

CSCI 420 Computer Graphics

Lecture 1

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-s22/>

- 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/spring2022/csci420/home>

About me

Associate (tenured)
professor in CS

Post-doc at MIT

PhD, Carnegie Mellon University

jnb@usc.edu

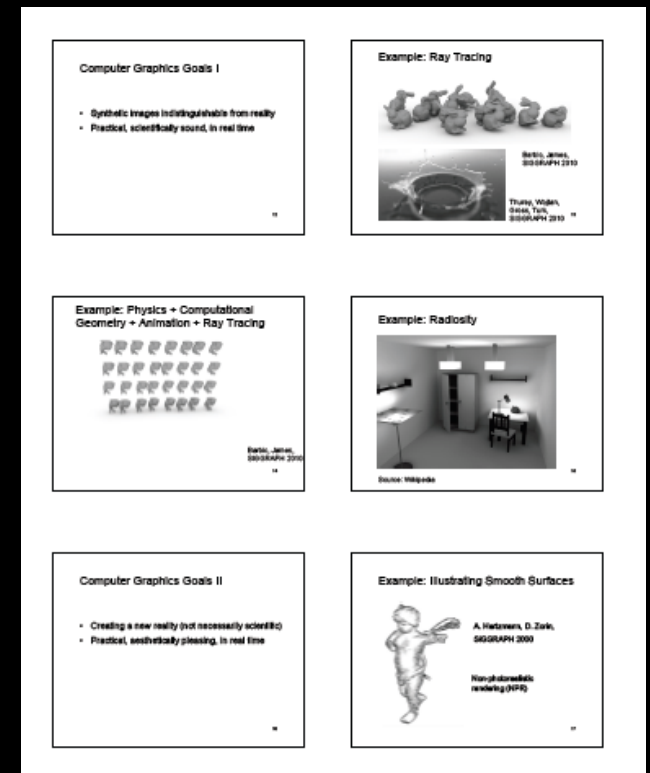
Mon 4:00-5:00, in person / on Zoom



Course slides

<http://viterbi-web.usc.edu/~jbarbic/cs420-s22/>

- 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

Jiahao Wen

Office hours:

Tuesday and Friday
4pm-5pm



Course Producer

Jingtao Huang

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 (open book, on Zoom)
- 30% Final (open book, on Zoom)

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

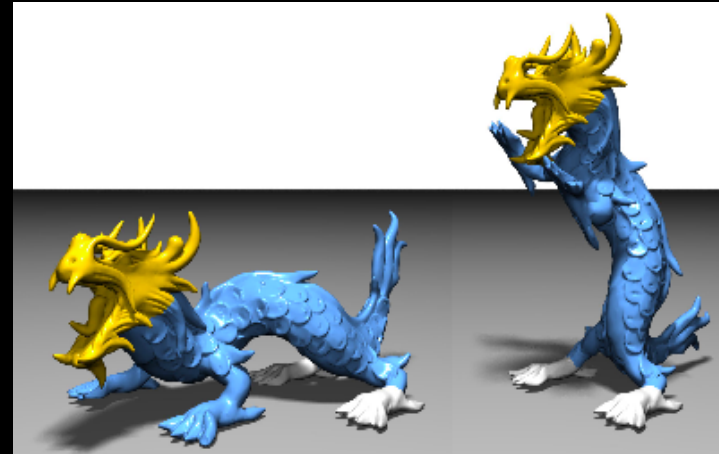
- Main focus:
Core OpenGL Profile (“Modern OpenGL”)
- OpenGL 3.2 and higher
- Shaders
- Homeworks use the Core Profile
- We will also study:
Compatibility Profile (“Classic OpenGL”)

Computer Graphics Disciplines



Source:
Jensen

Rendering



Source: Botsch et al.

