CS4620/5620: Introduction to Computer Graphics

Professor: Steve Marschner
**Computer graphics:** The study of creating, manipulating, and using visual images in the computer.
Or, to paraphrase Ken Perlin...

**Computer graphics:** What you need to show other people your dreams.
Graphics Applications

• Entertainment
  – film production
  – film effects
  – games
• Science and engineering
  – computer-aided design
  – visualization (scientific, information)
• Virtual Prototyping
• Cultural Heritage
• Training & Simulation
• Graphic Arts, Fine Art
Graphics Applications

• Entertainment
  – film production
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• Graphic Arts, Fine Art
Pixar—*Luxo Jr.* (1986)
The Hobbit: An Unexpected Journey (New Line Cinema, 2012)—visual effects by Weta Digital
Crytek—Crysis 3 (2013)
Quantic Dream—Two Souls (2013)
Polytron—Fez (2010)
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Simulated deformation of citrate synthase during substrate binding
Graphics Applications

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Autodesk 360 Cloud Render

Autodesk® 360 Rendering
Create photorealistic images and panoramas using our Rendering cloud services with your Autodesk® 360
[Walter et al. 2005] model: University of Bristol
Digital Michelangelo Project
Marc Levoy, Stanford
Digital Michelangelo Project
Marc Levoy, Stanford
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Computer aided sculptures
Ergun Akleman
What is graphics about?
3D Modeling

- representing 3D shapes
- polygons, curved surfaces, …
- procedural modeling
3D Modeling

- representing 3D shapes
- polygons, curved surfaces, …
- procedural modeling

[Hoppe et al. 1993]

[Prusinkiewicz et al. 2001]
3D Rendering

- 2D views of 3D geometry
- projection and perspective
- removing hidden surfaces
- lighting simulation
3D Rendering

• 2D views of 3D geometry
• projection and perspective
• removing hidden surfaces
• lighting simulation
Animation

• keyframe animation
• physical simulation

Avengers (2012)
Animation

- keyframe animation
- physical simulation

Avengers (2012)

Pixar
Animation

- keyframe animation
- physical simulation
Animation

- keyframe animation
- physical simulation

Avengers (2012)

INTERPOLATION

Pixar
Animation

• keyframe animation
• physical simulation

Avengers (2012)

INTERPOLATION

Differential Equations
Images

• 2D imaging
  – compositing and layering
  – digital filtering
  – color transformations

• 2D drawing
  – illustration, drafting
  – text, GUls
Images

• 2D imaging
  – compositing and layering
  – digital filtering
  – color transformations

• 2D drawing
  – illustration, drafting
  – text, GUls
User Interaction

• 2D graphical user interfaces
• 3D modeling interfaces
• virtual reality
User Interaction

• 2D graphical user interfaces
• 3D modeling interfaces
• virtual reality
Graphics Hardware
Computer graphics:
Mathematics made visible.
Introductions...
Translucent materials

Diffuse “milk”
Translucent materials

Diffuse “milk”

Skim milk
Translucent materials

Diffuse “milk”  Skim milk  Whole milk
Digital characters

Gollum from *The Lord of the Rings*: hair and skin are two major rendering challenges in film effects
Rendering hair

\[ a = 1.0 \]
Rendering hair

$a = 1.2$
Rendering hair

\[ a = 1.5 \]
Modeling knit cloth

[Yuksel et al. 2012]
High-quality woven cloth appearance

[Zhao et al. 2012]
Course Overview
Course mechanics

Web  http://www.cs.cornell.edu/Courses/cs4620

Teaching Assistants (3 Ph.D., ≥2 ugrad, more coming)
* Dan Schroeder
* Eston Schweickart
* Tim Langlois
* Jeremy Feinstein
* Nic Savva?
* Debarghya Das?

Piazza
Please sign up!
In CS4620/5620

• You will:
  – explore fundamental ideas
  – learn math essential to graphics
  – implement key algorithms
  – write cool programs
  – learn the basics of OpenGL

• You will not:
  – write very big programs
Topics

• Images, image processing, color science
• Modeling in 2D and 3D
• Rendering 3D scenes
  (using ray tracing and using the GPU)
• Geometric transformations
• The graphics pipeline
• Animation
Images

• What is an image?
• Compositing
• Resampling
• Color
Rendering

- ray tracing
- rasterization
- shading
- shadows
- texture mapping
Geometric transformations

• affine transforms
• perspective transforms
• viewing

rotate, then translate    translate, then rotate
Geometric transformations

- affine transforms
- perspective transforms
- viewing

rotate, then translate
translate, then rotate
Graphics pipeline

- rasterization
- interpolation
- z-buffer
- vertex and fragment ops
Graphics pipeline

- rasterization
- interpolation
- z-buffer
- vertex and fragment ops
Modeling

- splines
- parametric surfaces
- triangle meshes
CS4620 Prerequisites

• Programming
  – ability to read, write, and debug small Java programs (10s of classes)
  – understanding of very basic data structures
  – no serious software design required

• Mathematics
  – vector geometry (dot/cross products, etc.)
  – linear algebra (just basic matrices in 2-4D)
  – basic calculus (simple derivatives)
  – graphics is a good place to pick up some, but not all, of this
In CS4621

• You will also:
  – implement a modeling, rendering, animation system
    • in groups
  – learn a lot about
    • architecting good-sized interactive programs
    • OpenGL
    • programmable shaders, textures, animation
Workload

• CS 4620/5620
  – 3 homeworks
  – 4 programming assignments
  – No penalty for 1 late homework, then 10% per day

• CS 4621/5621
  – 3-4 programming assignments
Textbook

Shirley & Marschner

Fundamentals of Computer Graphics

third edition
More books

Steven Gortler
Foundations of Computer Graphics
first edition

OpenGL Programming Guide
(a.k.a. the "Red Book")
Older version available online:
http://www.opengl.org/documentation/red_book/

GLSL Shading Language
(a.k.a. the "Orange Book")
Academic Integrity
Course mechanics

Web  http://www.cs.cornell.edu/Courses/cs4620

Schedule, handouts, etc. all on the web page

Practicum
• Not this Friday
• Will send out mail when a practicum is planned