CS354
Course Introduction

Don Fussell
Computer Science Department
The University of Texas at Austin

CS 354 - Computer Graphics

- Instructor: Don Fussell
  - fussell@cs.utexas.edu
  - Office: GDC 5.510
  - http://www.cs.utexas.edu/users/fussell/
  - Office Hours: TTh 10-11am
- Teaching Assistant: Randy Smith
  - agrippa@cs.utexas.edu
  - Office Hours: TBD
- Location: GDC 5.302
- Lectures: TTh 11:00-12:30pm

Objectives

- Fundamentals of computer graphics
  - Transformations and viewing
  - Rasterization and ray tracing
  - Lighting and shading
  - Graphics hardware technology
  - Mathematics for computer graphics
- Practical graphics programming
  - OpenGL programming
  - Shader programming

Course Expectations

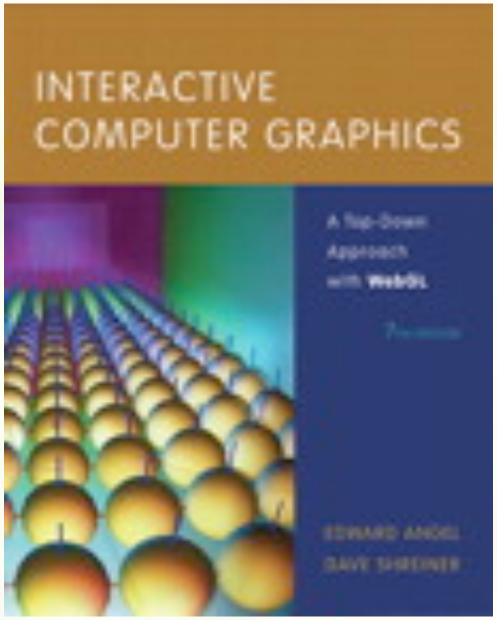
- You should
  - Attend regularly and keep up – in-class short quizzes
- Do the programming assignments
  - Nearly everything you learn in this course will come from these
  - You need to know C/C++
  - Use office hours if you need help
  - No cheating (see syllabus and UT Austin policy)
  - If they're not fun, you're doing it wrong
- Tests and homework
  - Less fun, and useful, than programming projects
  - Good for covering math and concepts

Grading

- Programming projects 60%
- Homework and quizzes 10% (if relevant, otherwise this 10% goes to programming projects)
- Exams 30%
  - 2 exams - Middle semester and end of class 15% each
  - No final

Textbook

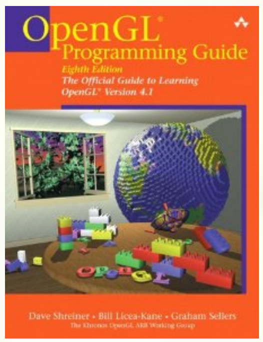
- *Interactive Computer Graphics: A Top-Down Approach with WebGL – 7/E*
  - by Edward Angel and Dave Shreiner
  - Pearson, 7th edition
- Currently only recommended
  - It costs $147 list
  - Very helpful, but we don't require it
  - Older editions also useful

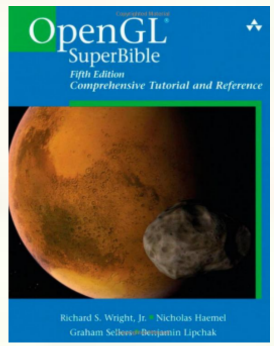


Other Useful Resources

- OpenGL
  - See links on course webpage

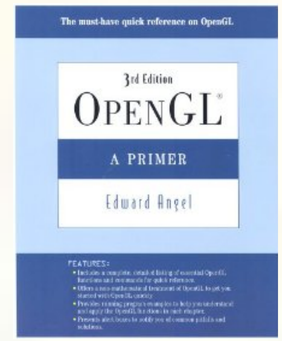
OpenGL Programming Guide
"the red book"





