15-462: Computer Graphics

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Introduction

• Administrivia
• Who am I?
• What is Computer Graphics

Administration

• Web page
• TA’s: Jernej Barbic, Ian Graham, and Mike Hensen
  – Office hours and contact info on the web
• Textbook: Watt, 3D Computer Graphics
• Textbook: Open GL

Administration

• Prerequisites (talk to me if you’re missing these!)
  15-213: Introduction to Computer Systems
  21-241: Matrix Algebra (matrix & vector algebra)
  21-259: Calculus in Three Dimensions (i.e. planes, quadratic surfaces, basic 3-D geometry, partial derivatives) or equivalent
• Midterm and Final (13% and 22%)
• Four programming assignments (10-13% each)
• Three written assignments (20% total)

You will do fun things in this class!

Quarup Barreirinhas
You will do fun things in this class!
Paint program
Spline roller coaster
Cube of jello
Ray tracer

Warning: mathematical programming may be different than what you’ve done in the past.

Administration

- Late Policy: 3 late days that you can use for any assignment. More than three requires a really good excuse.
- Cheating: Please don’t! The detailed definition is in the syllabus. We will pursue the case…
- If you didn’t get into this class, talk to me—the waitlist is empty

Other Graphics-related Courses

- 15-???: Computer Animation, Hodgins, Duesing (S03)
- 15-???: Video Games, Kuffner (F02)
- 15-6??: Simulation for Animation, James (S02)
- 15-385: Computer Vision
- 05-331: Building Virtual Worlds, Pausch (F02)
- 24-384A: Computational Geometry, Shimada
- 60-41x: 3-D Animation, Duesing

Introduction

- Administrivia
- Who am I?
- What is Computer Graphics

Any questions?

Who am I?

PhD CS, CMU
Legged Locomotion For Rough Terrain Locomotion
On the faculty at Georgia Tech from 1992-2000
Joined CMU in fall 2000
Legged Locomotion

From physical robots to animations

And on to humans

And on to humans

All motion in this animation was generated using dynamic simulation.

Now--Capturing data of humans

Controlling an avatar
And back to robots

What is this course about?

Computer Graphics…

One agenda: Faking Reality

- Make synthetic images that are *indistinguishable* from the real thing
- Do it in a way that’s both practical and scientifically sound. In real time, obviously.
  And make it look easy…

Another Agenda:
Create a new Reality

- Non-photorealistic Rendering
- Example: Illustrating smooth surfaces
  A.Hertzmann, D. Zorin.

Another Example


Things that this course isn’t about
The three big topics:

- Modeling: how to represent objects; how to build those representations.
- Animation: representing/controlling the way things move.
- Rendering: how to create images

Modeling

- How to represent real environments
  - geometry: modeling surfaces, volumes
  - photometry: light, color, reflectance
- How to build these representations
  - declaratively: write it down
  - interactively: sculpt it
  - programmatically: let it grow
  - via 3D sensing: scan it in

Modeling by Sculpting

Freeform from Sensable Technologies

Modeling by Growing

Reproduction of the topiary garden at Levens, England.
R. Mech, P. Prusinkiewicz, SIGGRAPH 1994

User-interfaces

That rely on graphics:
- interactive simulations
- vision-based interfaces

Or graphic design,
Software packages (as opposed to software API’s like GL),
and much about graphics hardware.
**Modeling by Growing**

Modeling Seashells
P. Prusinkiewicz, Deborah Fowler, Hans Meinhardt, SIGGRAPH 92.

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**Modeling by Scanning**

Cyberware

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**Animation**

- Model how things move
- How to represent motion
  - sequence of stills, parameter curves
- How to specify motion
  - by hand: tweak it till it looks right
    - key-framing, constraints
  - rule-based behaviors: artificial life
  - physics: simulate Newton’s laws
  - motion capture: data from the real world

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**Hand Animation**

Making of Toy Story

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**Rule-based Behaviors**

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**Physics for Natural Phenomena**

Antz water simulation, related techniques were used in Shrek
Physics for Natural Phenomena


Physics for Characters

Motion Capture

Microsoft’s Motion Capture Group

Motion Capture

Titanic, House of Moves

Motion Capture

Motion Analysis

Motion Capture

Titanic, House of Moves
Rendering

- What’s an image?
  - distribution of light energy on 2D “film”: \( E(x,y,\lambda,t) \) (\( \lambda \) is wavelength.)
- How do we represent and store images
  - sampled array of “pixels”: \( p[x,y] \)
- How to generate images from scenes
  - input: 3D description of scene, camera
  - solve light transport through environment
    - ray tracing
    - radiosity
  - project to camera’s viewpoint

Raytracing

May-June 2001 First Place Winner Internet Ray Tracing Competition
warm_up by Norbert Kern

Radiosity

Lightscape, Autodesk

Image-based Rendering

Mike Harris Martin Løvvold
Caligari, True Space

Hot Application Areas

- Special effects
- Feature animation
- PC graphics boards
- Video games, location-based entertainment
- Visualization (science, architecture, space)
- The web

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
Starting out Simple

• The field didn't start out with all this difficult stuff.
• First there were wireframes. Then faceted and smooth shading. Advanced ideas such as radiosity and physically based animation came later.
• Only gradually did the idea of “physically based” take hold.
• The simpler models and methods are still very much in use, because they're well understood, they're amenable to hardware implementations, and fast.
• In this class, we concentrate on the simple stuff, but sprinkle in some advanced topics here and there.