
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

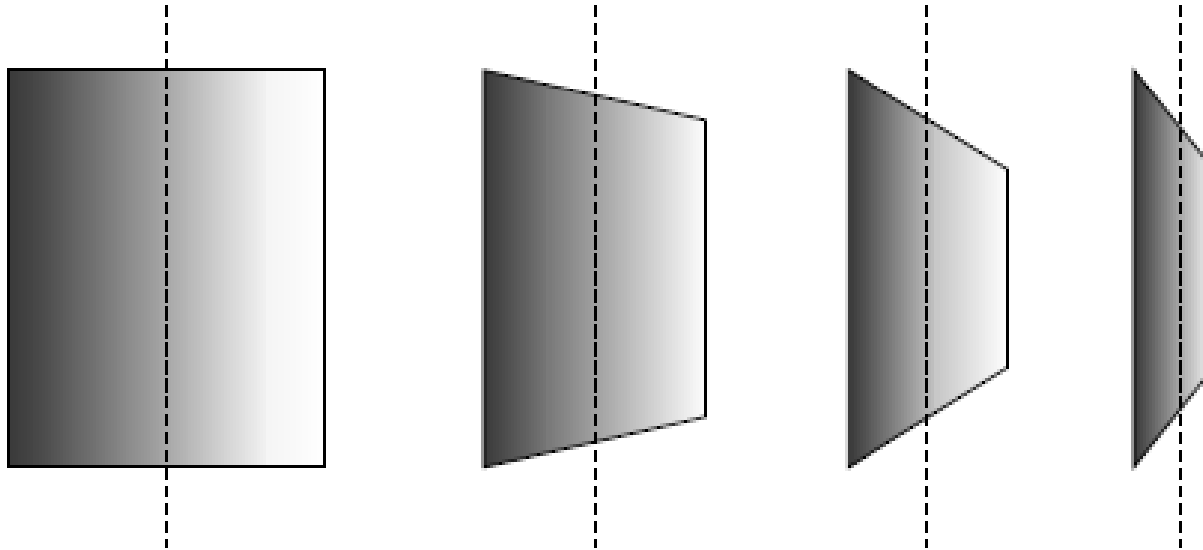
History

- **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



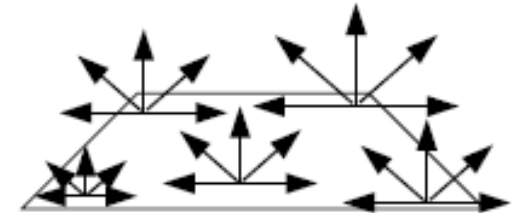
From kavita's slides

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

Diffuse Surfaces

- Diffuse emitter

- $L(x \rightarrow \Theta) = \text{constant over } \Theta$



- Diffuse reflector

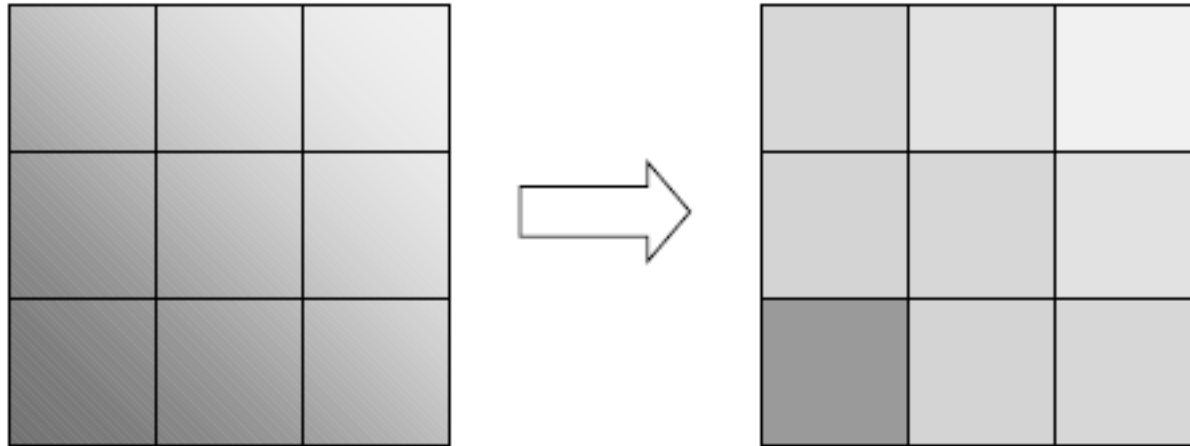
