Course Overview

Administrative Issues
Modeling
Animation
Rendering
OpenGL Programming

[Angel Ch. 1]

Course Information On-Line

http://barbic.usc.edu/cs420-s21/
- Schedule (slides, readings)
- Assignments (details, due dates)
- Software (libraries, hints)
- Resources (books, tutorials, links)

Submit assignments on Blackboard:
https://blackboard.usc.edu

Forum for questions is on Piazza:
https://piazza.com/usc/spring2021/csci420/home

About me

Associate (tenured)
professor in CS

Post-doc at MIT

PhD, Carnegie Mellon University

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Mon 4:00-5:00, SAL 240

Background:
BSc Mathematics
PhD Computer Science

Research interests:
graphics, animation, real-time
physics, control, sound, haptics

Practice:
Tech transfer, startup companies (Ziva Dynamics)

Teaching Assistant

Bohan Wang
Office hours:
Tuesday 6pm-7pm,
and Friday 4pm-5pm
Course Producer

Same office hours as TA

Jingtao Huang

Prerequisites

• CSCI 104 (Data Structures and Object-Oriented Design)
• MATH 225 (Linear Algebra and Differential Equations)
• Familiarity with calculus and linear algebra
• C programming skills
• Junior, senior, MS or PhD student, or explicit permission of instructor
• See me if you are missing any and we haven’t discussed it

Grading

• 51% Programming Assignments (3x 17%)
• 19% Midterm (one sheet of notes only, in class)
• 30% Final (one sheet of notes only, in class)

Textbooks

• Interactive Computer Graphics
  A top-down approach with OpenGL, Sixth Edition
  Edward Angel, Addison-Wesley

• OpenGL Programming Guide ("Red Book")
  Basic version also available on-line (see Resources)

Academic integrity

• No collaboration!
• Do not copy any parts of any of the assignments from anyone
• Do not look at other students’ code, papers, assignments or exams
• USC Office of Student Judicial Affairs and Community Standards will be notified

Assignment Policies

• Programming assignments
  - Hand in via Blackboard by end of due date
  - Functionality and features
  - Style and documentation
  - Artistic impression
• 3 late days, usable any time during semester
• All assignments must be completed to pass the course
• Academic integrity policy applied rigorously
Computer Graphics
One of the "core" computer science disciplines:
Algorithms and Theory
Artificial Intelligence
Computer Architecture
Computer Graphics and Visualization
Computer Vision
Computer Security
Computer Systems
Databases
Networks
Programming Languages
Software Engineering

Course Overview
Theory: Computer graphics disciplines:
- Modeling: how to represent objects
- Animation: how to control and represent motion
- Rendering: how to create images of objects
- Image Processing: how to edit images

Practice: OpenGL graphics library

Not in this course:
- Human-computer interaction
- Graphic design
- User interface libraries

OpenGL Graphics Library

- Main focus:
  Core OpenGL Profile ("Modern OpenGL")
- OpenGL 3.2 and higher
- Shaders
- Homeworks use the Core Profile
- We will also study:
  Compatibility Profile ("Classic OpenGL")

Computer Graphics Disciplines

Example: Ray Tracing

Barbic, James, SIGGRAPH 2010
Thürey, Wojtan, Gross, Turk, SIGGRAPH 2010

Computer Graphics Goals I

- Synthetic images indistinguishable from reality
- Practical, scientifically sound, in real time
Computer Graphics Goals II

• Creating a new reality (not necessarily scientific)
• Practical, aesthetically pleasing, in real time

Example: Illustrating Smooth Surfaces

A. Hertzmann, D. Zorin,
SIGGRAPH 2000
Non-photorealistic rendering (NPR)

Example: Scene Completion

Original
Input
Scene Matches
Output
J. Hays, A. Efros,
SIGGRAPH 2007

SIGGRAPH

• Main computer graphics event in the world
• Once per year
• 30,000 attendees
• Academia, industry
1. Course Overview
   • Administrative Issues
   • Topics Outline (next)

2. OpenGL Basics
   • Graphics pipeline
   • Primitives and attributes
   • Color
   • OpenGL core and compatibility profiles
   • [Angel, Ch. 1, 2]

3. Input and Interaction
   • Clients and servers
   • Event driven programming
   • Hidden-surface removal
   • [Angel, Ch. 2]

4. GPU Shaders
   • Vertex program
   • Fragment program
   • Pipeline program
   • Shading languages
   • GLSL shading language
   • Interaction with OpenGL

5. Objects & Transformations
   • Linear algebra review
   • Coordinate systems and frames
   • Rotation, translation, scaling
   • Homogeneous coordinates
   • OpenGL transformation matrices
   • [Angel, Ch. 3]

6. Viewing and Projection
   • Orthographic projection
   • Perspective projection
   • Camera positioning
   • Projections in OpenGL
   • [Angel, Ch. 4]
7. Hierarchical Models
- Re-using objects
- Animations
- OpenGL routines
- Parameters and transformations
- [Angel, Ch. 8]

8. Light and Shading
- Light sources
- Ambient, diffuse, and specular reflection
- Normal vectors
- Material properties in OpenGL
- Radiosity
- [Angel, Ch. 5]

9. Curves and Surfaces
- Review of 3D-calculus
- Explicit representations
- Implicit representations
- Parametric curves and surfaces
- Hermite curves and surfaces
- Bezier curves and surfaces
- Splines
- Curves and surfaces in OpenGL
- [Angel, Ch. 10]

10. Rendering
- Clipping
- Bounding boxes
- Hidden-surface removal
- Line drawing
- Scan conversion
- Anti-aliasing
- [Angel, Ch. 6]

11. Textures and Pixels
- Texture mapping
- OpenGL texture primitives
- Bump maps
- Environment maps
- Opacity and blending
- Image filtering
- [Angel, Ch. 7]

12. Ray Tracing
- Basic ray tracing [Angel, Ch. 11]
- Spatial data structures [Angel, Ch. 8]
- Motion Blur
- Soft Shadows

www.yafaray.org
13. Radiosity
- Local vs global illumination model
- Interreflection between surfaces
- Radiosity equation
- Solution methods
- [Angel Ch. 11]

14. Physically Based Models
- Particle systems
- Spring forces
- Cloth
- Collisions
- Constraints
- Fractals
- [Angel, Ch. 9]

15. Scientific Visualization
- Height fields and contours
- Isosurfaces
- Volume rendering
- Texture mapping of volumes
- [Angel Ch. 11]

Guest Lecture: TBA

“Wildcard” Lectures:
- Graphics hardware
- More on animation
- Motion capture
- Virtual reality and interaction
- Special effects in movies
- Video game programming
- Non-photo-realistic rendering

Hot Application Areas
- Film visual effects
- Feature animation
- Virtual reality
- PC graphics boards
- Video games
- Visualization (science, architecture, space)

Hot Research Topics
- Modeling
  - getting models from the real world
  - multi-resolution
- Animation
  - physically based simulation
  - motion capture
- Rendering:
  - more realistic: image-based modeling
  - less realistic: impressionist, pen & ink
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