Geometry
(Modeling)



Source: Baraff and
Witkin

Animation



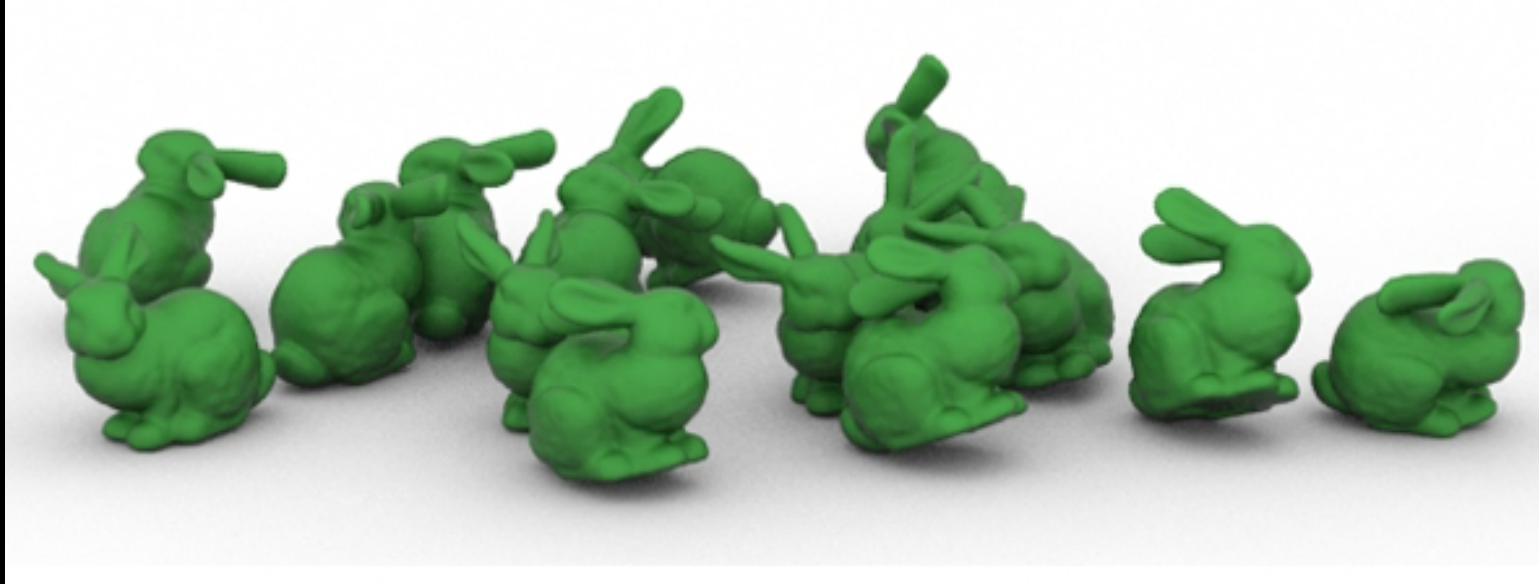
Source: Durand

Image Processing

Computer Graphics Goals I

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

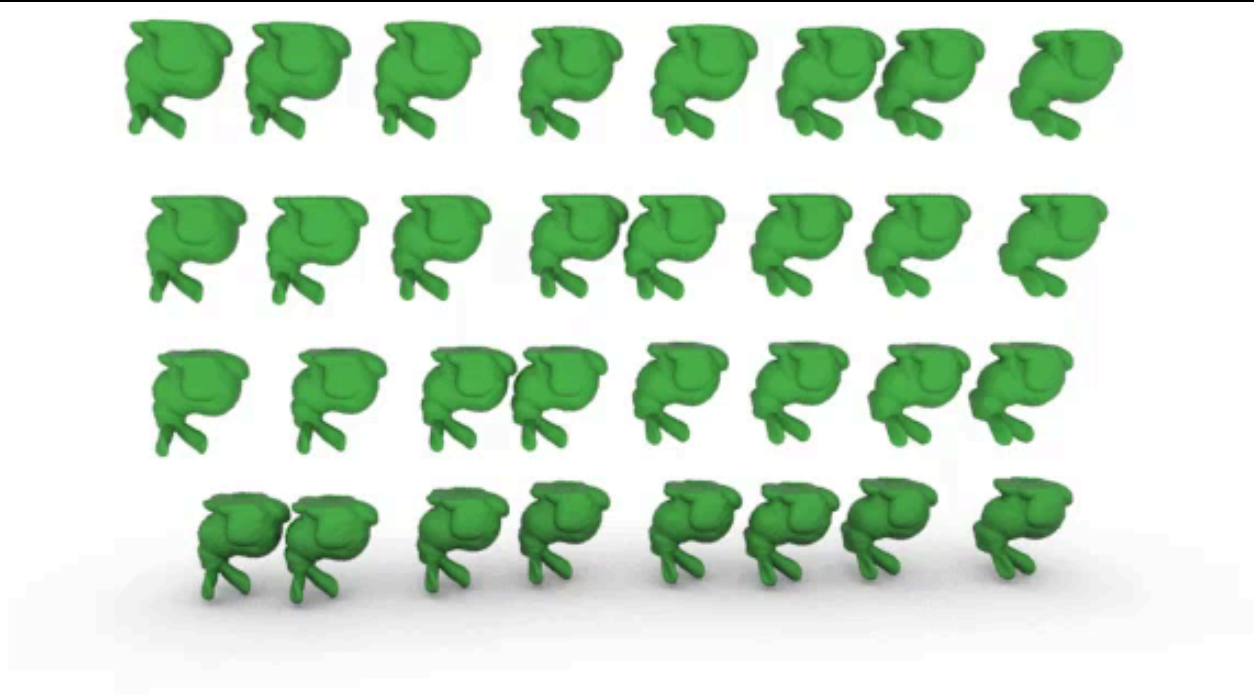