- Constant reflectivity



From kavita's slides

Key Idea #2: Constant Polygons

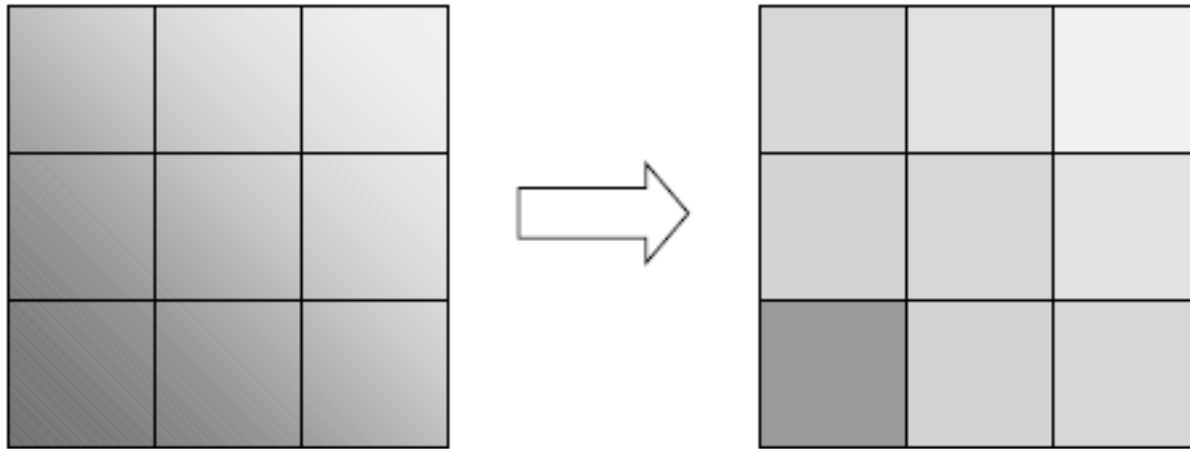
- Radiosity is an approximation
 - Due to discretization of scene into patches



From kavita's slides

- Subdivide scene into small polygons

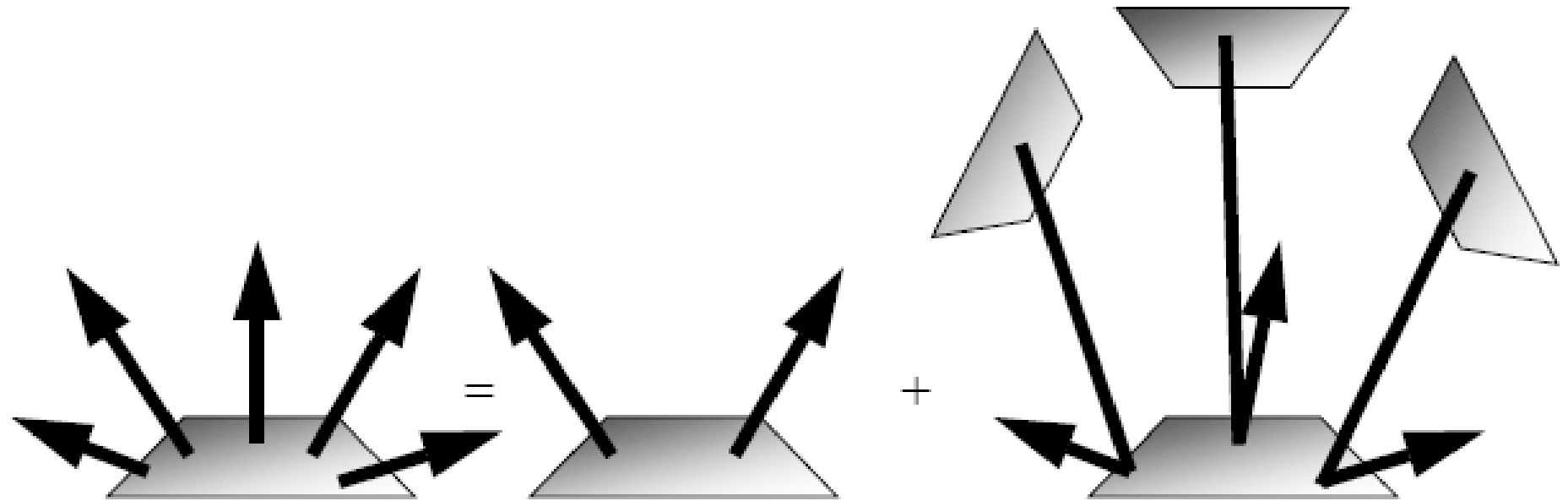
Constant Radiance Approximation



From kavita's slides

- Radiance is constant over a surface element
 - $L(x) = \text{constant over } x$

