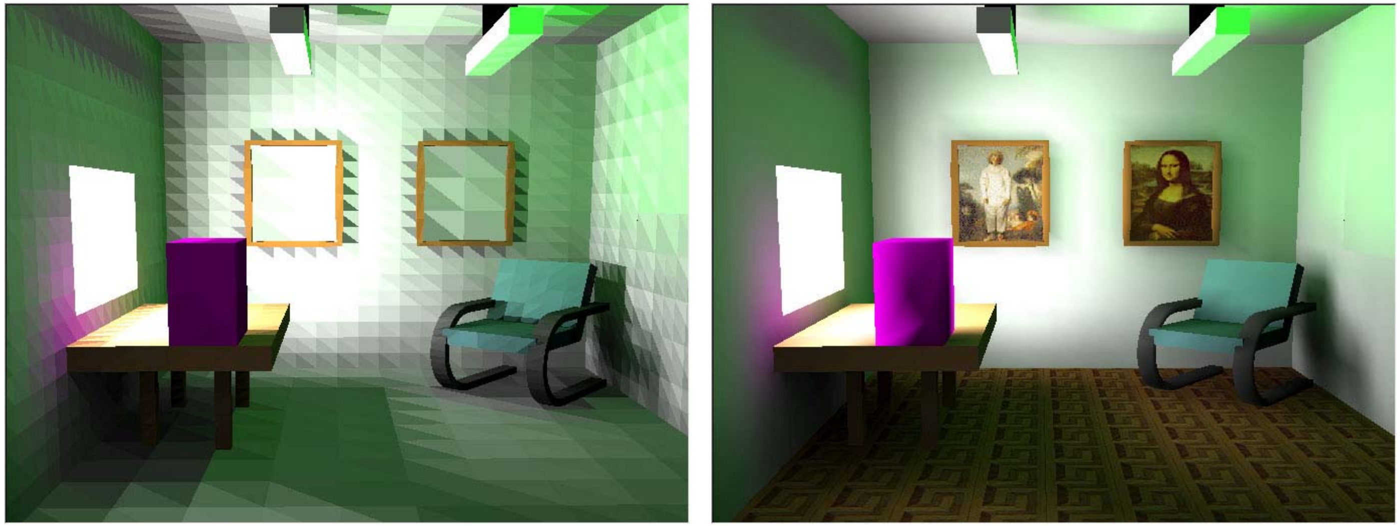
$$\vdots$$

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

- **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



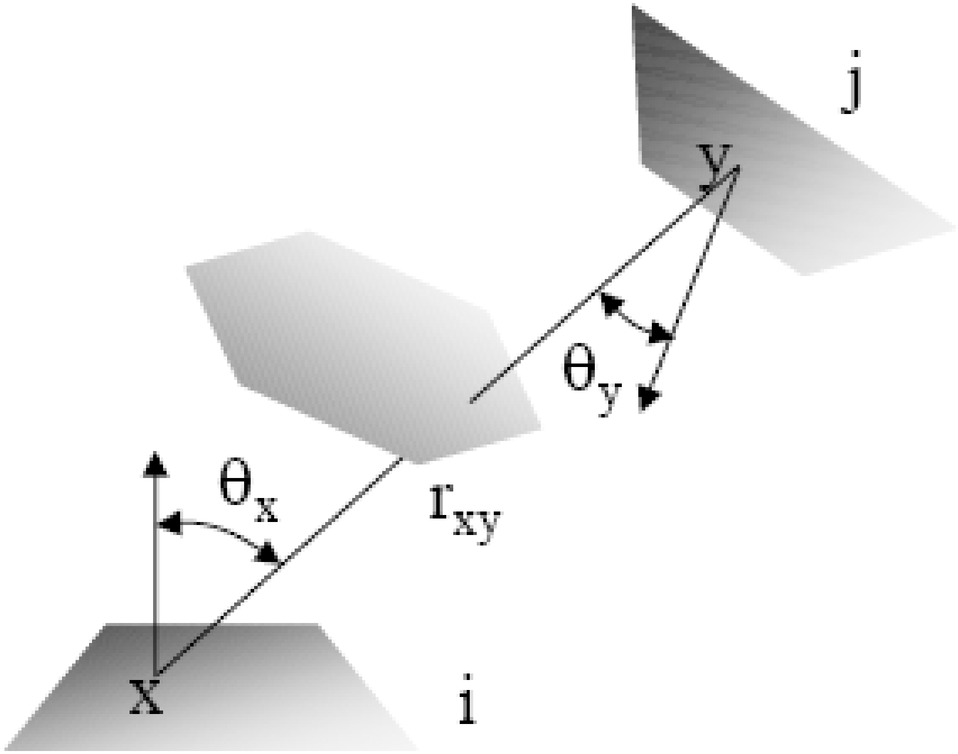
From Donald Fong's slides

Radiosity Result

Theatre Scene

Compute Form Factors

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



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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)
  - $F(i \rightarrow j)$: 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

