CSCI 420 Computer Graphics
Lecture 1

Course Overview

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

Jernej Barbic
University of Southern California

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Course Information On-Line

http://viterbi-web.usc.edu/~jbarbic/cs420-s25/

– Schedule (slides, readings)
– Assignments (details, due dates)
– Software (libraries, hints)
– Resources (books, tutorials, links)

Submit assignments on Brightspace:
https://brightspace.usc.edu

Forum for questions is on Piazza:
https://piazza.com/usc/spring2025/csci420/home

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About me

Full professor in CS

Post-doc at MIT

PhD, Carnegie Mellon University

jnb@usc.edu

Mon 4:00-5:00, in person

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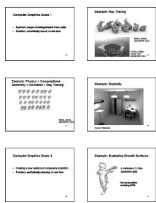
Course slides

http://viterbi-web.usc.edu/~jbarbic/cs420-s25/

• 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)

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Background:
BSc Mathematics
PhD Computer Science

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

Practice:
Tech transfer, startup companies (Ziva Dynamics)

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Teaching Assistant

Jiahao Wen

Computer graphics PhD
student. Three papers
at top conferences.
Excellent student.
Undergrad from Zhejiang
Univ. – top university in China.

Office hours:
Tuesday and Friday
4pm-5pm

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Course Producer

Shidong Zhang

MS student

Top of the class.

Took CSCI 420 last
year with me –
excellent student.

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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

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Grading

• 51% Programming Assignments (3x 17%)

• 19% Midterm Exam

• 30% Final Exam

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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)

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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

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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 **before the final
  exam** to pass the course.

• Academic integrity policy applied rigorously

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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

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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

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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")

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Computer Graphics Disciplines
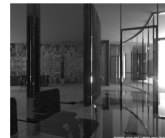
Source: Jensen
Rendering

Source: Botsch et al.
Geometry
(Modeling)

Source: Baraff and Witkin
Animation

Source: Durand
Image Processing

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Computer Graphics Goals I

• Synthetic images indistinguishable from reality
• Practical, scientifically sound, in real time

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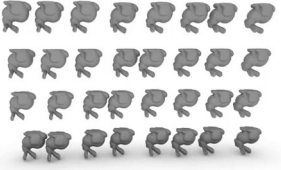## Example: Ray Tracing

Barbic, James,
SIGGRAPH 2010

Thurey, Wojtan,
Gross, Turk,
SIGGRAPH 2010

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Example: Physics + Computational Geometry + Animation + Ray Tracing

Barbic, James,
SIGGRAPH 2010

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Example: Radiosity

Source: Wikipedia

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Computer Graphics Goals II

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

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Example: Illustrating Smooth Surfaces
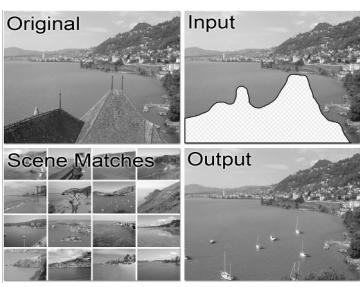
A. Hertzmann, D. Zorin,
SIGGRAPH 2000

Non-photorealistic
rendering (NPR)

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Example: Scene Completion

J. Hays, A. Efros,
SIGGRAPH 2007

Original   Input

Scene Matches   Output

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SIGGRAPH

ACM**SIGGRAPH**

- Main computer graphics event in the world

- Once per year

- 30,000 attendees

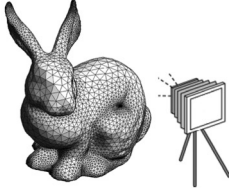- Academia, industry

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1. Course Overview

- Administrative Issues
- Topics Outline (next)

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2. OpenGL Basics

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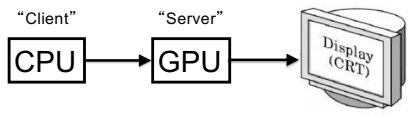- [Angel, Ch. 1, 2]

