

CS348B: Image Synthesis

Goal: How to generate realistic images?

Applications

- Movies
- Interactive entertainment
- Industrial design
- Virtual reality



Final Fantasy

Interdisciplinary

- Art and perception
- Physics and mathematics
- Computer science

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The Everyday World ...



Troy Maxwell-Hanrahan

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The Everyday World ...



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Modeling & Simulating Appearance

Models

- Light
- Light Sources
- Shapes
- Materials
 - Interfaces: Reflection and texture models
 - Medium: Atmospheric scattering models
- Camera
 - Lens and film

Simulation

- Illumination

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History: Geometric Aspects First

Transformation/clipping and the graphics pipeline

- **Evans and Sutherland**

Hidden line and surface algorithms

- **Sutherland, Sproull, Shumacker**

Simple shading and texturing

- **Gouraud: interpolating colors**
- **Phong: interpolating normals**
- **Blinn, Catmull, Williams ⇒ texturing**

History: Optical Aspects Second

Reflection and texture models

- **Cook and Torrance ⇒ BRDF**
- **Cook, Perlin ⇒ Procedural textures**

Illumination algorithms

- **Whitted ⇒ Ray tracing**
- **Cohen, Goral, Wallace, Greenberg, Torrance
Nishita, Nakamae ⇒ Radiosity**
- **Kajiya ⇒ Rendering equation**

Lighting

Lighting Simulation

The Rendering Equation

Given a scene consisting of geometric primitives with material properties and a set of light sources, compute the illumination at each point on each surface

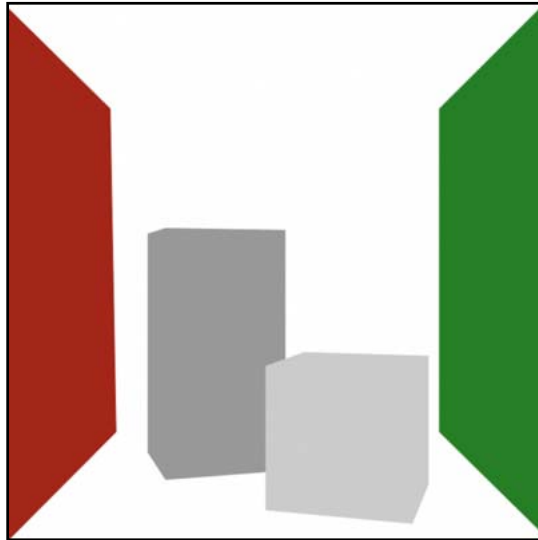
Challenges

- Primitives complex: lights, materials, shapes
- Exponential number of paths, dense coupling

How to solve it?

- Radiosity \Rightarrow Finite element
- Ray tracing \Rightarrow Monte Carlo

Lighting Example: Cornell Box

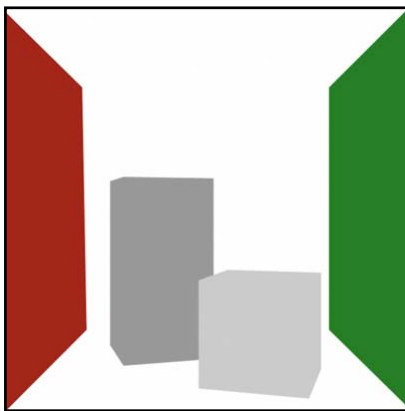


Surface Color

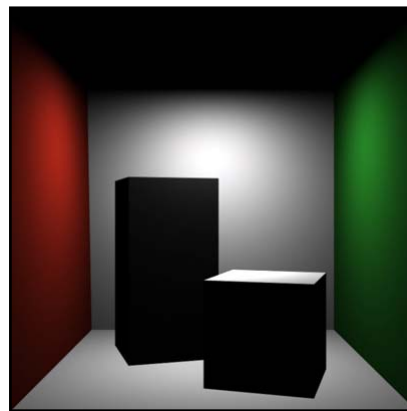
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Lighting Example: Diffuse Reflection