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**

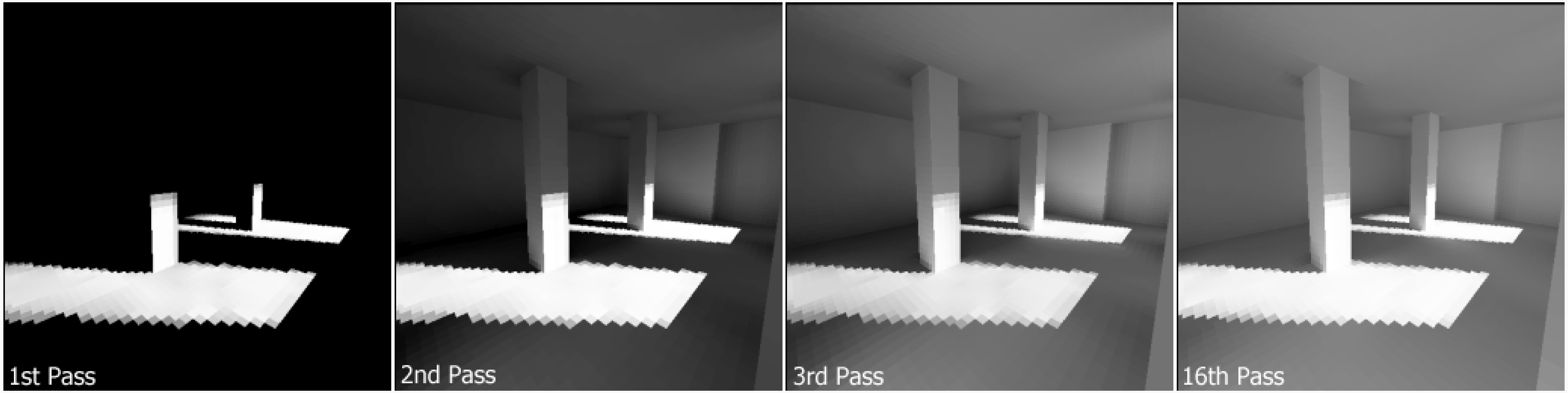
$$B_i = B_{e,i} + \rho_i \sum_j B_j F(i \rightarrow j)$$

New values **Old values**

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

Progress of Update Steps

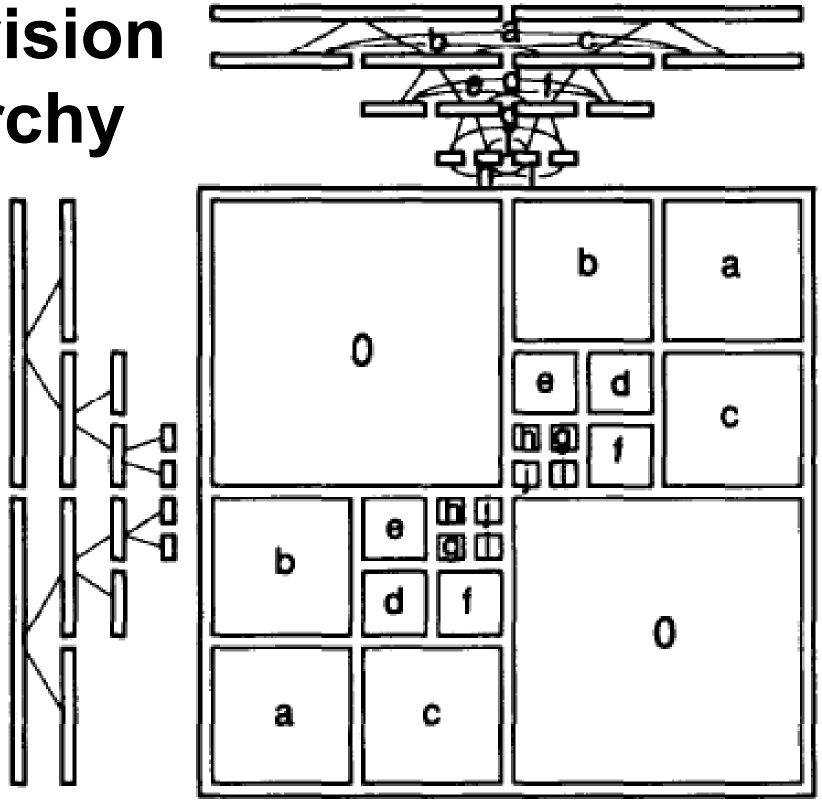
- **Update step supports the light bounce**



