Today’s Class

• Whirlwind intro to graphics – basic steps
• This class: Fundamental issues underlying these.
• Class structure and logistics
Computer Graphics: Possible Definitions

• Using computers to create images?
• Creating realistic images of the world
• Also creating semi-realistic images
• Information visualization
Realistic Images

• Geometry
• Lighting/Intensities
• Motion
Geometry

• 3D Models
• Projection
• Visibility
Graphics steps

- Modeling
- Rendering
- Lighting
  - Including variations in surface properties
- Motion
- Non-realistic images
Create 3D Models

7 MODELS ARE SCULPTED AND ARTICULATED

Using the art department’s model packet—a set of informational drawings—the characters, sets and props are either sculpted by hand and then scanned in threedimensionally or modeled in 3-D directly in the computer. They are then given “avars,” or hinges, which the animator will use to make the object or character move. Woody has 100 avars in his face alone.
3D Models - Scanning

(http://graphics.stanford.edu/projects/mich/).
On the left is a photograph of Michelangelo's David. On the right is a computer rendering made from a geometric model. (http://graphics.stanford.edu/projects/mich/).
Build Models on Computer

Visualmagic.awn.com/html/tutorials/santa.html
Realistic modeling and rendering of plant ecosystems: Oliver Deussen1 Pat Hanrahan2 Bernd Lintermann3 Radom´ır Mˇech4 Matt Pharr2 Przemyslaw Prusinkiewicz4

Fractal Landscape, Wikipedia
Geometry – Projection, Visibility

https://www.youtube.com/watch?v=OE7zhVSVfYY
Lighting

- Modeling Lighting
- Reflectance
- Texture
- Shadows (visibility)
- Interreflections
Lighting

(from Debevec)
Source emits photons

Photons travel in a straight line

When they hit an object they:
• bounce off in a new direction
• or are absorbed
• (exceptions later).

And then some reach the eye/camera.
Horn, 1986

**Figure 10-7.** The bidirectional reflectance distribution function is the ratio of the radiance of the surface patch as viewed from the direction \((\theta_e, \phi_e)\) to the irradiance resulting from illumination from the direction \((\theta_i, \phi_i)\).

\[
BRDF = f(\theta_i, \phi_i, \theta_e, \phi_e) = \frac{L(\theta_e, \phi_e)}{E(\theta_i, \phi_i)}
\]
Measuring BRDF
Skin Reflectance

http://graphics.stanford.edu/papers/bssrdf/  
(Jensen, Marschner, Levoy, Hanrahan)
Hair

http://graphics.stanford.edu/papers/hair/hair-sg03final.pdf
Texture

Photo

Pattern Repeated
Texture

Photo

Computer Generated
Shadows

(from Langer and Zucker)
Interreflections

Falling Water model, Bruce Walter thesis.  
http://www.graphics.cornell.edu/~bjw/bwthesis.pdf
Motion Capture

http://mocap.cs.cmu.edu/search.php?subjectnumber=%&motion=%
Physically real motion

Figure 10: (a) Starting pose. (b) Arm moves in tightly. (c) Close-up view of (b) with right arm invisible. Note how the arm position forces cloth to intersect both itself and the body. (d) Without GIA, a cloth/cloth intersection persists as the arm pulls out, snagging the sleeve. (e) The same frame as (d), but using GIA, the cloth doesn’t snag as the arm pulls out.
Images based on realism

(De Carlo and Santella)
Visualization – Pre-graphics
Visualization of Brain

Datavisualization.ch
Modern Applications
(slides courtesy of Prof. Varshney)

• Computer-Aided Design/Manufacturing
• Medicine
• Biochemistry
• Simulation
• Cartography
• Electronic publishing
• Computer Animation / Film Production
• Art
• Games
• Virtual/Augmented Reality
Film Production
Computer Games
Computer-Aided Design

Virtual Car
Images courtesy Mercedes-Benz
Drug Design

Complementarity of Transthyretin Domains
Architectural Walkthroughs

Image Courtesy
Lightscape
Medical Imaging

CT Volume Rendering
Image courtesy: GE CRD Labs
Computational Simulations

Flow Fields for Space Shuttle Launch Vehicle

ImageCourtesy: Fred Martin et al., NASA Johnson Space Center
What this class is about: Topics

• Geometry
  – Geometric primitives for modeling
  – Motion
  – Perspective
  – Visibility – intersecting lines and surfaces.

• Light
  – How it travels, and is reflected from surfaces.
  – Shadows, radiosity, shading, ray tracing

• Image Processing
  – Blurring, sharpening, image resizing
  – Going between the continuous and the discrete
    • Building continuous objects from discrete input.
    • Movies from discrete input (morphing).
    • Digital images from continuous fields of light.
What class is about: Fundamentals (math) and algorithms

- Inner product – distance in a direction
  - Containment, creating coordinate systems, visibility
- Projection
  - Turning 3D into 2D
- Interpolation
  - Representing lines, z-buffers, morphing, shading, curves, key-frame animation, Perlin noise, image-based rendering
- Sampling – Fourier transform and aliasing
  - Turning light into pixels, image resizing, texture mapping
- Optics
  - Specularities, refraction, shadows, BRDFs, color spaces
Other principles we won’t have much to say about

• Physics
  – Gravity constrains how things move.
  – Simulation of materials (hair, clothing).

• Aesthetics
  – Does it *look* real.
  – Non-realistic may look better.
What we’ll learn

- Fundamental principles/math
- Algorithms
- Programming – OpenGL
Text

• **Recommended:**
  - *Computer Graphics with OpenGL* by Hearn
  - *Interactive Computer Graphics* by Angel
  - *OpenGL Superbible* by Sellers
Course Requirements

• Prerequisites
  – Linear Algebra
  – CMSC 420 (programming experience)

• Assignments
  – Problem Sets (7)
    • Programming in OpenGL
    • Pencil and paper problems.
    • Challenge problems
  – Quiz, Midterm, Final
  – Presentation for final problem set.
Syllabus
Logistics

• Teacher–David Jacobs djacobs@cs.umd.edu
  – Office hours, Tue: 3-4, Wed. 4-5 (or email for an appt. or stop by).

• TA – Zheng Xu
  – Office hours Wed. 10-12

• Assignments
  – Handing in – Email with paper copies
  – Late policy - Homework due start of class. Due Thursday, late penalty of 10% if 24 hours late. 30% penalty if 11am next Monday. Not accepted later. Due Tuesday, late penalty 10% for 24 hours, 20% for 48 hours, no later.

• Piazza