15-462: Computer Graphics

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Robotics Institute and
Computer Science Department

Introduction

- Administrivia
- Who am I?
- What will we do in this course?
- What is Computer Graphics?

Administration

- Web page
  - http://www.cs.cmu.edu/~nsp/course/15-462/Fall04
- TA's:
  - Steven Osman, Mark Tomczak, and Hua Zhong
- Graphics lab – Wean 5336
  - TA hours will be held in graphics lab
  - Access to the lab will be available later in the week
- Textbook:
  - Shirley, "Fundamentals of Computer Graphics"
  - Open GL (The Red Book)

Administration

- Prerequisites

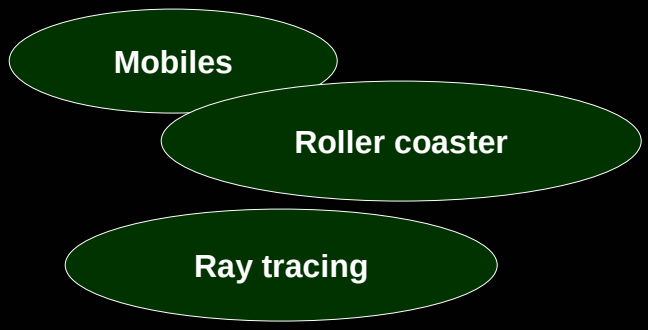
  15-213: Introduction to Computer Systems

  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!

Past course projects



You will do fun things in this class!

- Height field
- Roller coaster
- Ray tracer
- Texture synthesis

Administration

- Late Policy: 3 late days that you can use for any assignment. More than three requires a really good excuse.
- Collaboration:
  - You can talk about strategies and algorithms to solve problems, but the programming work and written homework answers must be your own
  - If you use WWW or other resources to provide background for written homeworks, please cite your references

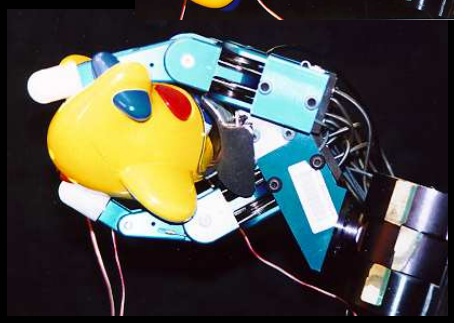
Other Graphics-related Courses

- 15-505: Animation Art and Technology, Hodgins/Duesing
- 15-463: Rendering and Image Processing, Efros
- 15-493: Computer Game Programming, Kuffner

- 05-331: Building Virtual Worlds, Pausch
- 15-863: Simulation for Animation, James
- 15-869: Physically Based Character Animation, Pollard
- 15-???: Other specialized graduate courses in graphics

- 15-385: Computer Vision
- 60-415: 3-D Animation, Duesing

Who am I?