Surface Color

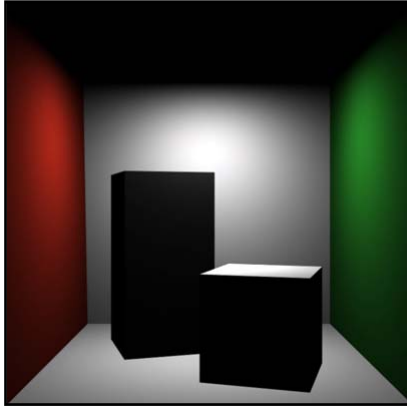


Diffuse Shading

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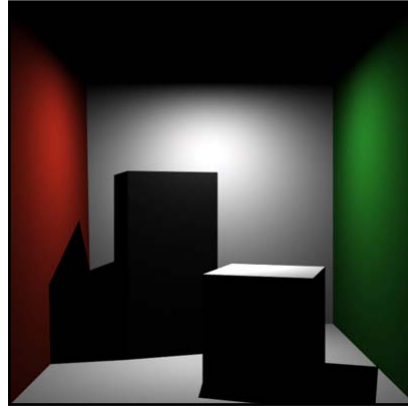
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Lighting Example: Shadows



No Shadows

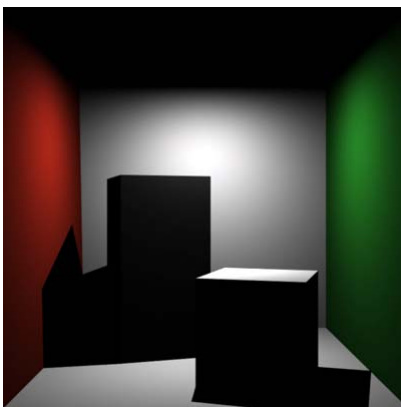
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Shadows

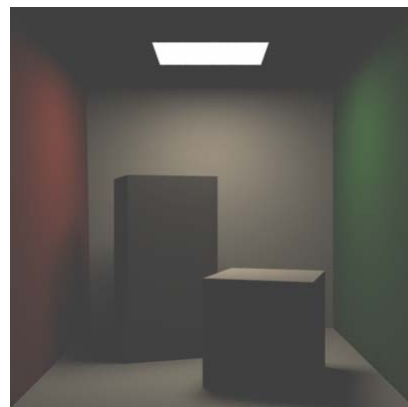
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Lighting Example: Soft Shadows



**Hard Shadows
Point Light Source**

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**Soft Shadows
Area Light Source**

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Radiosity: Cornell Experiment



Measured



Simulated

Program of Computer Graphics
Cornell University

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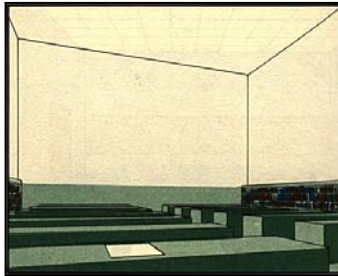
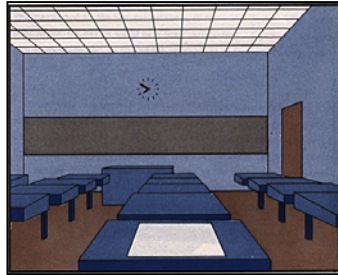
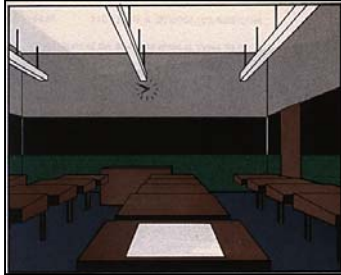
Early Radiosity



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Early, Early Radiosity



Parry Moon and Domina Spencer (MIT), *Lighting Design*, 1948
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Early Diffuse+Glossy

