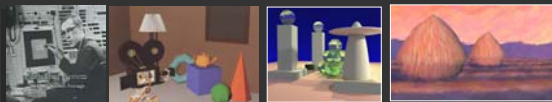


Computer Graphics (Fall 2008)

COMS 4160, Lecture 1: Overview and History

Ravi Ramamoorthi

<http://www.cs.columbia.edu/~cs4160>



Goals

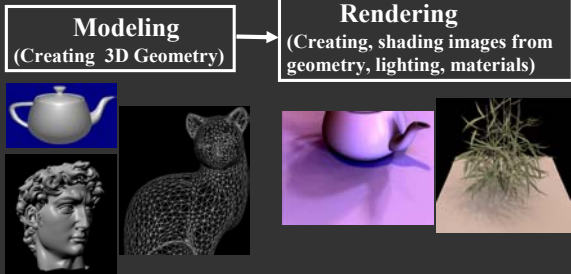
- **Systems:** Be able to write complex 3D graphics programs (real-time in OpenGL, offline raytracer)
- **Theory:** Understand mathematical aspects and algorithms underlying modern 3D graphics systems
- This course is *not* about the specifics of 3D graphics programs and APIs like Maya, Alias, AutoCAD, DirectX but about the concepts underlying them.

Demo: Surreal and Crazy World (HW 3)



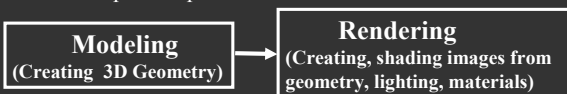
Course Outline

- 3D Graphics Pipeline



Course Outline

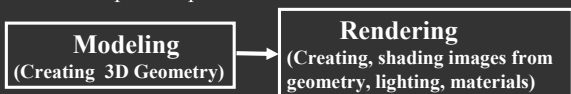
- 3D Graphics Pipeline



Unit 1: Transformations
Resizing and placing objects in the world. Creating perspective images.
Weeks 1 and 2
Ass 1 due Sep 25 ([Demo](#))

Course Outline

- 3D Graphics Pipeline



Unit 1: Transformations
Weeks 1,2. Ass 1 due Sep 25

Unit 2: Spline Curves
Modeling geometric objects
Weeks 3,4
Ass 2 due Oct 7 ([Demo](#))

Course Outline

- 3D Graphics Pipeline



Unit 1: Transformations

Weeks 1,2. Ass 1 due Sep 25

Unit 3: OpenGL

Weeks 5-7.

Unit 2: Spline Curves

Weeks 3,4. Ass 2 due Oct 7

Ass 3 due Nov 11

Midterm on units 1-3: Oct 20

Course Outline

- 3D Graphics Pipeline



Unit 1: Transformations

Weeks 1,2. Ass 1 due Sep 25

Unit 3: OpenGL

Weeks 5-7.

Unit 2: Spline Curves

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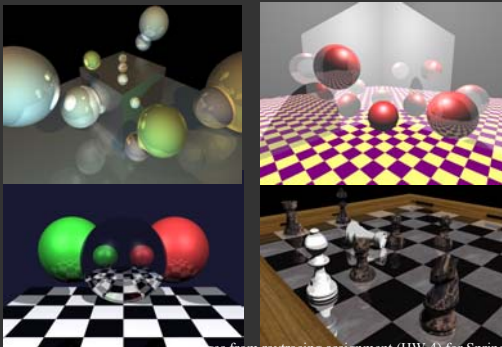
Unit 4: Shading, Ray Trace

Weeks 8,9.

Ass 4 due Dec 9

Midterm on units 1-3: Oct 20

Image Synthesis Examples



Images from raytracing assignment (HW 4) for Spring 2008

Course Outline

- 3D Graphics Pipeline



Unit 1: Transformations

Weeks 1,2. Ass 1 due Sep 25

Unit 3: OpenGL

Weeks 5-7.

Unit 2: Spline Curves

Weeks 3,4. Ass 2 due Oct 7

Ass 3 due Nov 11

Unit 4: Shading, Ray Trace

Weeks 8,9.

Ass 4 due Dec 9

Midterm on units 1-3: Oct 20

Logistics

- Website <http://www1.cs.columbia.edu/~cs4160> has most of information (look at it)
- Office hours: before or after class (or just send me e-mail)
- TA: Dhruv Mahajan, CEPSR 6LE4?
- Course bulletin board, cs4160@lists.cs.columbia.edu
- Textbook: Fundamentals of Computer Graphics by Shirley (2nd edition), OpenGL Programming Guide 5/6th ed by Woo
- Website for late, collaboration policy, etc
- Questions?