Example: Ray Tracing



Barbic, James,
SIGGRAPH 2010

Thurey, Wojtan,
Gross, Turk,
SIGGRAPH 2010

Example: Physics + Computational Geometry + Animation + Ray Tracing



Barbic, James,
SIGGRAPH 2010

Example: Radiosity

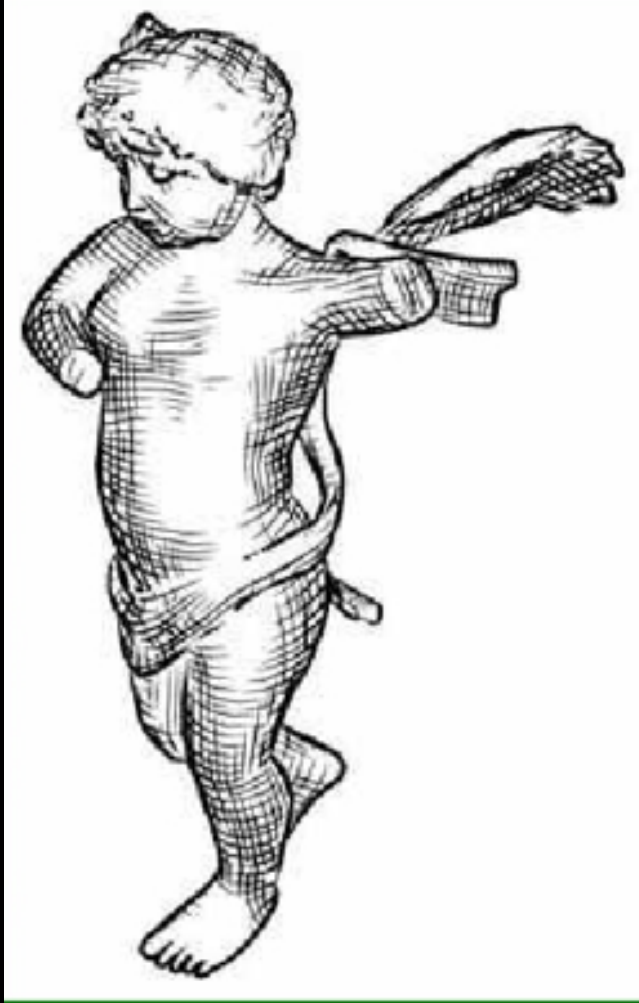


Source: Wikipedia

Computer Graphics Goals II

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

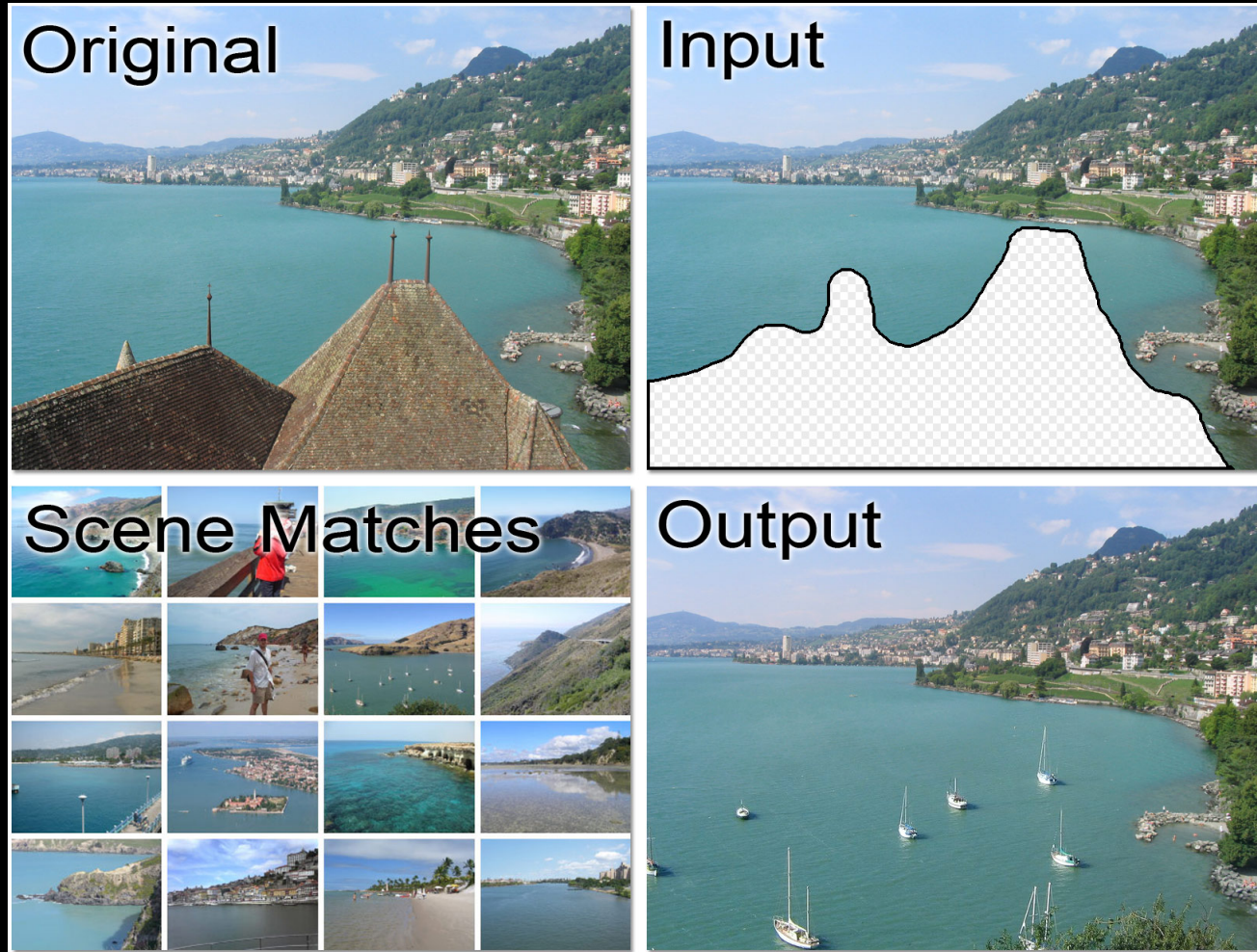
Example: Illustrating Smooth Surfaces



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