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

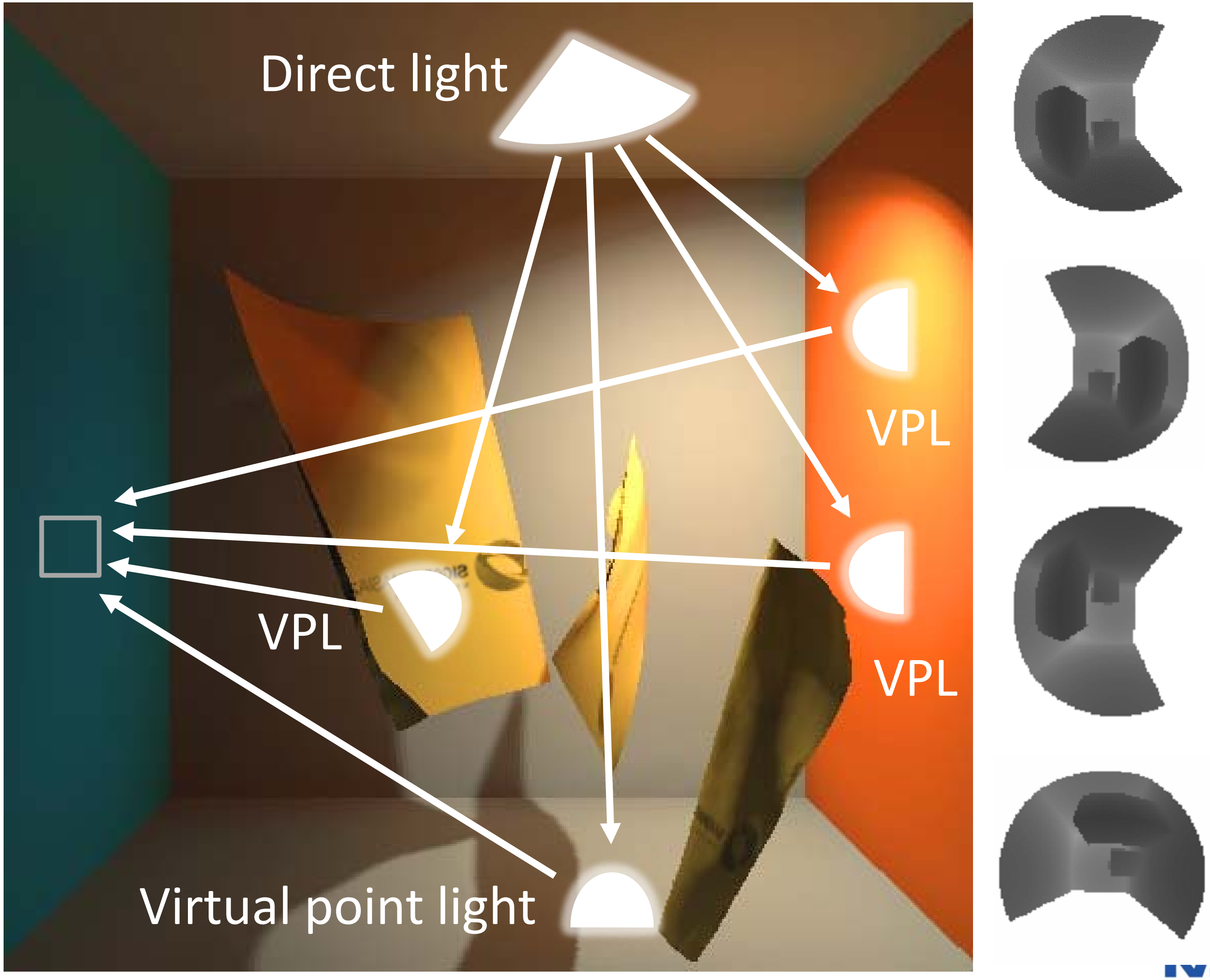
- Radiosity
  - Good for diffuse
  - Allows interactive rendering
  - Does not scale well for massive models

