Course Overview

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

Jernej Barbic
University of Southern California

Course Information On-Line

http://www-bcf.usc.edu/~jbarbic/cs420-s16/
- Schedule (slides, readings)
- Assignments (details, due dates)
- Software libraries, hints
- Resources (books, tutorials, links)

Blackboard:
- Forum
- Submit assignments

About me

Associate (tenured) professor in CS
Post-doc at MIT
PhD, Carnegie Mellon University
jnb@usc.edu
Mon 4:00-5:00, SAL 240

Teaching Assistant

Bohan Wang
Office hours TBA

Course slides

http://www-bcf.usc.edu/~jbarbic/cs420-s16/
• 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)

About the teacher

Background:
BSc Mathematics
PhD Computer Science

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

Practice:
Tech transfer, startup companies, intellectual property law
Chief Technology Officer, Ziva Dynamics
Course Producer
Vathsal Shashidhar
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
• See me if you are missing any and we haven’t discussed it

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)

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

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
- 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 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
- DirectX API

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

Computer Graphics Goals

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

Example: Physics + Computational Geometry + Animation + Ray Tracing

Example: Radiosity

Example: Illustrating Smooth Surfaces

Example: Scene Completion

Computer Graphics Goals II

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