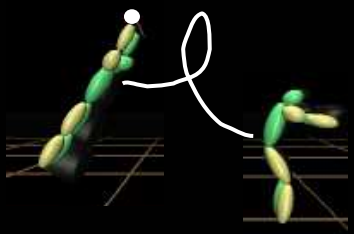


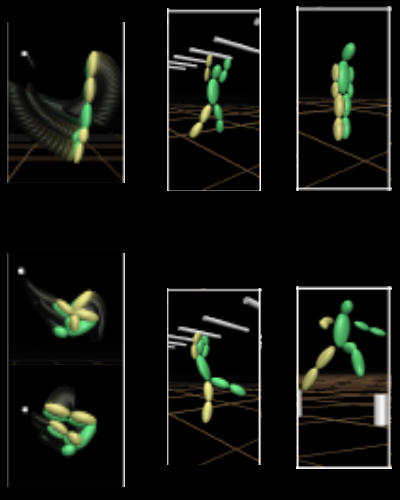
PhD CS, MIT
Robot Grasp Planning

On the faculty at Brown University from 1998-2003

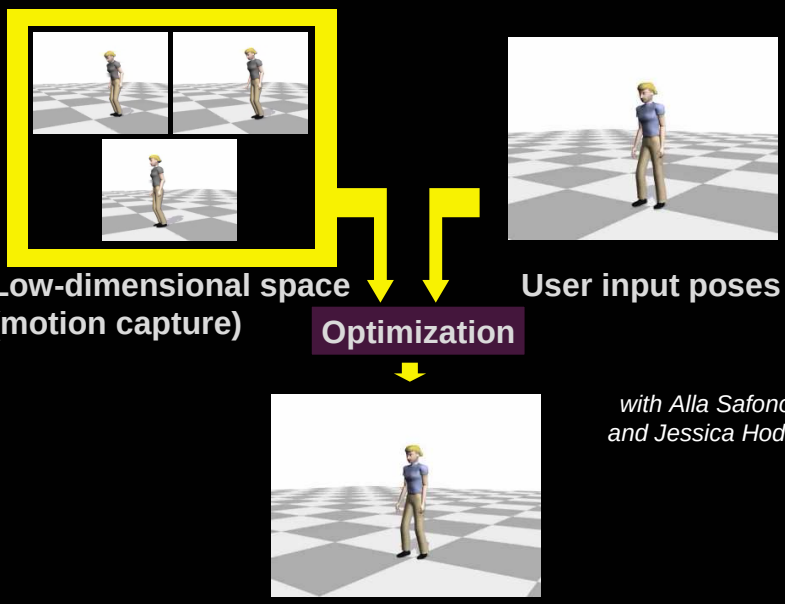
Joined CMU in fall 2003

Animation





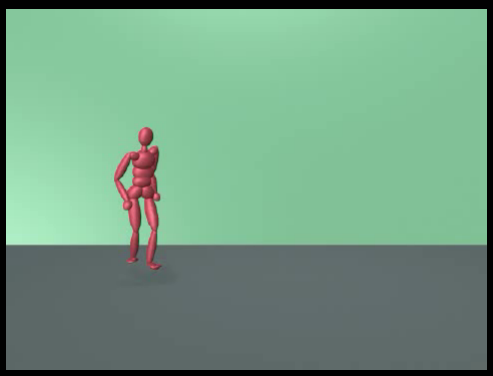
Animation



with Alla Safonova and Jessica Hodgins

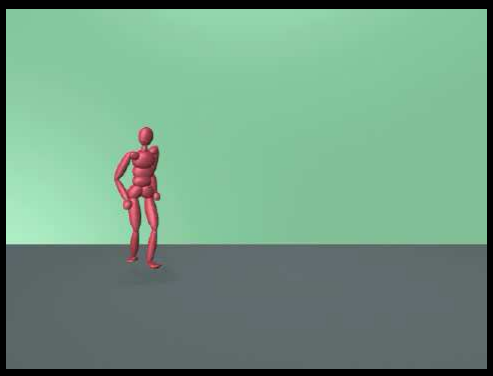
Perception of Animation

80% Gravity



Perception of Animation

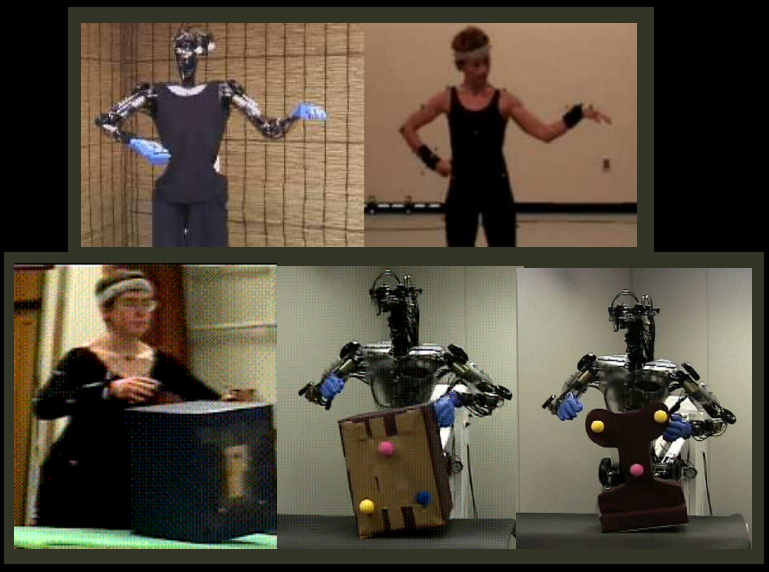
60% Gravity



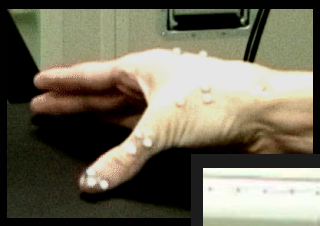
Perception of Animation

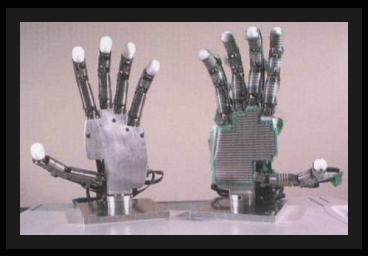
15% Gravity

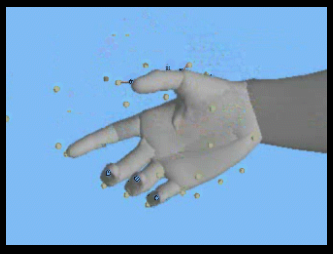