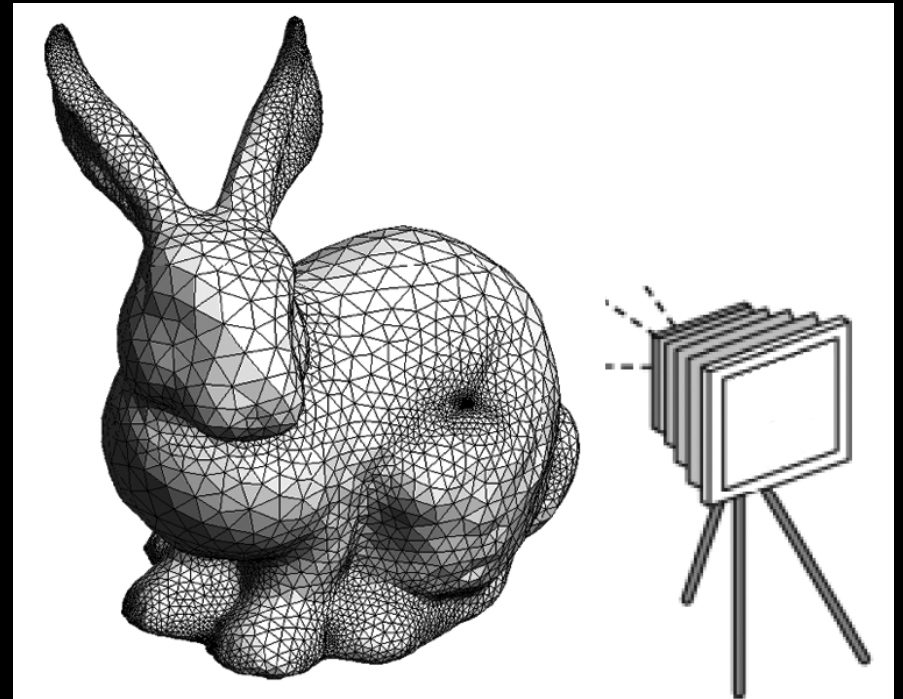


1. Course Overview

- Administrative Issues
- Topics Outline (next)

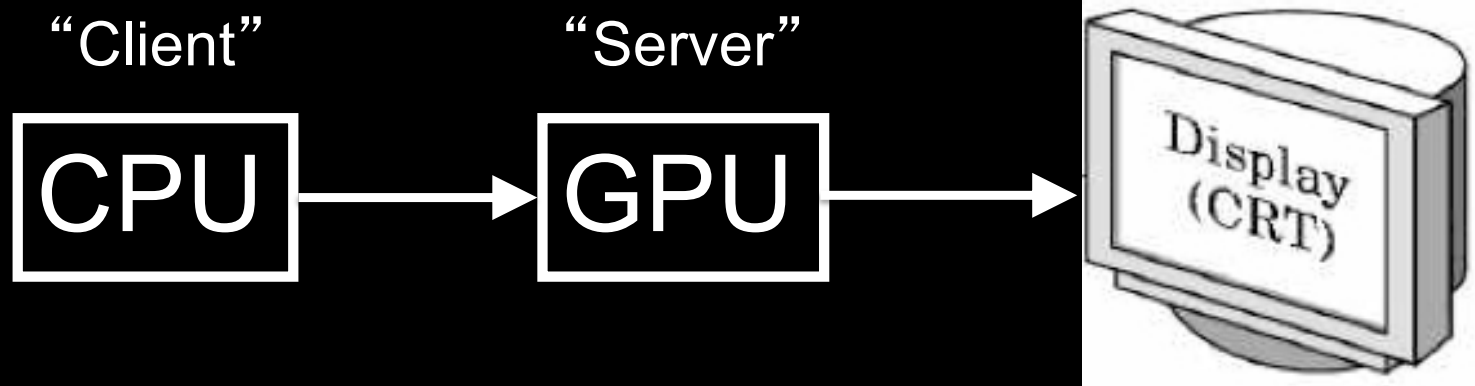
2. OpenGL Basics

- 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]



