# 15-462: Computer Graphics

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## Introduction

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

## Administration

- Web page
  - http://www-2.cs.cmu.edu/afs/cs.cmu.edu/user/jkh/www/462_f02/
- 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!


Michael Maxim

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

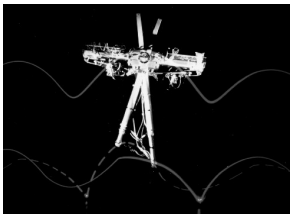
Any questions?

## Who am I?

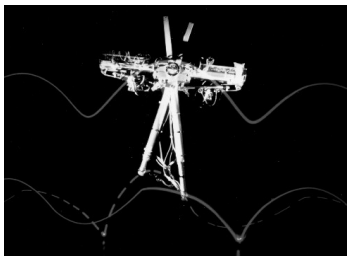
PhD CS, CMU
Legged Locomotion For Rough Terrain Locomotion

On the faculty at Georgia Tech from 1992-2000

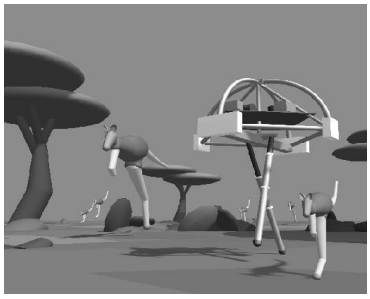
Joined CMU in fall 2000



## Legged Locomotion

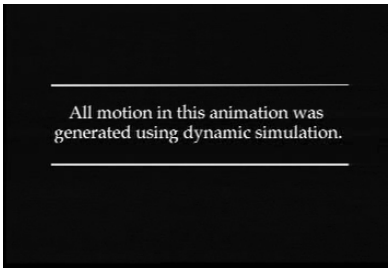


## From physical robots to animations

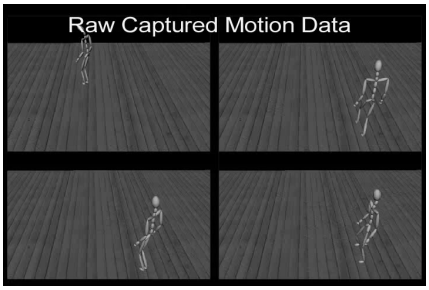


## And on to humans

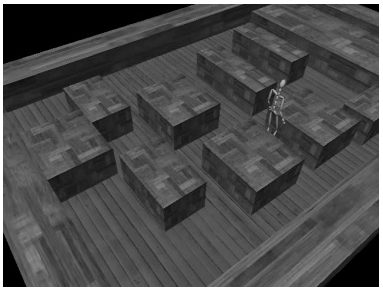
## And on to humans



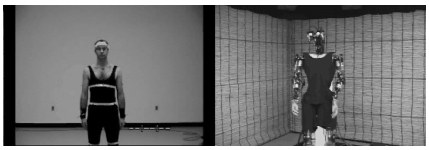

## Now--Capturing data of humans




## 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

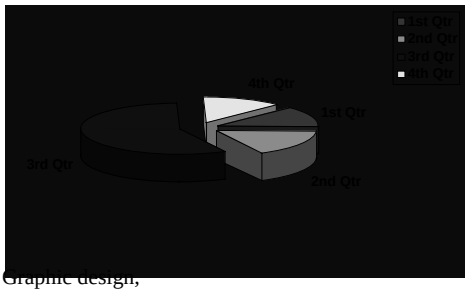
- Non-photorealistic Rendering
- Example: Illustrating smooth surfaces

  A.Hertzmann, D. Zorin. SIGGRAPH 2000 Conference Proceedings.

## Another Example

- Image Analogies A. Hertzmann, C. Jacobs, N. Oliver, B. Curless, D. Salesin. SIGGRAPH 2001 Conference Proceedings.

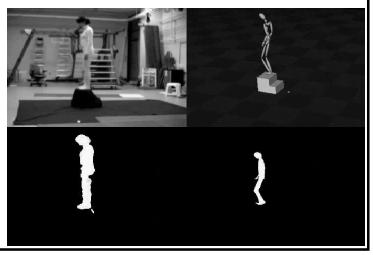
## Things that this course isn't about




Or Graphic design,
Software packages (as opposed to software API's like GL), and much about graphics hardware

## User-interfaces

That rely on graphics:
interactive simulations
vision-based interfaces



## 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


Synapse Modelmaking

## Modeling by Growing

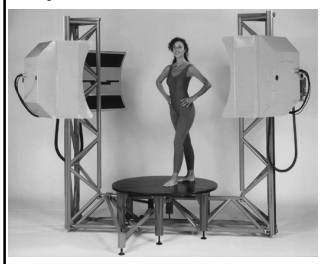
Reproduction of the topiary garden at Levens, England. R. Mech, P. Prusinkiewicz, SIGGRAPH 1994

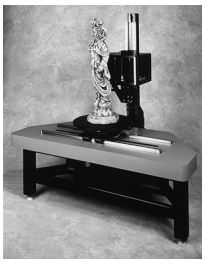
## Modeling by Growing

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

## Modeling by Scanning

Cyberware

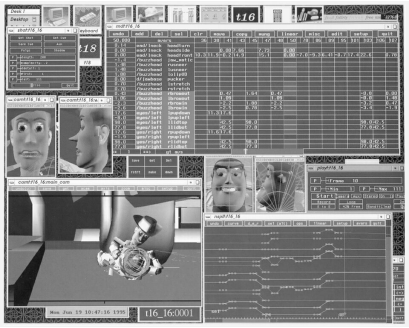




## Animation

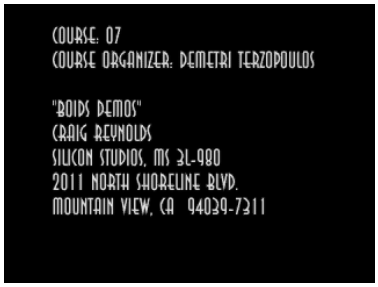
- Model how things *move*
- How to represent motion
  - sequence of stills, parameter curves
- How to specify motion
  - by hand: tweak it till it looks right
    - key-framing, constraints
  - rule-based behaviors: artificial life
  - physics: simulate Newton's laws
  - motion capture: data from the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

## Hand Animation



Making of Toy Story

## Rule-based Behaviors



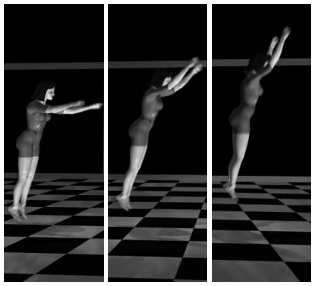

## Physics for Natural Phenomena

Antz water simulation, related techniques were used in Shrek

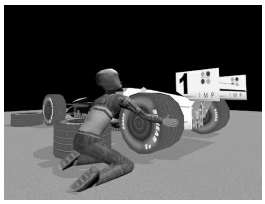
## Physics for Natural Phenomena

O'Brien, J. F., Hodgins, J. K., (1999) Graphical Modeling andAnimation of Brittle Fracture. The proceedings of ACM SIGGRAPH 99,

## 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,λ,t) *(λ 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

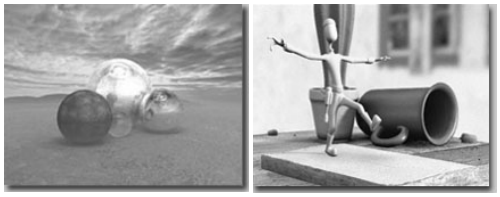
## Raytracing

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.