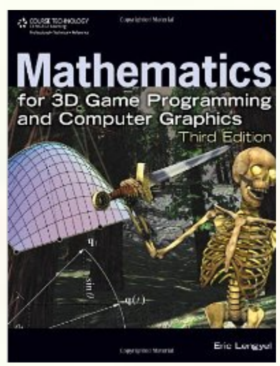
OpenGL SuperBible

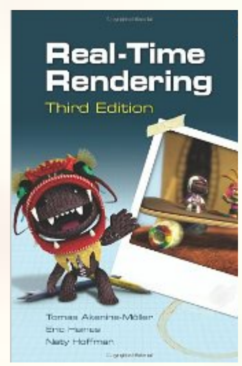
OpenGL A Primer



- Supplemental books

Eric Lengyel
Mathematics for 3D Game Programming and Computer Graphics





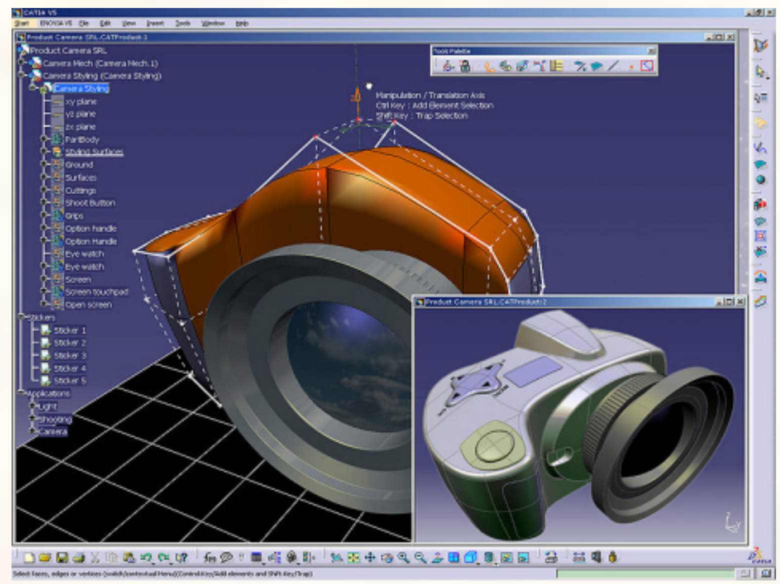
Real-Time Rendering
Eric Haines, Tomas Akenine-Moller, Naty Hoffman

Computer Graphics Applications

Film, television

[Pixar 2010]

Product design



[CATIA]

Computer Graphics Applications

Games

[Skyrim]

Training

[Commercial simulators]

Computer Graphics Applications

GUIs

[Android 4.0]

Apps

[Audi]

Computer Graphics Applications

2d and 3d printing

[HP]

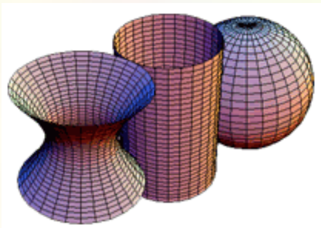
[MakerBot]

Digital imaging, computational photography

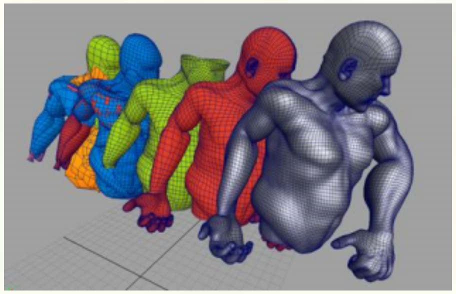
[Canon]