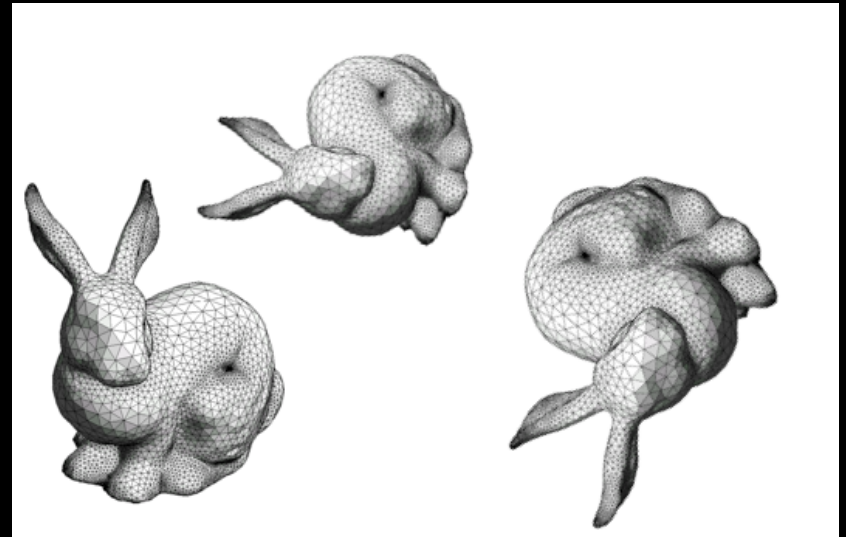
4. GPU Shaders

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



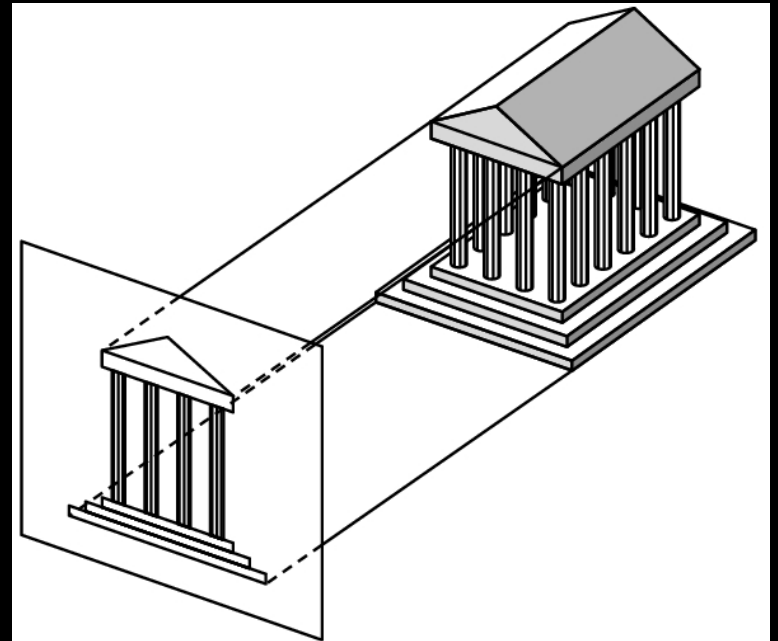
5. Objects & Transformations

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



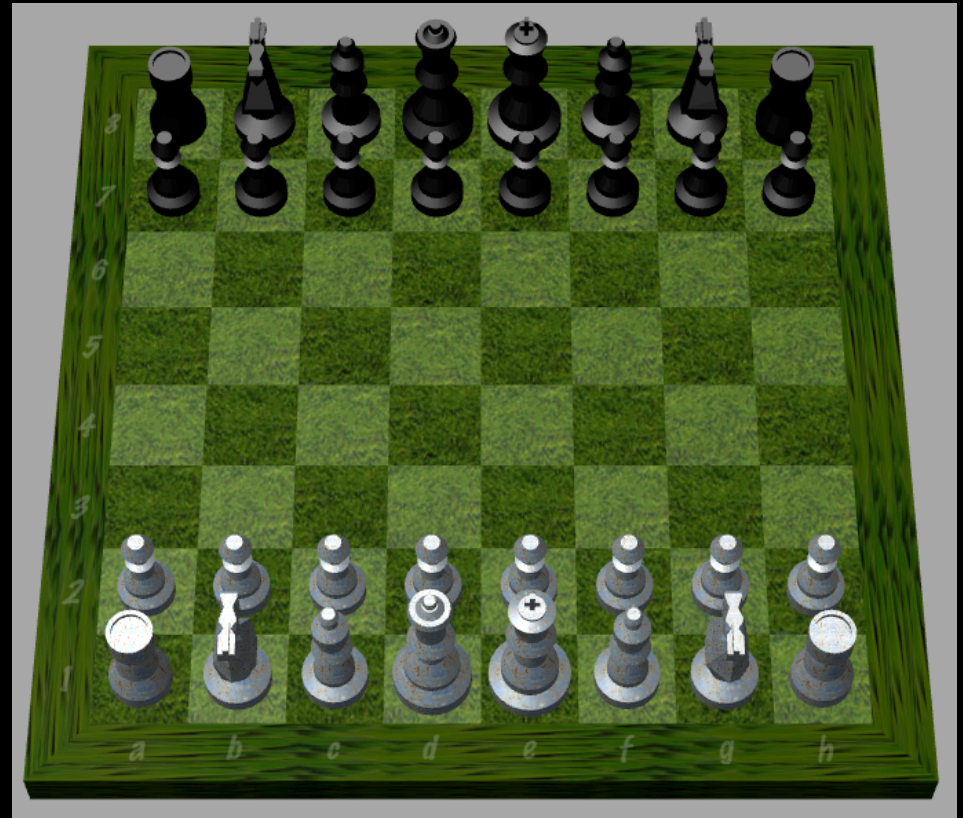
6. Viewing and Projection

- 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

