Course Overview

Administrative Issues
Modeling
Animation
Rendering
OpenGL Programming

[Angel Ch. 1]
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
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 me

Associate (tenured) professor in CS

Post-doc at MIT

PhD, Carnegie Mellon University

jnb@usc.edu

Mon 4:00-5:00, SAL 240
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
Teaching Assistant

Bohan Wang

Office hours TBA
Course Producer

Vathsal Shashidhar

Same office hours as TA
The Hobbit: The Desolation of Smaug (2013)

Visiting professor, Weta Digital Film Studio, New Zealand, 2013
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
  - Source: Jensen
- Animation
  - Source: Baraff and Witkin
- Geometry (Modeling)
  - Source: Botsch et al.
- Image Processing
  - Source: 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

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 andProjection

• 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]

Tobias R. Metoc
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
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