Humanoid robots



And hands







What is this course about?

Computer Graphics…

One agenda: Faking Reality

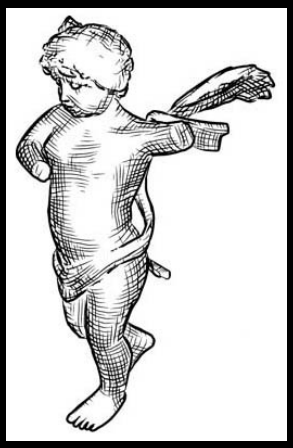
- Make synthetic images that are *indistinguishable* from the real thing
- Do it in a way that's both practical and scientifically sound**.** In real time, obviously.

And make it look easy…

Another Agenda: Create a new Reality

- Non-photorealistic Rendering
- Example: Illustrating smooth surfaces

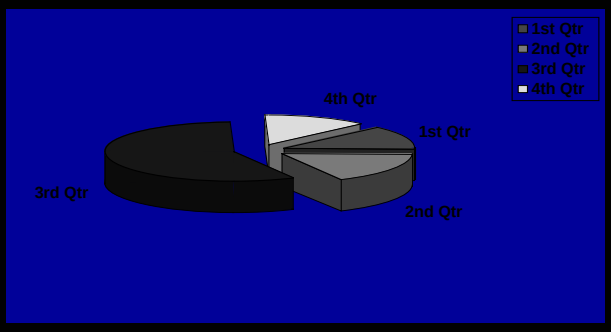
  A.Hertzmann, D. Zorin. SIGGRAPH 2000 Conference Proceedings.



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

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.