- Hybrid methods
  - Combine both of them in a way

Instant Radiosity

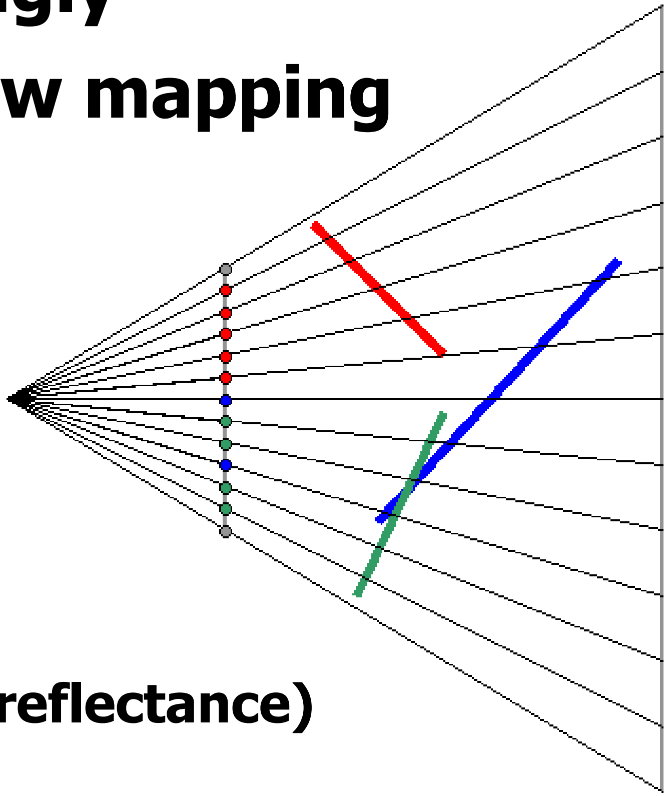
- **Use the concept of radiosity**
- **Map its functions to those of classic rendering pipeline**
  - **Utilize fast GPU**
- **Additional concepts**
  - **Virtual point lights**
  - **Shadow maps**