Radiosity Equation



Emitted radiosity = self-emitted radiosity + received & reflected radiosity

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

Radiosity Equation

- Radiosity equation for each polygon i

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

$$Radiosity_2 = Radiosity_{self,2} + \sum_{j=1}^N a_{j \rightarrow 2} Radiosity_j$$

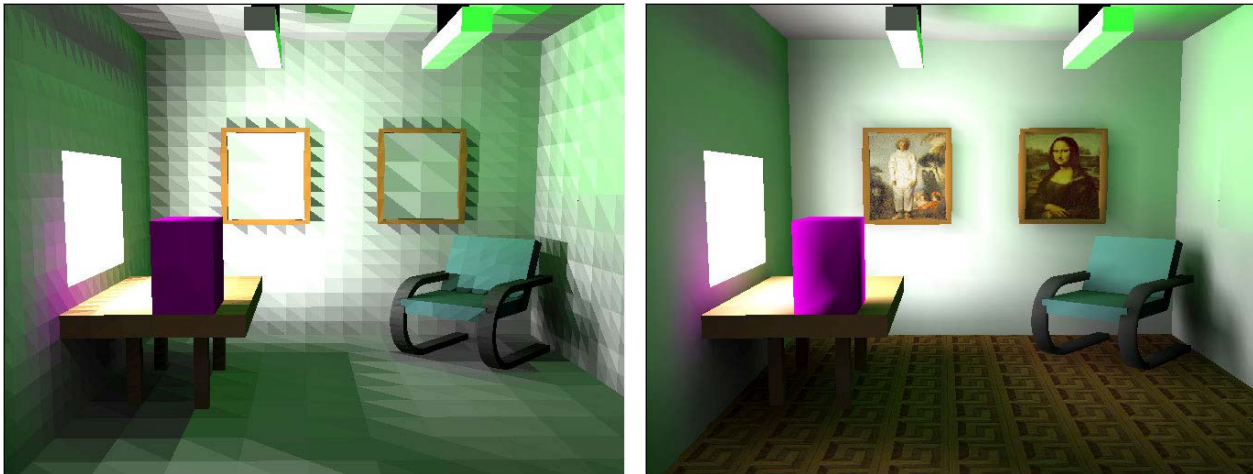
...