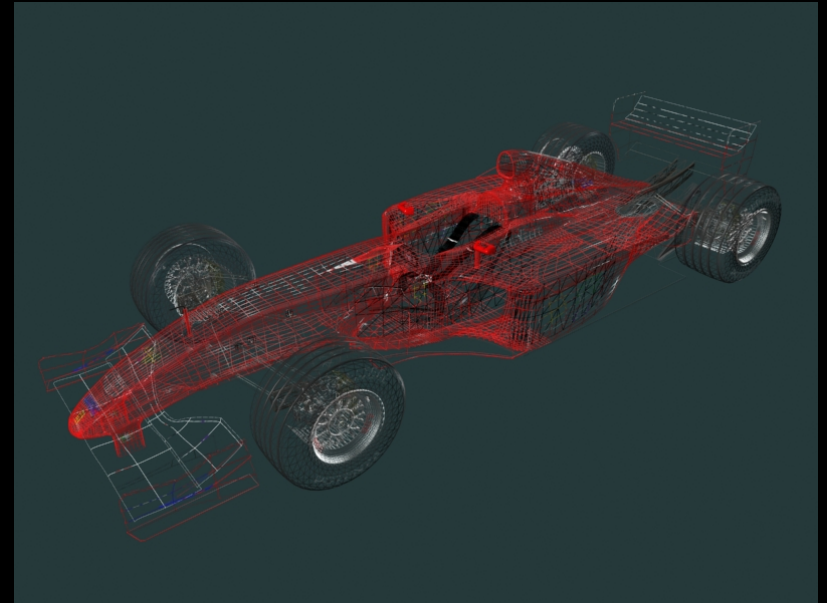
- Light sources
- Ambient, diffuse, and specular reflection
- Normal vectors
- Material properties in OpenGL
- Radiosity
- [Angel, Ch. 5]



Tobias R. Metoc

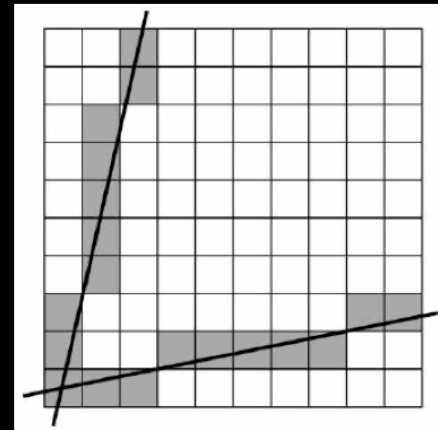
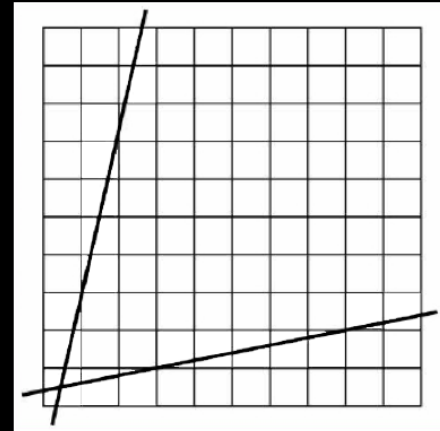
9. Curves and Surfaces

- 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]

