

Computer Animation: It's Past, It's Present And its Future at UW



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Outline

- A brief history of computer animation
 - (animation appreciation) – Video!
- Overview of the Production Process
 - Where motion comes from – Video!
- Animation at UW CS
 - (what we do) – Video!
- Graphics and Animation Classes
 - (what you can do) – Video!



Goals

- Give you some idea of what Computer Animation is about
- Give you some idea of where (some of) the hard problems are
- Give you an idea of we do
- Try to get you excited about doing it
- **Show some fun video**

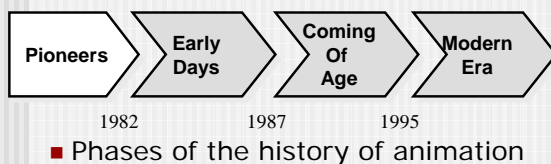


Caveats

- This talk is skewed toward 3D Animation for film and video
- That ignores lots of interesting stuff
 - 2D and image effects
 - Games, Visualization, Simulation, ...
- Focus on character animation
 - Over-emphasize my heroes
- This is a rehash of some old stuff
- Little (or no) technical content



Timeline



Pioneer Days (pre-1980s)

- What was happening:
 - Early pioneers (in research labs) started making movies with computers
- General Story:
 - It was hard to make pictures with computers, but people did it anyway
- Why it ended:
 - Computer Animation becomes feasible



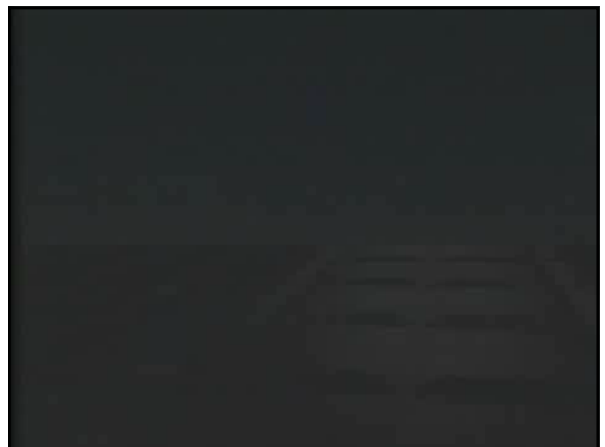
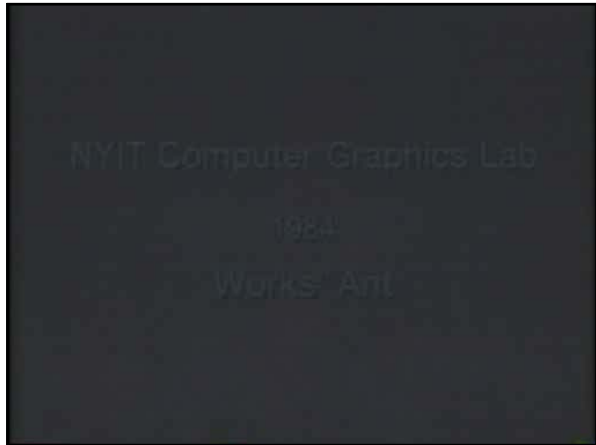
Early Days (early to mid-1980s)

- What was happening:
 - Computer animation in film and video
- What it looked like:
 - Computer graphics
 - Things computers could draw well
 - Chrome! Flying Logos!



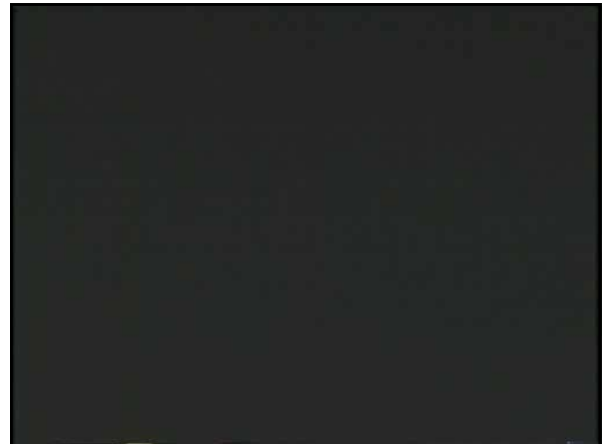
Early Days (early to mid-1980s)

- Notable examples:
 - TRON ('82), The Last Starfighter ('84)
 - Many TV spots and commercials
- What it looks like today:
 - Quaint
- Why it ended
 - AUDIENCES grew more savvy



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A critical moment in history...