Workload

- Lots of fun, rewarding but may involve significant work
- 4 programming projects; latter two are time-consuming (but you have > 1 month, groups of two, intermediate milestones). **START EARLY !!**
- Course will involve some understanding of mathematical, geometrical concepts taught (explicitly tested on midterm, open book take home written assignments at end)
- Prerequisites: Solid C/C++/Java programming background. Linear algebra (review on Mon) and general math skills
- Should be a difficult, but fun and generously graded course

To Do

- Look at website
- Various policies etc. for course. Send me e-mail if confused.
- Skim assignments if you want. All are ready
- Assignment 0, Due Sep 9 Tue (see website). Send e-mail to cs4160@lists.cs.columbia.edu telling us about yourself and sending us a digital photo (so we can put names to faces).
- Any questions?

History

- Brief history of significant developments in field
- Couple of animated shorts for fun
- Towards end of course: movie, history of CG



What is Computer Graphics?

- Anything to do with visual representations on a computer
- Includes much of 2D graphics we take for granted
- And 3D graphics modeling and rendering (focus of course)
- Auxiliary problems: Display devices, physics and math for computational problems

The term Computer Graphics was coined by William Fetter of Boeing in 1960
First graphic system in mid 1950s USAF SAGE radar data (developed MIT)

2D Graphics

Many of the standard operations you're used to:

- Text
- Graphical User Interfaces (Windows, MacOS, ..)
- Image processing and paint programs (Photoshop, ...)
- Drawing and presentation (Powerpoint, ...)

How far we've come: TEXT



Manchester Mark I

Display →

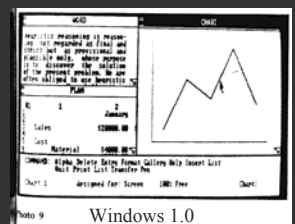


From Text to GUIs

- Invented at PARC circa 1975. Used in the Apple Macintosh, and now prevalent everywhere.



Xerox Star



Windows 1.0

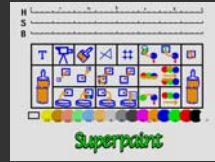
Drawing: Sketchpad (1963)

- Sketchpad (Sutherland, MIT 1963)
- First interactive graphics system (VIDEO)
- Many of concepts for drawing in current systems
 - Pop up menus
 - Constraint-based drawing
 - Hierarchical Modeling



Paint Systems

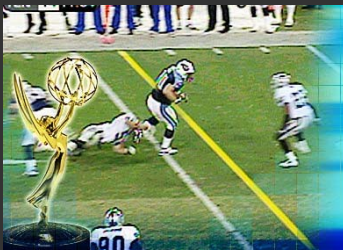
- SuperPaint system: Richard Shoup, Alvy Ray Smith (PARC, 1973-79)



- Nowadays, image processing programs like Photoshop can draw, paint, edit, etc.

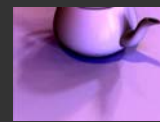
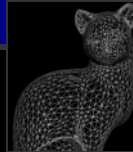
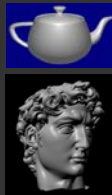
Image Processing

- Digitally alter images, crop, scale, composite
- Add or remove objects
- Sports broadcasts for TV (combine 2D and 3D processing)



3D Graphics

- 3D Graphics Pipeline



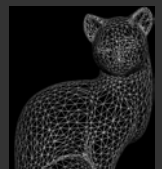
Applications

- Entertainment (Movies), Art
- Design (CAD)
- Video games
- Education, simulators, augmented reality



Modeling

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



Rendering: 1960s (visibility)

- Roberts (1963), Appel (1967) - hidden-line algorithms
- Warnock (1969), Watkins (1970) - hidden-surface
- Sutherland (1974) - visibility = sorting



Images from Pi-DFH, Peter's Shutterbug
Slide ideas for history of Rendering courtesy Marc Levoy

Rendering: 1970s (lighting)

1970s - raster graphics

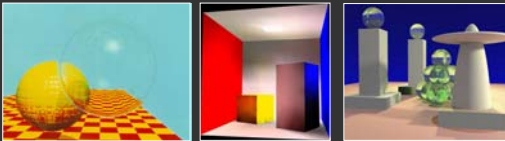
- Gouraud (1971) - diffuse lighting, Phong (1974) - specular lighting
- Blinn (1974) - curved surfaces, texture
- Catmull (1974) - Z-buffer hidden-surface algorithm



Rendering (1980s, 90s: Global Illumination)

early 1980s - global illumination

- Whitted (1980) - ray tracing
- Goral, Torrance et al. (1984) radiosity
- Kajiya (1986) - the rendering equation



Short Videos

Related courses

- COMS 4162, follow on to 4160 taught by me alternate years in the spring.
- Many 6000-level courses (e.g. COMS 6160 High Quality Real-Time Rendering, Representations of Visual Appearance)
- Part of Vision and Graphics track in BS and MS programs. Columbia Vision and Graphics Center
- Other related courses: Computer Vision, Robotics, User Interfaces Computational Geometry, ...