Course Overview

Administrative Issues
Modeling
Animation
Rendering
OpenGL Programming
[Angel Ch. 1]

Jernej Barbic
University of Southern California
Course Information On-Line

http://viterbi-web.usc.edu/~jbarbic/cs420-s23/

- 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/spring2023/csci420/home
About me

Associate (tenured) professor in CS

Post-doc at MIT

PhD, Carnegie Mellon University

jnb@usc.edu

Mon 4:00-5:00, in person / on Zoom
Course slides

http://viterbi-web.usc.edu/~jbarbic/cs420-s23/

• Full-color version

• 6-slides-per-page B&W version -- good for printing

• Posted in advance of lectures -- bring to class & annotate

• Color viewing in Acrobat Reader: Disable “Replace Document Colors” in Preferences.Accessibility (if enabled)
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

Mianlun Zheng

Office hours:
Tuesday and Friday
4pm-5pm
Teaching Assistant

Jiahao Wen

Office hours:

Tuesday and Friday
4pm-5pm
Course Producer

TBA

Same office hours as TA
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 (TBA)
• 30% Final (TBA)
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

- Rendering
- Geometry (Modeling)
- Animation
- Image Processing

Sources:
- Jensen
- Botsch et al.
- Baraff and Witkin
- Durand
Computer Graphics Goals I

• Synthetic images indistinguishable from reality
• Practical, scientifically sound, in real time
Example: Ray Tracing

Barbic, James, SIGGRAPH 2010

Thurey, Wojtan, Gross, Turk, SIGGRAPH 2010
Example: Physics + Computational Geometry + Animation + Ray Tracing

Barbic, James, SIGGRAPH 2010
Example: Radiosity

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

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
- Antialiasing
- [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
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
Acknowledgments

- Jessica Hodgins (CMU)
- Frank Pfenning (CMU)
- Paul Heckbert (Nvidia)