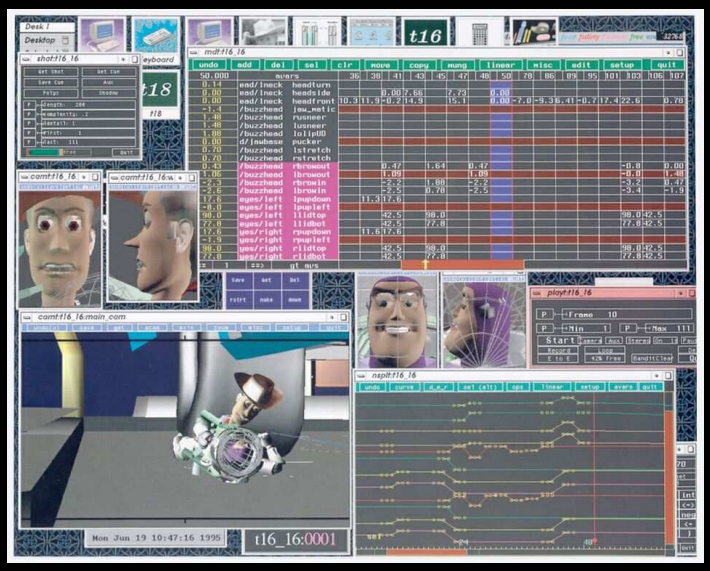
Modeling by Scanning

Cyberware

Animation

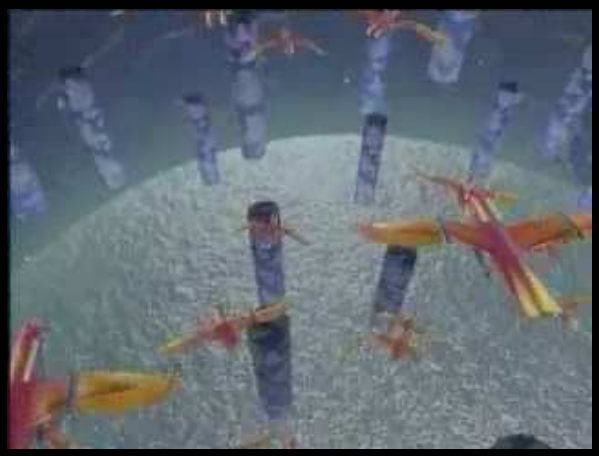
- Model how things *move*
- How to represent motion
  - sequence of stills, parameter curves
- How to specify motion
  - by hand: tweak it till it looks right
    - key-framing, constraints
  - rule-based behaviors: artificial life
  - physics: simulate Newton's laws
  - motion capture: data from the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

Hand Animation



Making of Toy Story

Rule-based Behaviors



Reynolds, C. W., “Flocks, Herds, and Schools: A Distributed Behavioral Model,” SIGGRAPH ’87.

Physics for Natural Phenomena

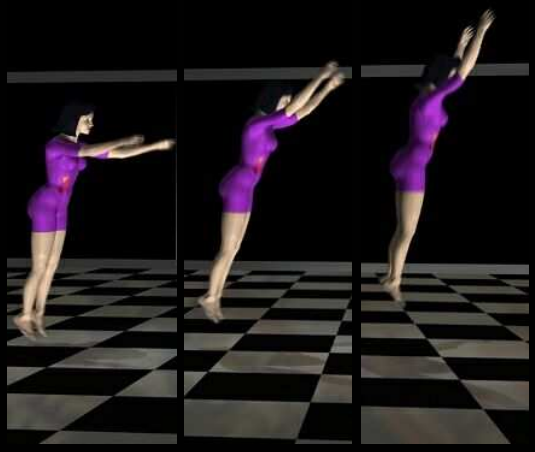
Antz water simulation .. since then simulated water has become commonplace in movies

Enright, D., Marschner, S. and Fedkiw, R.,
"Animation and Rendering of Complex Water Surfaces", SIGGRAPH 2002.

Physics for Natural Phenomena

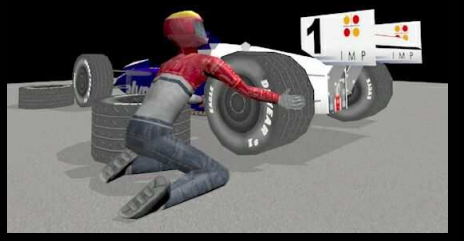
O'Brien, J. F., Hodgins, J. K., (1999) Graphical Modeling andAnimation of Brittle Fracture. SIGGRAPH 99,

Physics for Characters



Hodgins, J. K., Wooten, W. L., (1998) Animating Human Athletes. Robotics Research: The Eighth International Symposium.

Motion Capture

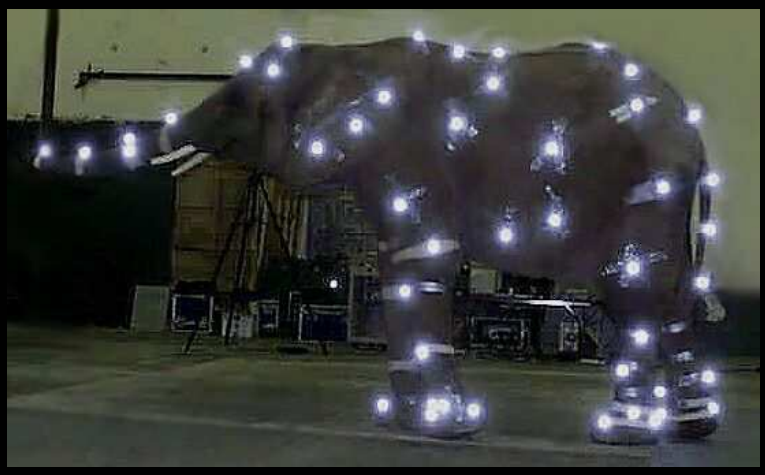


Microsoft's Motion Capture Group

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)

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.