Luxo Jr.
Pixar, 1986
J. Lasseter (dir)

- First computer animation nominated for an Academy Award
- Notable character animation
 - It's the motion! (well, it looks good too)



Computer Animation Comes of Age (late 80s – mid 90s)

- Computer Animation not just for computer animation's sake



Beauty and the Beast, 1991



Jurassic Park, 1993



Glory Days of Computer Animation

- What will they do next?
- Notable examples
 - Tin Toy '88 (and other Pixar Shorts)
 - Terminator 2 '91
 - Beauty and the Beast '91
 - Jurassic Park '93
 - ... more and more and more ...



Another important film...

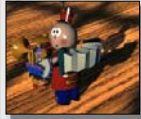


Toy Story
Pixar, 1995
J. Lasseter (dir)

- Feature length, 3D animated film
- Financially and artistically successful
- Everybody wants to copy



Why is Toy Story Different?



Tin Toy
1988



Toy Story
1995

- Same basic technology as shorts
- Different magnitude of problems
 - How to deal with all the bits!
- Must hold attention for 90 minutes



End of the Glory Days?

- No more firsts?
- Glory is for good films, not cool effects
 - Not just animation for animation's sake
 - Hackers are not the heroes anymore
- Technology is generally available.
 - (Kindof)
- Artistic factors drive



Toy Story++

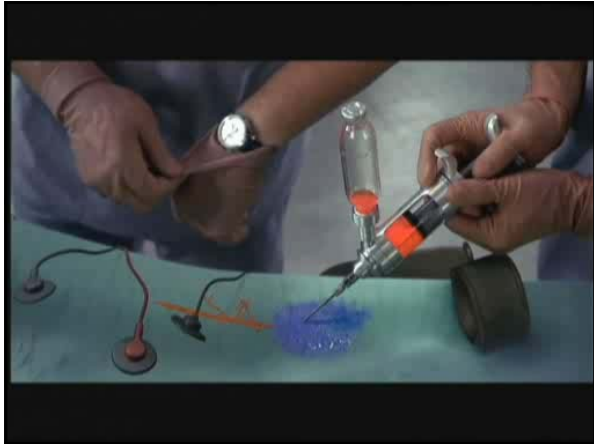
- More and more animated films
- Greater levels of complexity
 - Antz, Bugs Life, Toy Story 2, ...
- New artistic styles and possibilities
 - Tarzan, Prince of Egypt
 - Final Fantasy,...
- Current state of the art



The Modern Era ('95 - ...)

- No more firsts?
- Don't believe your eyes!
 - Anything is possible!
 - Seamless integration of CG and real
- Some landmarks
 - Titanic '97
 - What Dreams May Come '98
 - The Mummy, Episode 1, The Matrix '99
 - Hollowman, Perfect Storm '00
 - Pearl Harbor '01





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How do you do it?



- "Typical" or Traditional pipeline
- Divides tasks
- Variants exist



Design



- One of the most important pieces
- Deciding what animation is to be made



Modeling



- What are the objects?
- What do they look like?
- How do they move?



Animation



- Animate: to bring to life
- Making things move



Lighting



- Making choices in how things look
 - Term is a “Pixarism”
- Catch-all for lots of appearance design



Rendering



- Let the computers color the pixels
- The compute intensive part



Post-Production



- Put the pictures into final form



Why focus on motion?

- It is the heart of animation
- It's the most unique aspect of animation
- It's the thing we have the least experience with
- It's the thing I am most interested in



What is a character? (for the purposes of motion)

- Some “object” (geometry)
- *Configuration* or *Pose* given by a set of numbers
 - Parameters
 - Control knobs
- Process to (or draw) geometry given parameters
- *Articulation*: define how parameters drive geometry



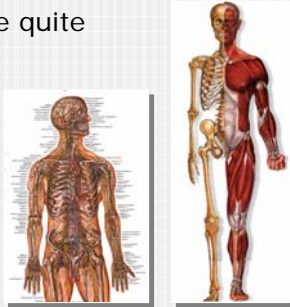
What parameters?

- It depends!
- Enough controls to be expressive
- Few enough to be easy
- Standard methods for gross motion
- Anything goes for details



What are those parameters? How do we model a human?

- Humans are quite complex...