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

- N equations; 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

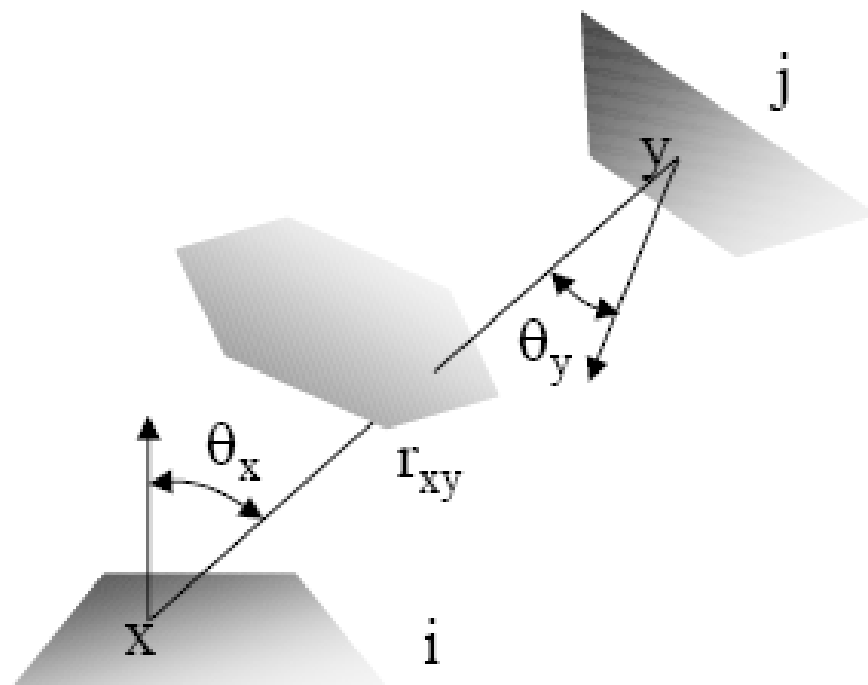


Theatre Scene



Compute Form Factors

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



Radiosity Equation

- Radiosity for each polygon i

$$\forall i : B_i = B_{e,i} + \rho_i \sum_{j=1}^N B_j F(i \rightarrow j)$$

- 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 Equations

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

known known

↓

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

$$B_i = B_{e,i} + \rho_i \sum_{j=1}^N B_j F(i \rightarrow j)$$

new value

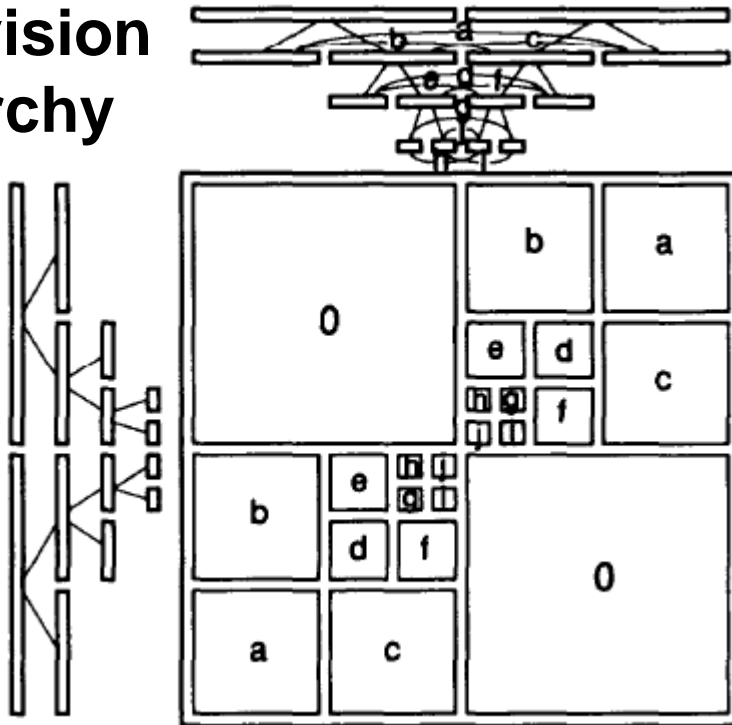
old values

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

Multi-Resolution Approach

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

