

CS348B: Image Synthesis

Goal: How to generate realistic images?

Applications

- **Movies**
- **Interactive entertainment**
- **Industrial design**
- **Virtual reality**



Final Fantasy

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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**

History: Simple Shading

Simple shading and texturing

- **Gouraud: interpolating colors**
- **Phong: interpolating normals**
- **Blinn, Catmull, Williams \Rightarrow 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

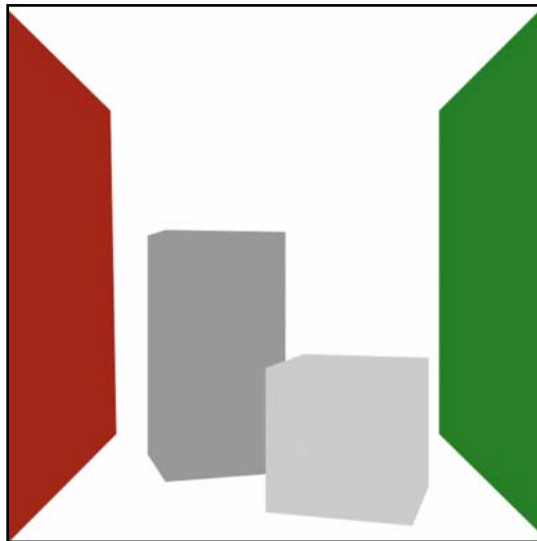
How to solve it?

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

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Lighting Example: Cornell Box

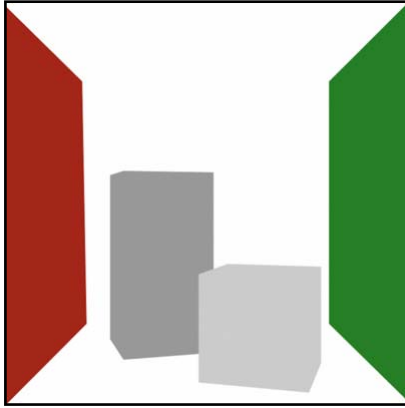


Surface Color

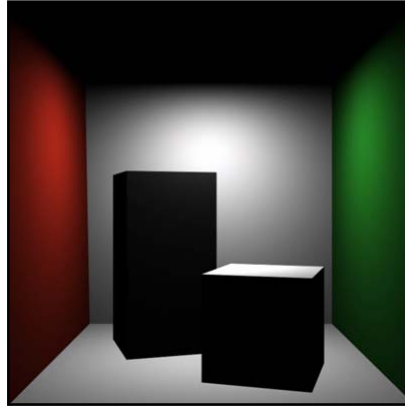
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Lighting Example: Diffuse Reflection



Surface Color

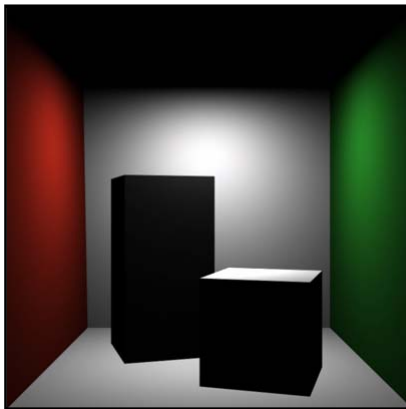


Diffuse Shading

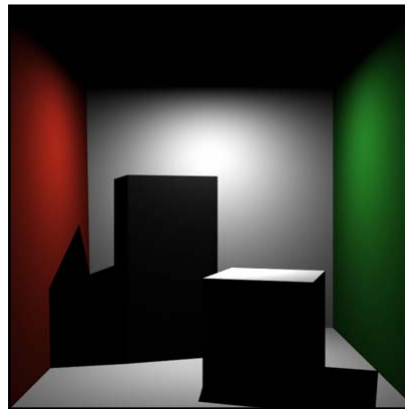
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Lighting Example: Shadows



