Advanced Computer Graphics
(Spring 2013)
CS 283, Lecture 1: Introduction and History
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http://inst.eecs.berkeley.edu/~cs283/sp13

Overview
- CS 283, Advanced Computer Graphics
  - Prerequisite: Done well in CS 184 or equivalent elsewhere
  - Strong interest in computer graphics
- Advanced topics in rendering/geometry-animation
  - Background for modern topics
  - Areas of current research interest
- Goal is background and up to research frontier
  - Aimed at advanced ugrads and beginning PhD students
- Regular lecture class but less rigid than CS 184
- Encourage you to take other CS 28x, 29x in graphics

Demo
- Precomputed relighting: Vase
- Interactive Global Illumination Video

Administrivia
- Website  http://inst.eecs.berkeley.edu/~cs283/sp13
- Lectures Tu-Th 12:30-2:00pm in Soda 320
- E-mail instructor directly for questions, meetings …
  - Generally available after class as well
- Piazza newsgroup
- Grader: Brandon Wang, brandonwang@berkeley.edu
- No books.  Lecture slides online, reading as needed
- TODO: E-mail HW 0 (basic info for roster) by Thu

Course Logistics
- Graded on basis of 4 mostly programming homeworks
  - Can be done in groups of two (or individually)
- Turned in by creating website, sending e-mail
  - Do not modify site after deadline
  - May schedule demo sessions
- No late days.  We assume you start early, work steady
  - Aimed at mature students, assignments 3-4 week duration
- Can substitute research or implementation project for one or more of assignments (encouraged to do so)
  - With instructor approval of specific plan
  - Allows you to focus on topics of interest and research
- See website for more details, assignments

Geometry
- Spline curves, surfaces: 70s – 80s
- Utah teapot: Famous 3D model
- More recently: Triangle meshes often acquired from real objects
Progressive Mesh Simplification

Subdivision Surfaces
- Coarse mesh + subdivision rule
  - Smooth surface = limit of sequence of refinements

Video

Rendering and Appearance
- Core area in computer graphics
- Efficiently and easily create visual appearance
- Long history (1960s to current time): Variety of old and new topics
- From basic visibility and shading, to global illumination, to image-based rendering, to data-driven appearance and light fields
- Many links to physics, math, computer science

Rendering: 1960s (visibility)
- Roberts (1963), Appel (1967) - hidden-line algorithms
- Sutherland (1974) - visibility = sorting

Images from FvDFH, Pixar’s Shutterbug
Slide ideas for history of Rendering courtesy Marc Levoy

Rendering: 1970s (lighting)
- 1970s - raster graphics
  - Blinn (1974) - curved surfaces, texture

Rendering (1980s, 90s: Global Illumination)
- early 1980s - global illumination
  - Whitted (1980) - ray tracing
  - Goral, Torrance et al. (1984) radiosity
  - Kajiya (1986) - the rendering equation
Outline

- Basic Ray Tracing
- Global Illumination
- Image-Based Rendering
- Real-Time Rendering

Ray Tracing History

Ray Tracing in Computer Graphics

"An improved Illumination model for shaded display," T. Whitted, CACM 1979

Resolution:
512 x 512
Time:
VAX 11/780 (1979)
74 min.
PC (2006):
6 sec.

Spheres and Checkerboard, T. Whitted, 1979

Heckbert’s Business Card Ray Tracer

Ray Tracing History

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Global Illumination

Radiosity
Successive Approximation

\[ L_s \]
\[ K \cdot L_s \]
\[ L_s + K \cdot L_s \]
\[ L_s + K \cdot L_s + \ldots K \cdot L_s \]

Rendering Equation (Kajiya 86)

\[ \text{Image-Based Rendering} \]

Outline

- Basic Ray Tracing
- Global Illumination
- Image-Based Rendering
- Real-Time Rendering
Dual Interpretation of Light Field

- Planar Light Field
  - Field radiance
  - UV Array of ST Images
- Surface Light Field
  - Surface radiance
  - ST Array of UV Images

Acquiring Reflectance Field of Human Face [Debevec et al. SIGGRAPH 00]

Illuminate subject from many incident directions

Outline
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Example Images

Images from Debevec et al. 00

Precomputed Radiance Transfer
- Better light integration and transport
  - dynamic, area lights
  - self-shadowing
  - interreflections
- For diffuse and glossy surfaces
- At real-time rates
- Sloan et al. 02

Lytro Light Field Camera

4 degree-of-freedom panorama

Images from Lytro Light Field Camera

Precomputed Radiance Transfer Examples

- Point light
- Area light
- Area lighting, no shadows
- Area lighting, shadows

Outline Examples

- Basic Ray Tracing
- Global Illumination
- Image-Based Rendering
- Real-Time Rendering
Precomputation: Spherical Harmonics

Diffuse Transfer Results

Arbitrary BRDF Results

Relighting as a Matrix-Vector Multiply

Physical Simulation and Animation

- Recent clothing animation video

Game footage recorded from Xbox 360 version of

Star Wars: The Force Unleashed

Game footage copyright 2008 LucasArts, Inc. Used with permission.
Imaging
- Processing of images important part of graphics
- Especially in context of photography: Combine photos, manipulate images
- Recent video on automatic cinemagraph portraits
- Computational photography. Examples flash/no-flash, fluttered shutter, new light field cameras
- Community and Internet photo collections
- Basic ideas like HDR and Texture Synthesis
  - Both largely developed at Berkeley

High Dynamic Range
- Photographs at multiple exposures
- Combine and tonemap

Multiple Photographs

Combined and Tonemapped

Texture Synthesis
- From small image to larger (keep texture)
- Novel idea: Copy image patches (quilting)

Summary
- Graphics is Modeling/Geometry, Rendering, Animation/Simulation, Imaging and much more
- Course looks at all of these
- Goal to develop modern ideas, understand topics at the research/industry frontier
- 4 programming assignments (groups of 2)
  - Progressive Meshes
  - Path Tracer
  - Real-Time / Image-Based Rendering
  - Project
- Can substitute research/implementation for any!