Computer graphics

Very interdisciplinary compared to many CS topics

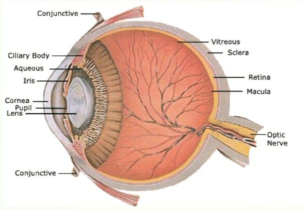


Geometry and
Mathematics of
Surfaces



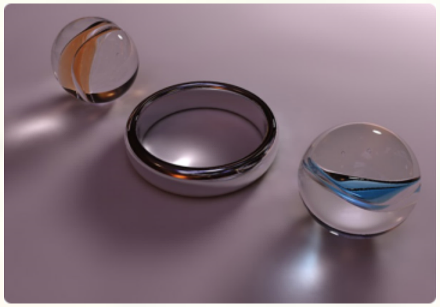
Animation &
Simulation

Display & Input
Technology



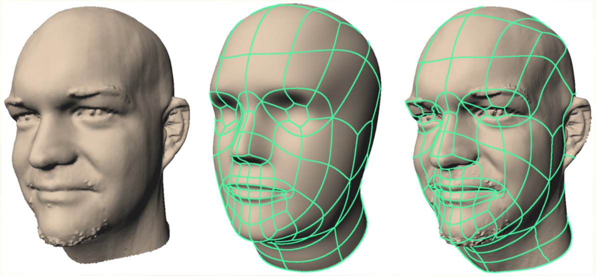
Human
Perception

Physics
of Light Transport



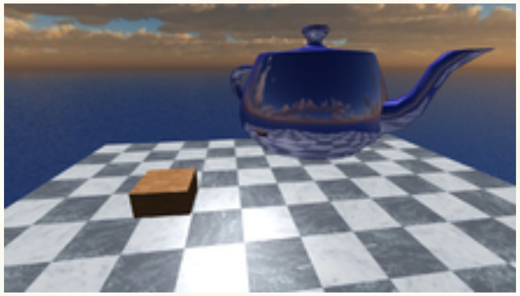
What we will cover

- Computer-based representation of
  - **Geometry**



[Litke et.al. 2001]

  - **Appearance**



[george3738]

  - **Motion**

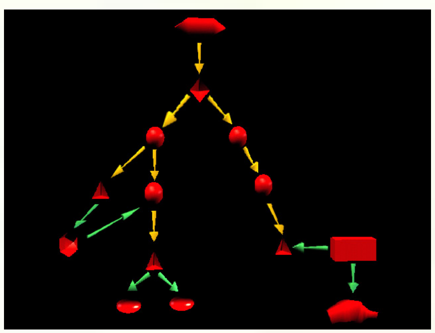
[Chai & Hodgins, 2005]

What we won't cover

- Digital content creation
  - No Photoshop, no Maya or 3D Studio Max
  - Computer Science class, not an art class
- 2d stuff, GUIs
- C/C++ programming
  - You should already know C or C++ under Linux
    - Not just the language
    - Need to know debugging and software practices
    - Programming projects assume Linux – supported in GDC labs
- Many advanced techniques

Graphics and vision

- Computer graphics
  - Takes an abstract representation of a “scene” within a computer’ s memory and converts it to concrete representing a view of that scene
  - 40 year old discipline – now very advanced because this is the easy stuff
- Visual system
  - Takes concrete imagery and converts into an abstract representation of a scene in your brain (what you see is a model you construct).
  - Computer vision tries to do this with a computer, it’s very hard



Computer graphics - easy →

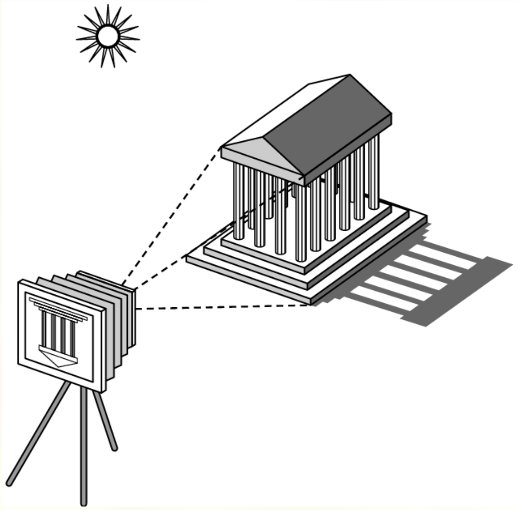
← Computer vision - hard

Image Formation

- In computer graphics, we form images which are generally two dimensional using a process analogous to how images are formed by physical imaging systems
  - Cameras
  - Microscopes
  - Telescopes
  - Human visual system

Elements of Image Formation

- Objects
- Viewer
- Light source(s)