Fortunately, we don't care about details

- "Gross Body Motion"
 - Overall movement
- Small details hidden
 - Under clothing
 - Under simplified drawing models
 - View from far enough away
- Chains of rigid segments

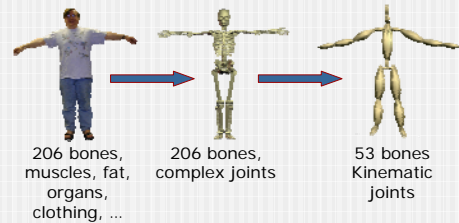


Animation Appreciation 101

- Brilliance (Sexy Robot)
 - Robert Abel and Associates, 1985
 - Early motion capture
 - Early computer graphics look (chrome)
- Final Fantasy
 - Square Studios, 2001
 - Realistic, animated, human characters
- Hollowman
 - Sony Imageworks (effects), 2000
 - Complex human models, terrible dialog

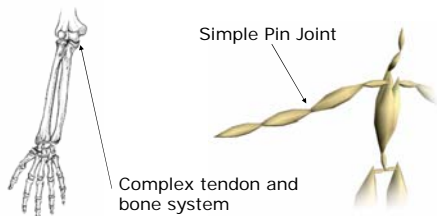


Abstractions

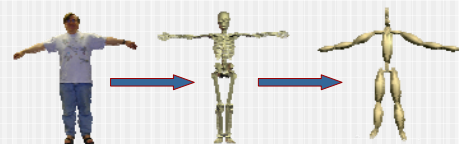


Abstractions vs. Reality (skeletons vs. humans)

Representation of complex human structure with varying degrees of simplification



Abstraction of Human Motion



- Question of Approximating DOF's
- Some number of connected, rigid pieces
 - (usually)
 - Kinematic joints

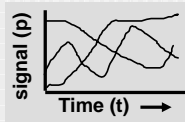
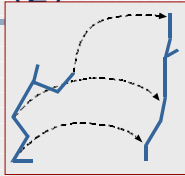


What is a motion (2)

- A motion maps times to configurations

$$\mathbf{m}(t) \in \mathcal{R} \Rightarrow \mathcal{R}^n$$

- Vector-valued, time-varying signal
- Representation comes from creation
 - typically interpolation
 - may not be convenient for editing



Why is this so hard?

- We are good at looking at motion!
- Motion is very expressive
 - Mood, activity, personality, ...
- But those attributes are subtle
 - What makes a motion sad? Realistic?
- We lack vocabulary
 - Talk about motion with metaphor



Three main ways to make motion

- Create it by hand
- Compute it
- Capture it from a performer

- Re-use an existing motion
 - (don't make it at all)



Creating Motion by Hand: Keyframing

- Skilled animators place "key" poses
 - Computer "in-betweens"
- Requires incredible amounts of talent
 - But can be done extremely well

Verdict: Produces the highest quality results, at a very high cost



Computing Motion: Procedural and Simulation

- Define algorithms to create motions
- Ad-hoc rules, or simulate physics
- Physics provides realism
- But how do you control it?

Verdict: Good for secondary effects, not for characters (yet)




All motion in this animation was generated using dynamic simulation.



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Motion Capture and Performance Animation

- Use sensors to record a real person
- Get high-degree of realism
 - Which may not be what you want...
- Possibility for real-time performance


Verdict: Good for realistic human motions. Scary to animators.



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Motion Capture Technology: Optical Tracking

- User markers and special cameras
- Tracking + Math



Motion Capture Technology: Video

- An interesting and open problem...
- Limited information
 - But seemingly enough
- Problem can be arbitrarily hard
 - Or easy – if you make assumptions
- Video is surprisingly bad



So now you have motion...

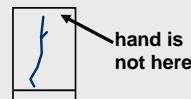
- Transform Motion to new uses



Problem: Motion is Specific

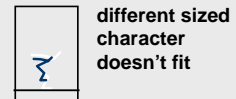


Specific Action



Edit motion to meet new needs

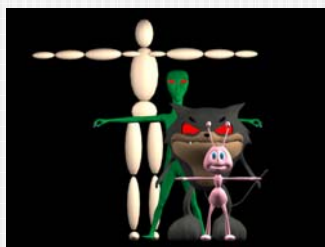
Specific Character



Retarget motion to new character

Retargetting Motion to New Characters

- Goal: one motion, a cast of characters
- Similar structure



Transformation Basics

Change what isn't important, retain what is

- Hard to define what is important
 - high-level properties
 - motion specific
- Stick to what's easy to define
 - geometric constraints
 - signal characteristics
 - framework for better metrics later