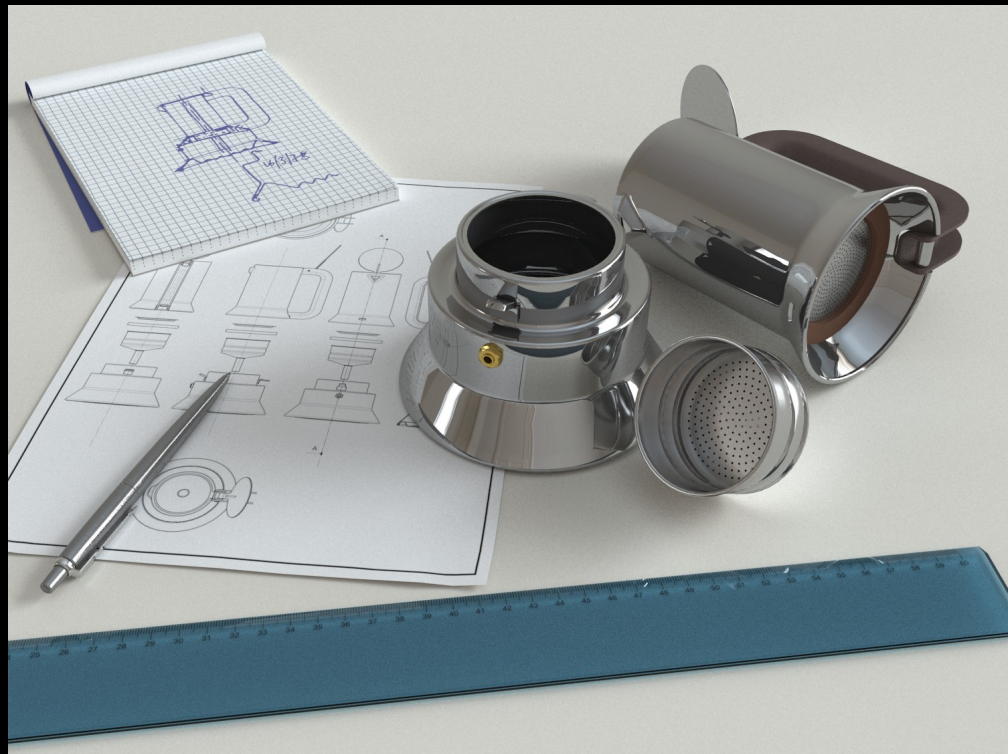


texture map



12. Ray Tracing

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



13. Radiosity

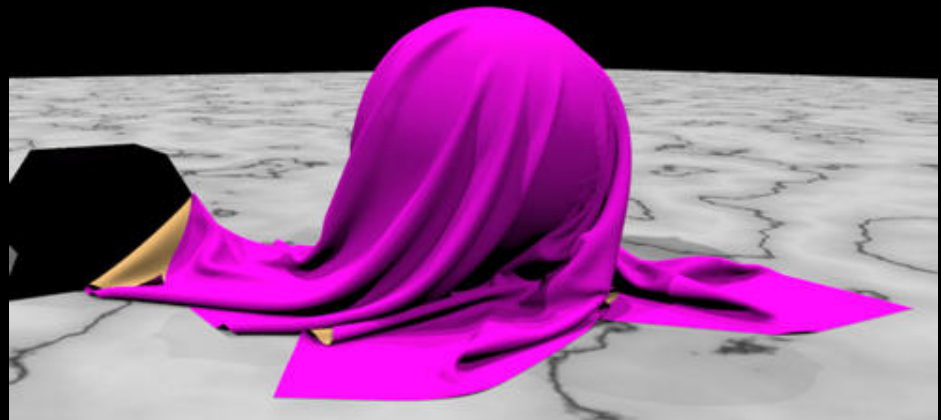
- Local vs global illumination model
- Interreflection between surfaces
- Radiosity equation
- Solution methods
- [Angel Ch. 11]



Cornell University

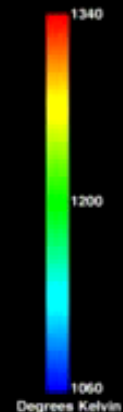
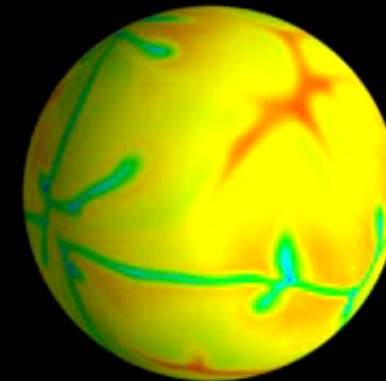
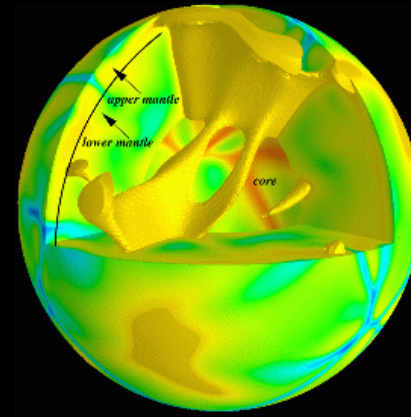
14. Physically Based Models

- 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]



ACL

Earth Mantle Heat Convection
University of Utah

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)