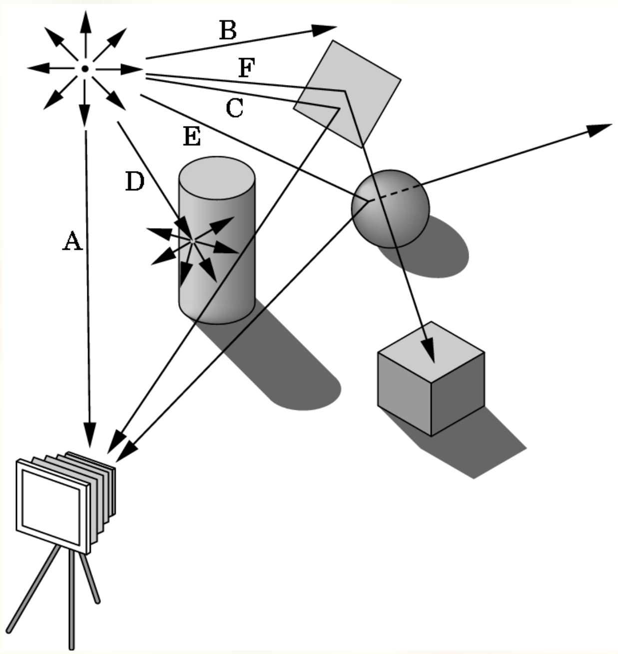
- Attributes that govern how light interacts with the materials in the scene
- Note the independence of the objects, the viewer, and the light source(s)

Light

- *Light* is the part of the electromagnetic spectrum that causes a reaction in our visual systems
- Generally these are wavelengths in the range of about 350-750 nm (nanometers)
- Long wavelengths appear as reds and short wavelengths as blues

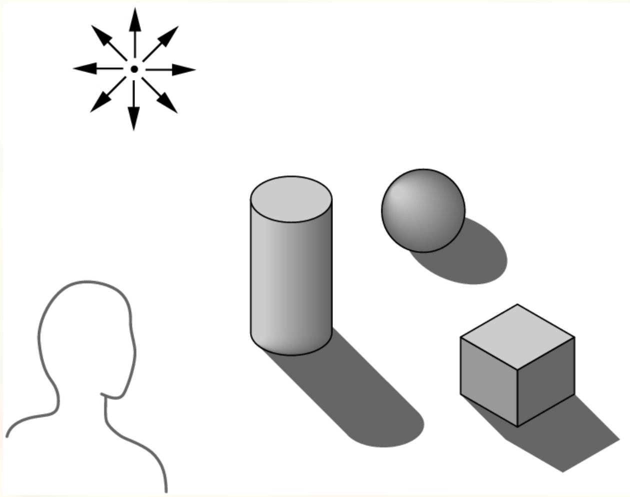
Ray Tracing and Geometric Optics

One way to form an image is to follow rays of light from a point source finding which rays enter the lens of the camera. However, each ray of light may have multiple interactions with objects before being absorbed or going to infinity.



Global vs Local Lighting

- Cannot compute color or shade of each object independently
  - Some objects are blocked from light
  - Light can reflect from object to object
  - Some objects might be translucent

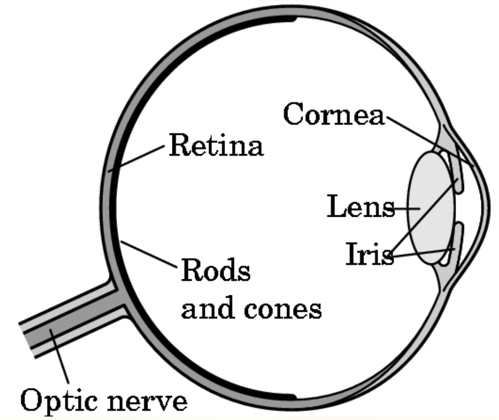


Luminance and Color Images

- Luminance Image
  - Monochromatic
  - Values are gray levels
  - Analogous to working with black and white film or television
- Color Image
  - Has perceptional attributes of hue, saturation, and lightness
  - Do we have to match every frequency in visible spectrum? No!