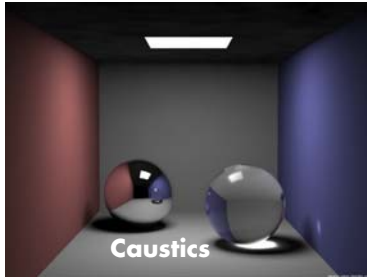
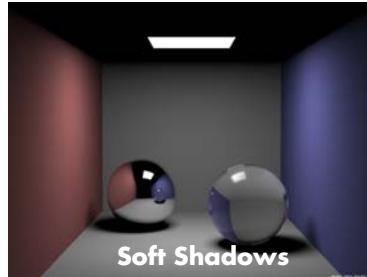


Tribute to Vermeer
Program of Computer Graphics, Cornell

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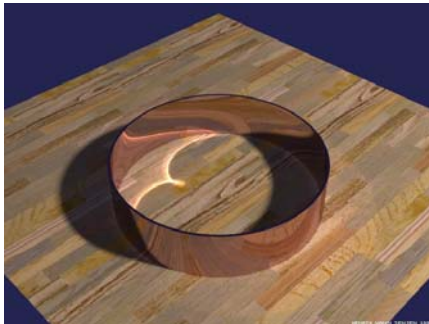
Lighting Effects



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Caustics



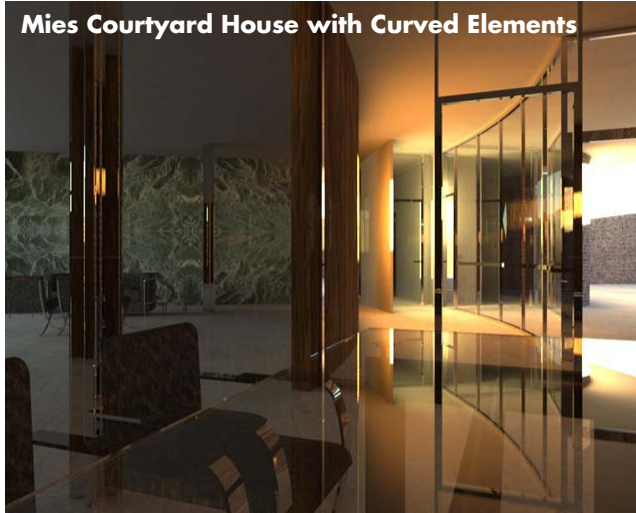
Jensen 1995

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Complex Indirect Illumination

Mies Courtyard House with Curved Elements



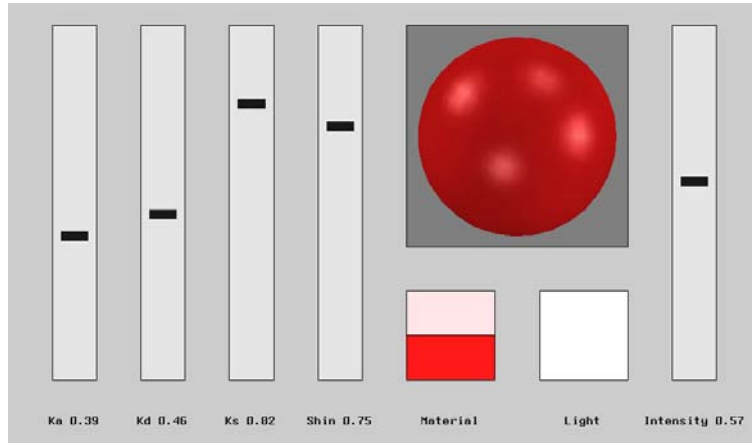
Modeling: Stephen Duck; Rendering: Henrik Wann Jensen

