Computer Animation
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Adminstrations

- [Link](http://www.cc.gatech.edu/classes/AY2012/cs4496_spring)
- Slides and assignments are online
- No textbook, but there are reading materials
- My office hours: Mon 12:15-1:30, TSRB 230A
- TA office hours: Fri 2:00pm-3:15pm
Contact

• Best way to get my attention
  • in class
  • office hours
• Worst way to get my attention
  • emails
Prerequisites

- Thorough understanding of linear algebra
- Vector calculus
- A good working knowledge of C and C++ programming
About Maya

- You need to bring a laptop with Maya installed on Friday
- No prior knowledge in Maya is required
- Simple Maya tutorial to help you start
- http://students.autodesk.com
OpenGL
FLTK
Tutorial on OpenGL and FLTK

- OpenGL Tutorial: http://www.opengl.org/sdk/
- One hour introduction lecture before Project 2 is assigned
Get ready for this class

- If you have a couple of hours this weekend
- skim through the first three chapters of your old linear algebra textbook
Given two vectors, \( a = (3, 0, 1) \) and \( b = (-2, 5, 2) \),

- What is the dot product of \( a \) and \( b \)?
- What is the cross product of \( a \) and \( b \)?
- What is the norm of \( a \)?
- What is the angle between \( a \) and \( b \)?
- What is the projection of \( a \) on \( b \)?
• Given three \( n \) by \( n \) matrices \( A, B, \) and \( C \)
  
• Is \( AB = BA \) true?

• Is \( A(BC) = (AB)C \) true?

• Is \( (AB)^T = A^TB^T \) true?

• Does \( A^{-1} \) always exist?

• What is the rank of \( A \)?
Grading schemes

• Reading assignment (0%)
• Project 1 (15%)
• Project 2 (20%)
• Project 3 (20%)
• Final project (20%)
• Midterm (25%)
Projects and homework

- Project 1: Splines
- Project 2: Particles
- Project 3: Physics games
- Final project: Inverse kinematics
- Late policy: 33% reduction per day if you don’t have a good reason
- Everything has to be turned in before 10 am on the due date
Partners

• For project 3 and project 4, you will work with one partner
What do I expect?

• Give you an overview of computer animation with an emphasis on physics-based animation and character animation

• Teach you how to be a good engineer who also understands art

• Inspire some of you to do research in computer animation
What should you expect?

• A class that
  • takes a lot of your time (I’m not kidding)
  • tests your programming skills
  • makes you revisit linear algebra and calculus
Course overview
Traditional animation

That was then...

- Film runs at 24 frames per sec; that is, 1440 pictures to draw in one minute
- Artistic vision has to be converted into a sequence of still “keyframes”
- Hard to draw consistent “in-between” frames
- Not enough to get the still right; must to look right at full speed
Computer assisted animation

- Generate the images by rendering a 3D model
- Manually set the parameters for each keyframe
- Automatically interpolate between two drawings to produce inbetweens

This is now
Does it really get better?

pencil and paper

computer

Do computers really expedite the process of creating animation?
What can’t be done by keyframes?
NVIDIA Physx
Physics simulation

- It’s an algorithm that produces a sequence of states over time under the laws of physics
- What is a state?
Simulation

\[ x_i + \Delta x = x_{i+1} \]
Simulation

\[ x_i \rightarrow \text{Newtonian laws} \rightarrow \Delta x \rightarrow x_{i+1} \]

- gravity
- wind gust
- elastic force

\[ x_{i+1} = x_i + \Delta x \]
Ordinary differential equations

An ODE is an equality equation involving a function and its derivatives

\[ \dot{x}(t) = f(x(t)) \]

known function

unknown function that evaluates the state given time

time derivative of the unknown function

\[ F = ma \]
Rigid bodies
Rigid bodies
Deformable objects
Fluids
Fluids

Rain in a Forest
And for my acting Oscar, I thank the special effects

“Acting is all about honesty, but something like this makes what you see on screen a dishonest moment,” said a leading technician (of *Blood Diamond*). “Everyone feels a bit dirty about it.”
Fluids
Fluids
Fluid-solid coupling
Water-thinshell interaction
Melted
Burned
Drowned
Deformed
Crushed
What can’t be done by simulation alone?
Controlled simulation

Popovic et al

Twigg and James
Fluid control
Fluid control
Controlled interaction

Original captured motion
Character control
Character animation

- Unknown internal forces
Simulation

\[ x_i + \Delta x = x_{i+1} \]

Newtonian laws
- gravity
- wind gust
- elastic force

\[ x_{i+1} = x_i + \Delta x \]
Simulation

Newtonian laws
- gravity
- wind gust
- elastic force

\[ \Delta x \]

\[ x_i \] \rightarrow \[ x_{i+1} \]
Simulation

\[ x_i \]

Newtonian laws

gravity

ground contact forces

internal forces

\[ \Delta x \]

\[ x_{i+1} \]
Robust Physics-Based Locomotion Using Low-Dimensional Planning

Igor Mordatch     Martin de Lasa     Aaron Hertzmann

University of Toronto
Character animation

- Unknown internal forces
- Natural human motion with variations
Motion capture

Humans

Objects

Animals

Celebrities
What is captured?

Whole body

Face

Hands
Optical systems

- Cameras
  - High temporal resolution (120+ fps)
  - Detect the locations of reflective markers
- Markers
  - Sensitive to infrared
Raw data

3D locations of markers
Inverse kinematics

- Input: articulated body with handles + desired handle positions
- Joint angles that move handles to desired positions
Final motion
The main problem with motion capture associated with characters has to do with mass distribution, weight and exaggeration. It is impossible for a performer to produce the kind of motion exaggeration that a cartoon character needs, and the mass and weight of the performer almost never looks good when applied to a character of different proportions.

Eric Darnell, codirector of Antz
The mapping of human motion to a character with non-human proportions doesn’t work, because the most important things you get out of motion capture are the weight shifts and the subtleties and that balancing act of the human body. If the proportions change, you throw all that out the door, so you might as well animate it.

Richard Chuang, VP at PDI
Path Fitting
Performance animation
Performance animation
Performance animation
Other Topics

• Facial animation
• Cloth simulation
• Hair modeling
• Sound simulation
• Crowd animation