CS348B: Image Synthesis

Goal: How to generate realistic images?

Applications
- Movies
- Games
- Industrial design
- Architecture
- eCommerce
- Cultural heritage
- Holy Grail: Virtual reality

Modeling & Simulating Appearance

Models
- Light and color
- Light sources
- Materials and shapes
  - Interfaces: Reflection and texture models
  - Media: Atmospheric scattering models
- Cameras

Simulation
- Illumination
History: Geometric Aspects First

Perspective viewing (transformations and clipping)
- Roberts, Evans, and Sutherland

Hidden line and surface algorithms
- Roberts (1963)
- Warnock – area subdivision (1969)
- Newell, Newell, Sanchez – painter’s algorithm (1972)
- Sutherland, Sproull, Shumacker (1973)
- Catmull (z-buffer) (1974)

History: Visual Cues Second

Simple shading and texturing
- Gouraud → interpolating colors
- Phong → interpolating normals
- Blinn, Catmull, Williams → texturing

SGI flight 1987

GE Apollo Simulator 1963
History: Physical Simulation Third

Reflection and texture models
- Cook and Torrance → BRDF
- Perlin → Procedural textures
- Cook, Perlin → Shading languages

Illumination algorithms
- Whitted → Ray tracing
- Cohen, Goral, Wallace, Greenberg, Torrance
  Nishita, Nakamae → Radiosity
- Kajiya → Rendering equation

Lighting
Lighting: Diffuse Reflection

Surface Color

Diffuse Shading
Point Light Source

Lighting: Shadows

No Shadows
Point Light Source

Shadows
Point Light Source
Lighting: Soft Shadows

- Hard Shadows
  - Point Light Source

- Soft Shadows
  - Area Light Source

Lighting: Radiosity

- Soft Shadows
  - Area Light Source

- Inter-reflection, Diffuse)
  - Area Light Source
Early Radiosity

Lighting: Inter-Reflection, Glossy

Inter-Reflection, Diffuse Area Light Source

Inter-Reflection, Glossy Area Light Source
“Turing Test”

Measured

Simulated

Program of Computer Graphics
Cornell University

Early Diffuse+Glossy

Tribute to Vermeer
Program of Computer Graphics, Cornell
Caustics

Jensen 1995

Complex Indirect Illumination

Mies Courtyard House with Curved Elements

Modeling: Stephen Duck; Rendering: Henrik Wann Jensen
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
- Infinite number of light paths

How to solve it?

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

Materials
Material Taxonomy

Plastic
Shiny Plastic
Rough Metal
Shiny Metal
Matte

From Apodaca and Gritz, *Advanced RenderMan*

Shadows on Rough Surfaces

Without self-shadowing
With self-shadowing

CS348B Lecture 1
Pat Hanrahan, Spring 2010
Translucency

Surface Reflection    Subsurface Reflection

Water Flows on the Venus

Page 12
Patinas

A Sense of Time

Virtual Actors: Faces

Final Fantasy
SquareUSA

Jensen, Marschner, Levoy, Hanrahan
Virtual Actors: Hair

Black

Brown

Coupling Modeling & Rendering

Fedkiw, Stam, Jensen 2001
Clouds and Atmospheric Phenomena

Hogum Mountain
Sunrise and sunset

7am

9am

Modeling:
Simon Premoze
William Thompson

Rendering:
Henrik Wann Jensen

6:30pm
The Everyday World …

Interdisciplinary

Computer science
- Computational geometry
- Software engineering

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

Mathematics
- Integral equations
- Monte Carlo methods

Perception

Art