No Shadows

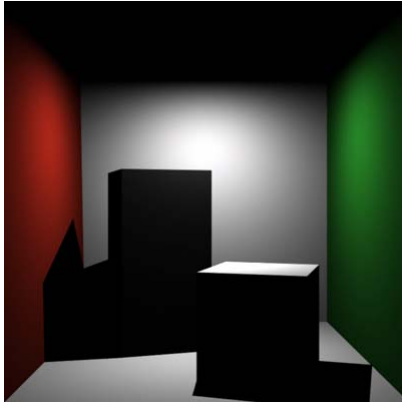


Shadows

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Lighting Example: Soft Shadows



Hard Shadows
Point Light Source



Soft Shadows
Area Light Source

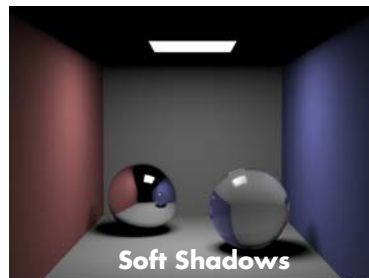
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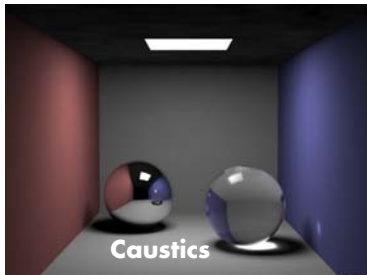
Lighting Effects



Hard Shadows



Soft Shadows



Caustics



Indirect Illumination

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Radiosity: Cornell Experiment



Measured



Simulated

Program of Computer Graphics
Cornell University

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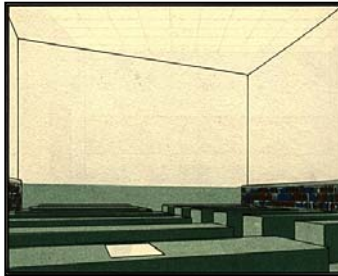
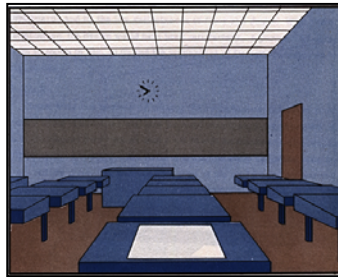
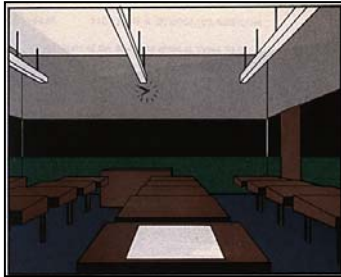
Early Radiosity



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Early, Early Radiosity



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

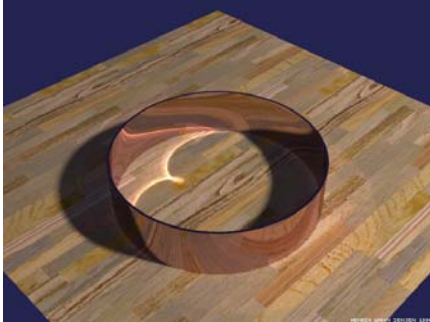


Tribute to Vermeer
Program of Computer Graphics, Cornell

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Caustics



Jensen 1995

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Complex Indirect Illumination



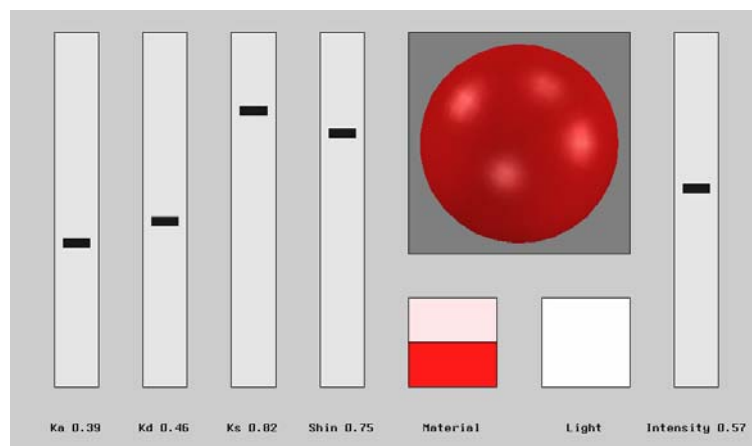
Modeling: Stephen Duck; Rendering: Henrik Wann Jensen