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Materials

Classic Computer Graphics Model

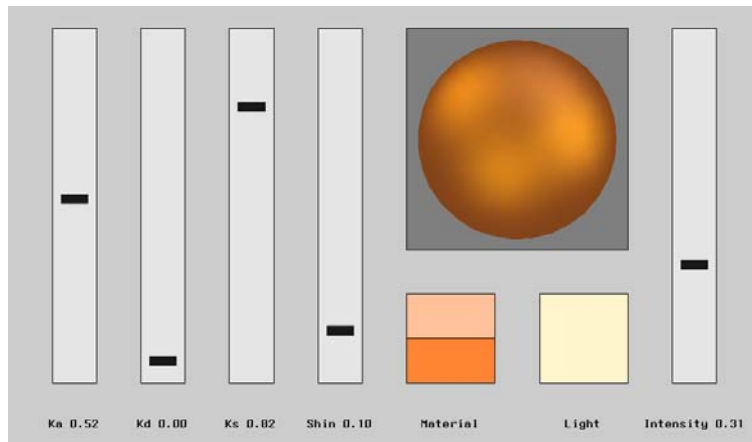


Plastic

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Classic Computer Graphics Model



Brushed Copper

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Material Taxonomy

RenderMan



Plastic
Shiny Plastic



Rough Metal
Shiny Metal



Matte

From Apodaca and Gritz, *Advanced RenderMan*

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Shadows on Rough Surfaces



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Translucency



Surface Reflection

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Subsurface Reflection

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Water Flows on the Venus



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Patinas



A Sense of Time

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Virtual Actors: Faces



Square USA
The digital heroine of the Final Fantasy film.



**Final Fantasy
SquareUSA**

**Jensen,
Marschner,
Levoy,
Hanrahan**

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Virtual Actors: Hair



Black



Brown

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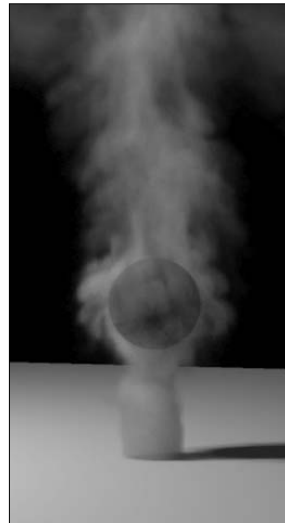
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Coupling Modeling & Rendering



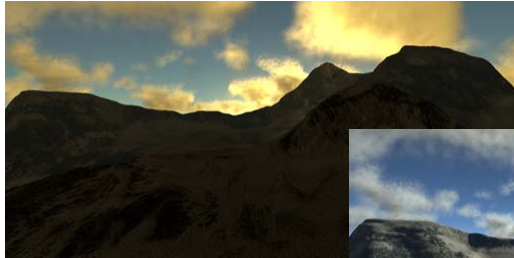
Fedkiw, Stam, Jensen 2001

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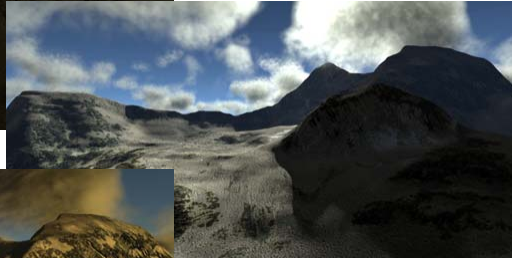
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Clouds and Atmospheric Phenomena



**Hogum Mountain
Sunrise and sunset**

7am



**Modeling: 9am
Simon Premoze
William Thompson
Rendering:
Henrik Wann Jensen**

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6:30pm

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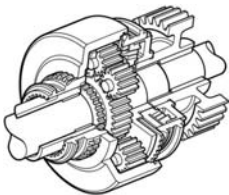


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Final Thoughts

The Nature of Realism



Intigra Engine
Kevin Hulsey



Café Express
Richard Estes, 1975
Oil on canvas

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Perception

Visual cues (space or depth perception)

- Motion
- Shape
- Binocular stereo
- Occlusion and silhouettes
- Linear perspective and foreshortening
- Shading
- Textures
- Shadows
- Aerial perspective: desaturation & blurring
- Transparency