Subdivision hierarchy



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

Block diagram of the form factor matrix

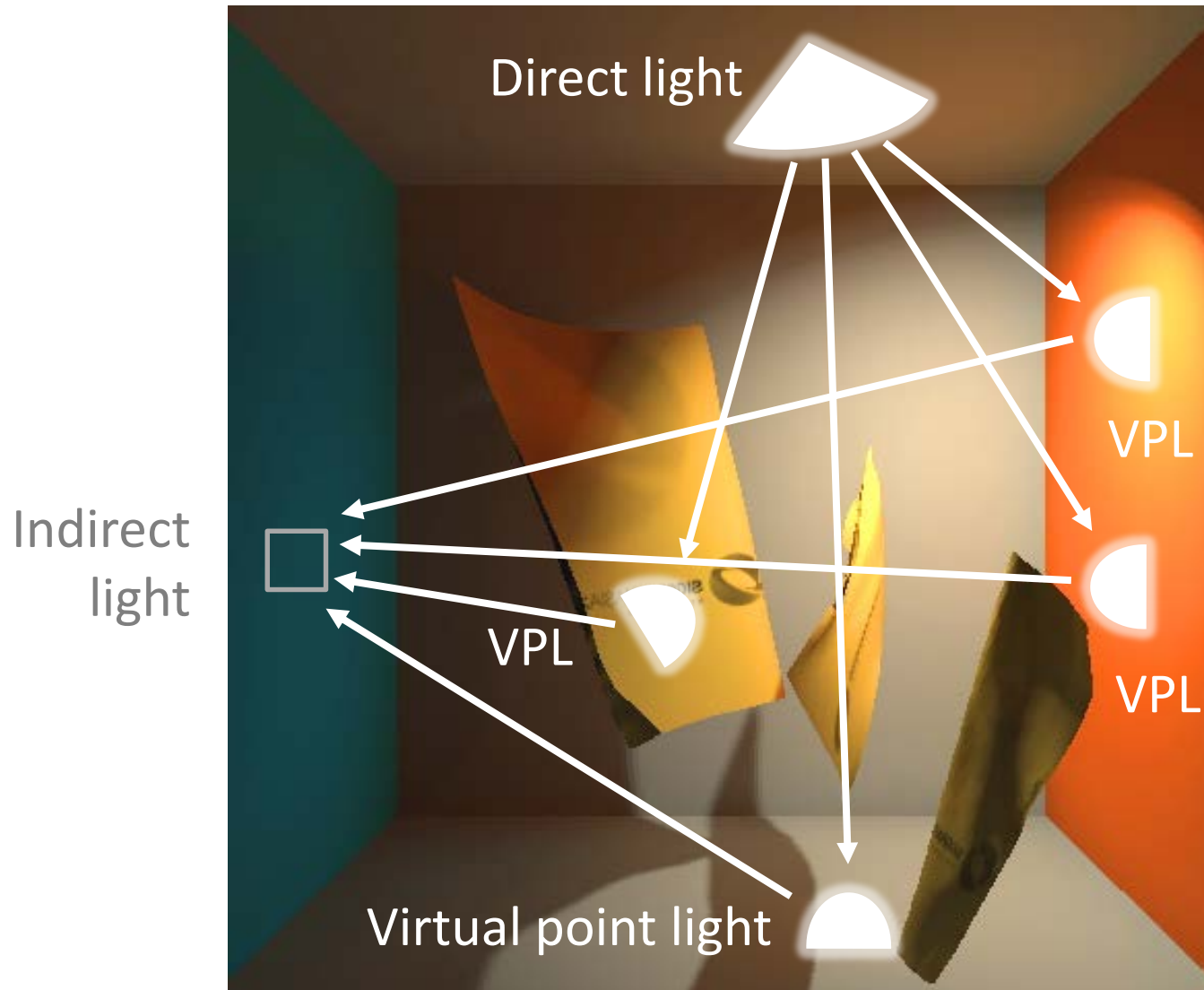
Hybrid and Multipass Methods

- **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

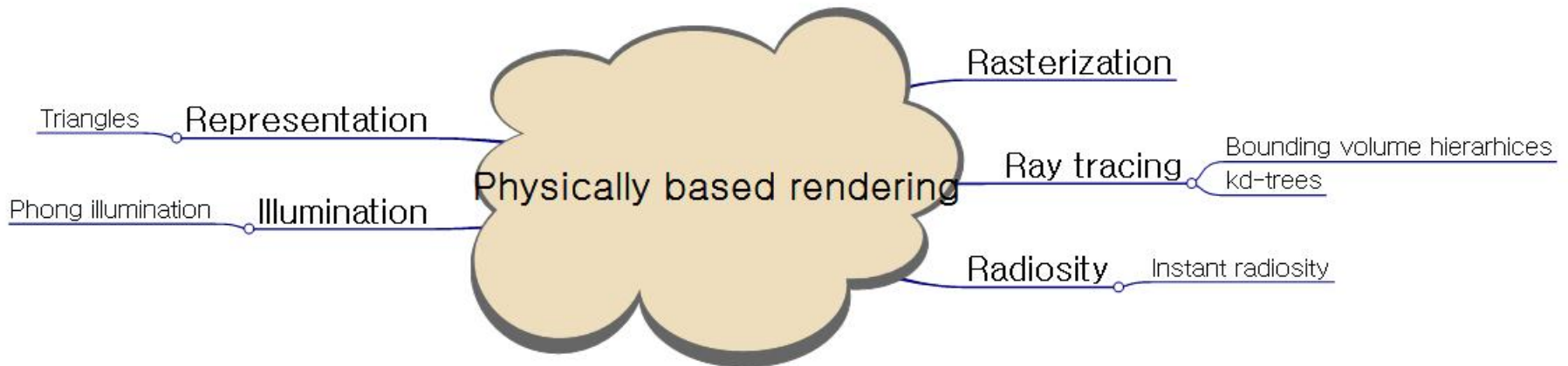
- Use the concept of radiosity
- Map its functions to those of classic rendering pipeline
 - Utilize fast GPU
- Additional concepts
 - Virtual point lights
 - Shadow maps

Instant Radiosity



Class Objectives were:

- Understand radiosity
 - Radiosity equation
 - Solving the equation



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 four times in Sep./Oct.**
- **Come up with one question on what we have discussed in the class and submit at the end of the class**
 - **1 for typical questions**
 - **2 for questions that have some thoughts or surprise me**