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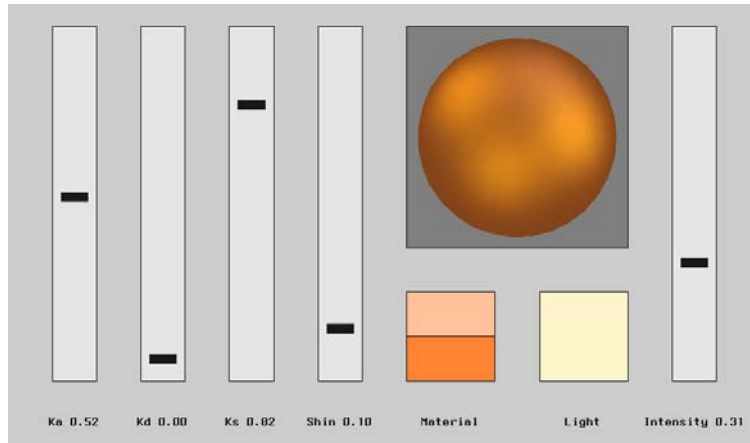
Materials

Classic Computer Graphics Model



Plastic

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



**Jensen,
Marschner,
Levoy,
Hanrahan**

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Virtual Actors: Hair



Black



Brown

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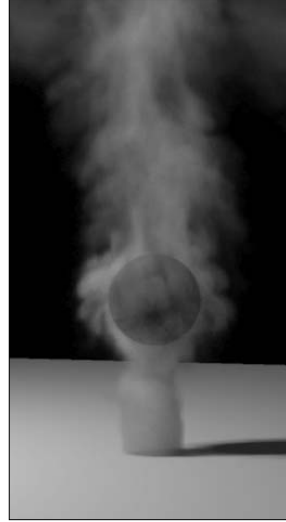
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Coupling Modeling & Rendering



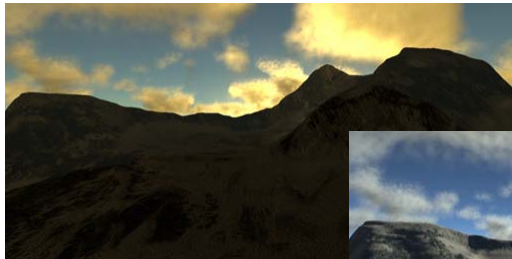
Fedkiw, Stam, Jensen 2001

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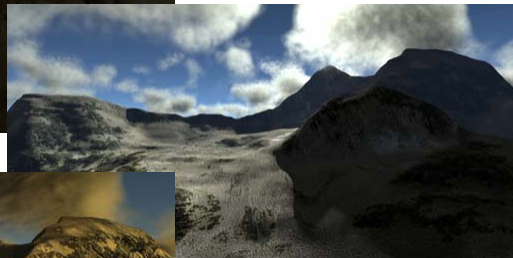
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Clouds and Atmospheric Phenomena



7am

**Hogum Mountain
Sunrise and sunset**



6:30pm

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

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The Everyday World ...



Troy Maxwell-Hanrahan

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The Everyday World ...



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Interdisciplinary

Computer science

- Computational geometry
- Software engineering

Physics

- Radiometry and light fields
- Bidirectional reflectance distribution function
- Radiative transport

Mathematics

- Integral equations
- Monte Carlo and finite element methods

Perception

Art

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