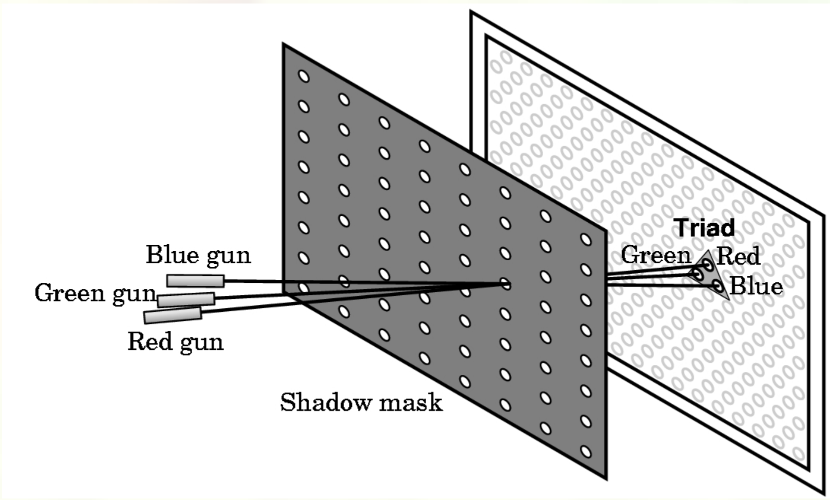
Three-Color Theory

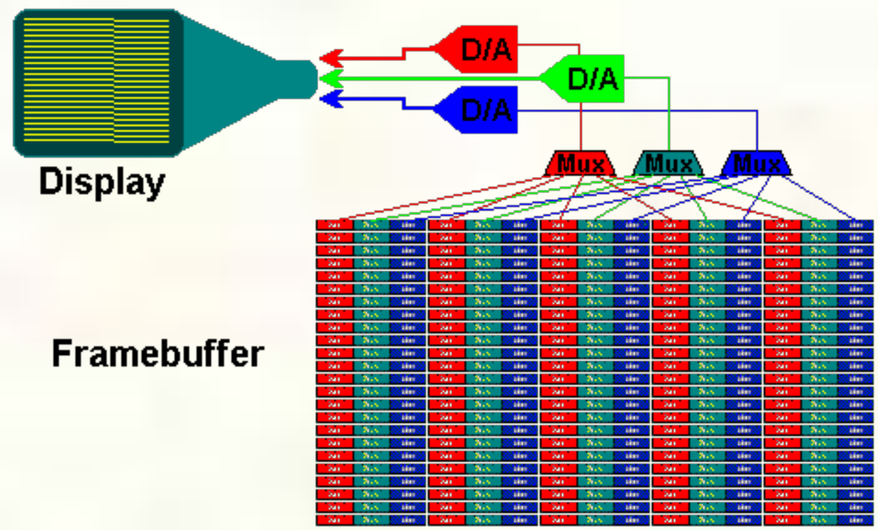
- Human visual system has two types of sensors
  - Rods: monochromatic, night vision
  - Cones
    - Color sensitive
    - Three types of cones
    - Only three values (the *tristimulus* values) are sent to the brain



- Need only match these three values
  - Need only three *primary* colors

Raster Displays





- Images are 2-d array of numbers corresponding to pixels on screen
- Numbers are in frame buffer memory
- 1-1 correspondence between frame buffer pixels and screen pixels

Additive and Subtractive Color

- Additive color
  - Form a color by adding amounts of three primaries
    - Monitors, projection systems, positive film
  - Primaries are Red (R), Green (G), Blue (B)
- Subtractive color
  - Form a color by filtering white light with cyan (C), Magenta (M), and Yellow (Y) filters
    - Light-material interactions
    - Printing
    - Film

Next Lecture

- Vector and affine math
- Assignments
  - Make sure your CS Unix account is active
    - Our first assignment will be pretty large – a ray tracer
- Thanks to Mark Kilgard and Ed Angel for material in many of these slides