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3. Input and Interaction

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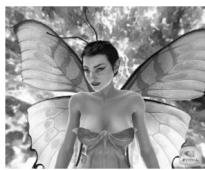- Hidden-surface removal
- [Angel, Ch. 2]

"Client"   "Server"

CPU → GPU → Display (CRT)

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4. GPU Shaders

- Vertex program
- Fragment program
- Pipeline program
- Shading languages
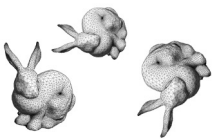- GLSL shading language
- Interaction with OpenGL

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5. Objects & Transformations

- Linear algebra review
- Coordinate systems and frames
- Rotation, translation, scaling
- Homogeneous coordinates
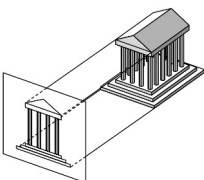- OpenGL transformation matrices
- [Angel, Ch. 3]

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6. Viewing and Projection

- Orthographic projection
- Perspective projection
- Camera positioning
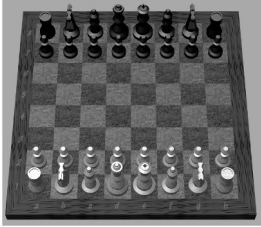- Projections in OpenGL
- [Angel, Ch. 4]

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7. Hierarchical Models

• Re-using objects

• Animations

• OpenGL routines

• Parameters and transformations

• [Angel, Ch. 8]

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8. Light and Shading

• Light sources

• Ambient, diffuse, and specular reflection

• Normal vectors

• Material properties in OpenGL
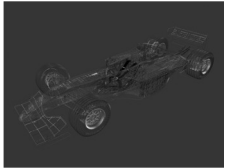
• Radiosity

• [Angel, Ch. 5]

Tobias R. Metoc

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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

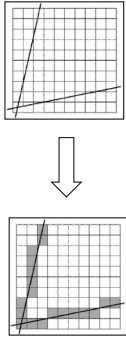• Curves and surfaces in OpenGL

• [Angel, Ch. 10]

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10. Rendering

• Clipping

• Bounding boxes

• Hidden-surface removal

• Line drawing

• Scan conversion
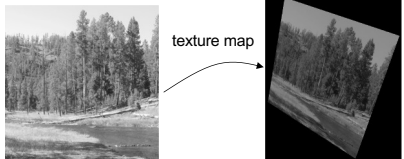
• Antialiasing

• [Angel, Ch. 6]

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11. Textures and Pixels

• Texture mapping

• OpenGL texture primitives

• Bump maps

• Environment maps

• Opacity and blending

• Image filtering

• [Angel, Ch. 7]
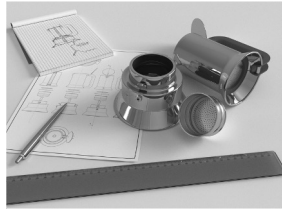
texture map

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12. Ray Tracing

• Basic ray tracing [Angel, Ch. 11]

• Spatial data structures [Angel, Ch. 8]

• Motion Blur

• Soft Shadows

www.yafaray.org

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13. Radiosity

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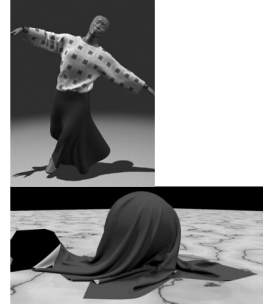- Solution methods
- [Angel Ch. 11]

Cornell University

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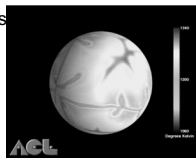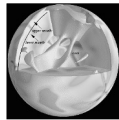
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14. Physically Based Models

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

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15. Scientific Visualization

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

Earth Mantle Heat Convection
University of Utah
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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

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Hot Application Areas

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

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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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Acknowledgments

• Jessica Hodgins (CMU)

• Frank Pfenning (CMU)

• Paul Heckbert (Nvidia)

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