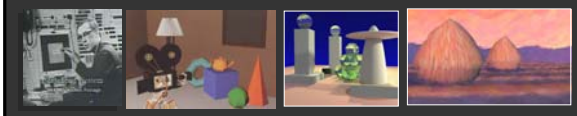
Computer Graphics (Fall 2004)

COMS 4160, Lecture 1: Overview and History

Ravi Ramamoorthi

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



Goals

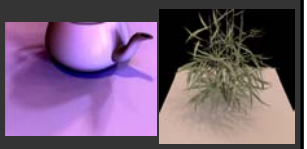
- **Systems:** Be able to write fairly complex interactive 3D graphics programs (in OpenGL)
- **Theory:** Understand mathematical aspects and algorithms underlying modern 3D graphics systems
- This course is ***not*** about the specifics of 3D graphics programs and APIs like Maya, Alias, AutoCAD, DirectX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

Demo: Surreal (HW 3)

Course Outline

- 3D Graphics Pipeline

Modeling (Creating 3D Geometry) → **Rendering** (Creating, shading images from geometry, lighting, materials)



Course Outline

- 3D Graphics Pipeline

Modeling (Creating 3D Geometry) → **Rendering** (Creating, shading images from geometry, lighting, materials)

Unit 1: Transformations
Resizing and placing objects in the world. Creating perspective images.
Weeks 1 and 2
Ass 1 due Sep 23 (Demo)

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- 3D Graphics Pipeline

Modeling (Creating 3D Geometry) → **Rendering** (Creating, shading images from geometry, lighting, materials)

Unit 1: Transformations
Weeks 1,2. Ass 1 due Sep 23

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

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Weeks 1,2. Ass 1 due Sep 23

Unit 2: Spline Curves
Weeks 3,4. Ass 2 due Oct 7

Unit 3: OpenGL
Weeks 5-7.
Ass 3 due Nov 9

Midterm on units 1-3: Oct 27

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Weeks 1,2. Ass 1 due Sep 23

Unit 2: Spline Curves
Weeks 3,4. Ass 2 due Oct 7

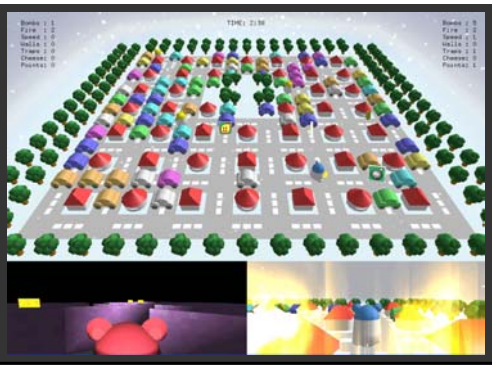
Unit 3: OpenGL
Weeks 5-7.
Ass 3 due Nov 9

Unit 4: Lighting, Shading
Weeks 8,9.
Written Ass 1 due Nov 18

Midterm on units 1-3: Oct 27

Ass 4: Interactive 3D Video Game (final project) due Dec 12

Example: HAMS (HW 4)



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Modeling (Creating 3D Geometry) → **Rendering** (Creating, shading images from geometry, lighting, materials)

Unit 1: Transformations
Weeks 1,2. Ass 1 due Sep 23

Unit 2: Spline Curves
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Unit 3: OpenGL
Weeks 5-7.
Ass 3 due Nov 9

Unit 4: Lighting, Shading
Weeks 8,9.
Written Ass 1 due Nov 18

Unit 5: Advanced Render
Weeks 11,12.
Written Ass 2 due Dec 7

Midterm on units 1-3: Oct 27

Ass 4: Interactive 3D Video Game (final project) due Dec 12

Logistics

- Website http://www1.cs.columbia.edu/~cs4160 has most of information (look at it)
- Office hours: after class (or just send me e-mail)
- TA: Aner Ben-Artzi, CEPSR 6LE4
- Course bulletin board, cs4160@cs.columbia.edu
- Textbook: Fundamentals of Computer Graphics by Shirley, OpenGL Programming Guide 4th 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

Related courses

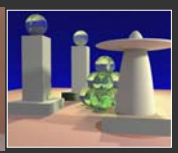
- COMS 4162, follow on to 4160 taught by me for first time in the spring. I hope many of you will enroll in that.
- Many 6000-level courses (e.g. COMS 6160 High Quality Real-Time Rendering taught by me this semester)
- Part of Vision and Graphics track in BS and MS programs. Columbia Vision and Graphics Center
- Other related courses: Computer Vision, Robotics, User Interfaces Computational Geometry, …

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 14 Tue (see website). Send e-mail to cs4160@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

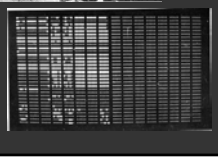
Many of the standard operations you're used to:

- 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

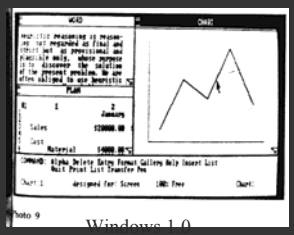
Display →



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
- 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.

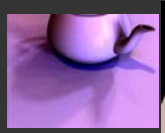
Image Processing

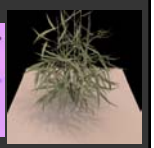
- Digitally alter images, crop, scale, composite
- Add or remove objects
- Sports broadcasts for TV (combine 2D and 3D processing)

3D Graphics

- 3D Graphics Pipeline

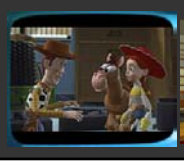
Modeling
(Creating 3D Geometry) → **Rendering**
(Creating, shading images from geometry, lighting, materials)





Applications

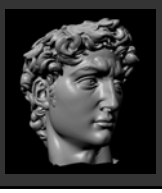
- Entertainment (Movies), Art
- Design (CAD)
- Video games
- Education, simulators, augmented reality

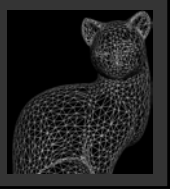


Modeling

- 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 FvDFH, Pixar's Shutterbug
Slide ideas for history of Rendering courtesy Marc Levoy

Rendering: 1970s (lighting)

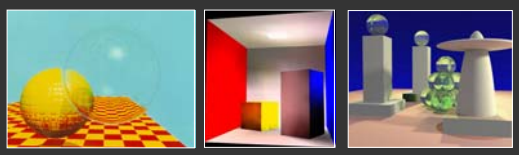
1970s - raster graphics

- 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