Instant Radiosity



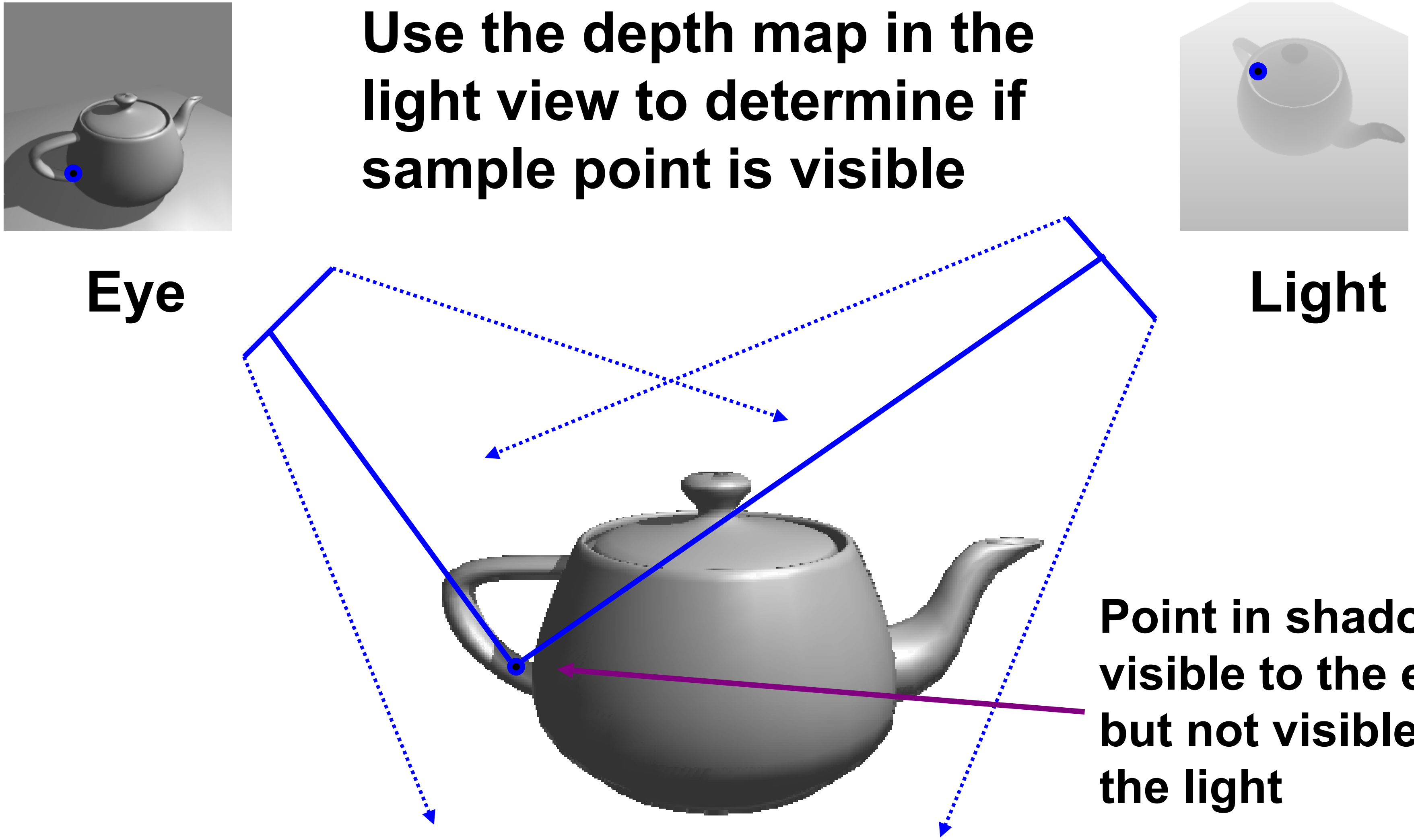
Ray Casting

- For each pixel, find closest object along the ray and shade pixel accordingly
- Produce similar results to shadow mapping



- Advantages
  - Conceptually simple
  - Can support CSG
  - Can take advantage of spatial coherence in scene
  - Can be extended to handle global illumination effects (ex: shadows and reflectance)
- Disadvantages
  - Renderer must have access to entire retained model
  - Hard to map to special-purpose hardware
  - Visibility computation is a function of resolution

Shadow Maps



Use the depth map in the light view to determine if sample point is visible

Point in shadow visible to the eye, but not visible to the light

Class Objectives were:

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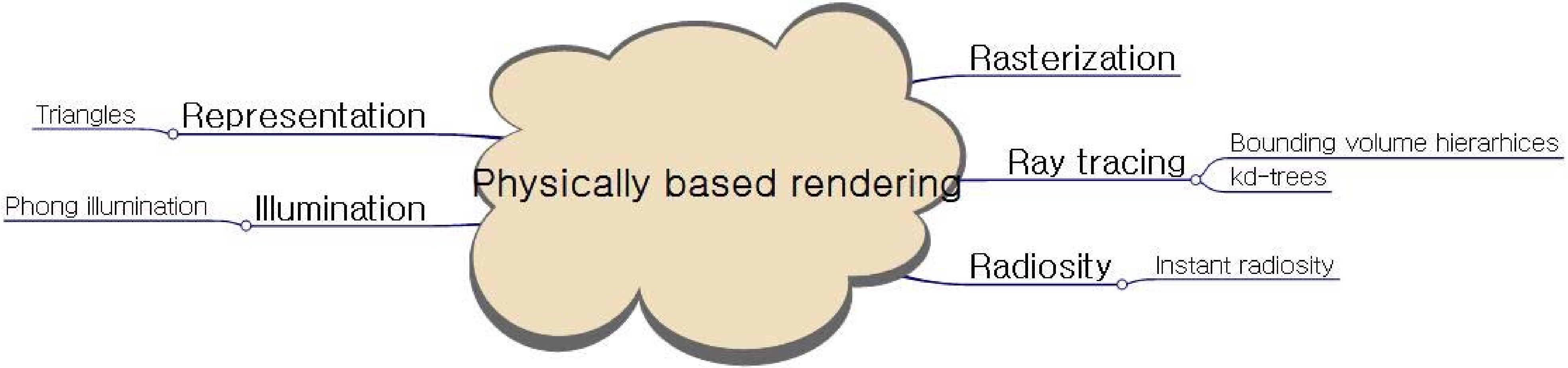

Homework

- **Go over the next lecture slides before the class**
- **Watch 2 paper videos and submit your summaries every Tue. 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**

Any Questions?

- Submit three times before the mid-term exam
- Come up with one question on what we have discussed in the class and submit at the end of the class
  - 1 for already answered questions
  - 2 for questions that have some thoughts or surprise me