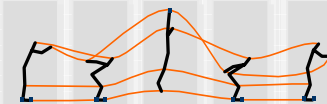


Transformation as Constrained Optimization

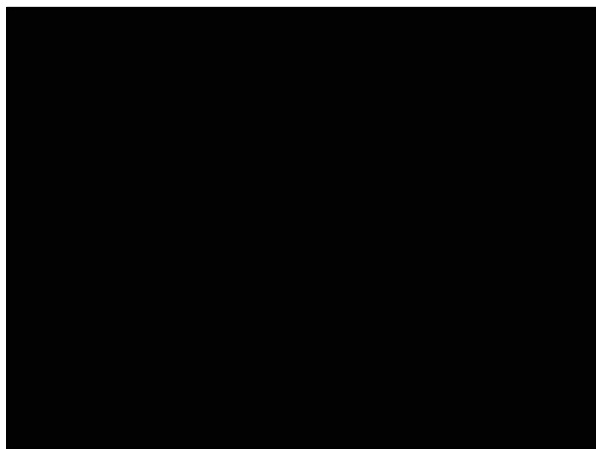
- Find a motion that...
 1. Meets any specific requests
 2. Keeps any specific characteristics of the original
 3. Is as similar as possible to the original
- Naturally posed as constrained optimization
 - subject to meeting the constraints (1 and 2)
 - minimize some objective (3)



Spacetime Constraints



- Consider all constraints simultaneously
 - NOT frame at a time
- Solve for motions
 - "best" motion that meets constraints

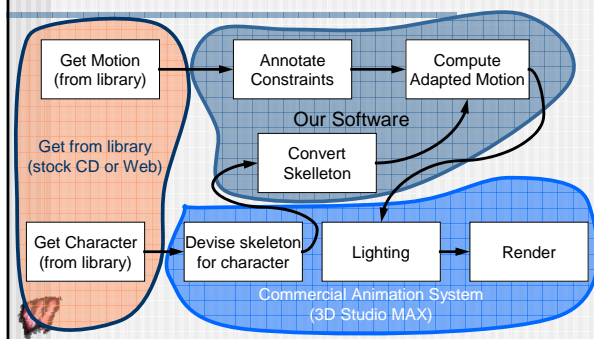


What does it take to do this?

- Setup and Solve a BIG math problem
 - Non-linear, variational, constrained optimization
- Thousands of simultaneous equations
- Yes, you can do it in real time
 - with some caveats...



How did we do that?



Where did we do that?

- The UW CS Graphics Group!
 - The initial retargeting work was done before I came here
- There's a graphics group here?
 - I thought we only do stuff like Databases and Architecture?



Graphics at UW CS

- Target for growth in the department
- New courses:
 - Introduction to Graphics
 - now taught as CS638, will get new number soon
 - Computer Animation
 - now taught as CS838, will get new number soon
 - Other courses elsewhere
 - Art (comp. anim), ECE (image proc), ...



← STYLIZED LOGO

← EASY TO REMEMBER URL →

← TOON MASCOT



- History
 - Early 80s – grad students try to do
 - Mid 90s – identified as “important new area”
 - 1998 – Perry Kivolowicz teaches first course
 - 1998 – Gleicher is hired to form group
 - 1999 – First animation course (838)
 - (survivors still exist)
 - 1999 – Regular undergrad graphics course
 - 2000 – Cheney hired, first graphics students
 - 2001 – Graphics qualifying exam, ...



- Faculty
 - Mike
 - Stephen
 - Friends (Chuck, Vadim, Nicola, ...)
- 7 graduate students (5 Mike, 2 Stephen)
 - The only RAs in the department without offices
- 4-5 undergrads
- Lab shared with Computer Vision group
 - 1347 CS&S



- | | |
|--|---|
| <p>Mike's Research</p> <p><i>Authoring by Adaptation</i></p> <ul style="list-style-type: none"> ■ Motion Editing ■ Automatic Stylization ■ Virtual Videography ■ Human motion reconstruction ■ Crowd Simulation | <p>Stephen's Research</p> <p><i>Scalability and Control of Physical Systems</i></p> <ul style="list-style-type: none"> ■ Control of Physics ■ Scaling Physics ■ Terrain Synthesis ■ Cartoon Physics ■ Crowd Simulation |
|--|---|



CS Graphics Courses

- Undergraduate & Graduate
 - CS559 – Computer Graphics
 - General intro of field
 - Required for everything else
 - The “Extra Session” experiment
 - CS679 – Computer Games Technology
 - Graduate
 - CS777 – Computer Animation
 - CS779 – Rendering
- Elsewhere on campus...





Answers to Frequently Asked Questions

- It depends.
- Yes, 559 is a lot of work, requiring both hacking and math.
- Maybe.
- Yes, we do get undergrads involved in our research projects.
- 42
- Stephen is in Peru this week.
- No, the software is not available for you to try yourself.
- It depends.
- C++ is the programming language of choice for 559, just as English is the lecture language of choice. It's mainly a matter of what is most convenient. Many students pick it up as they go.
- Yes, there is one more distinguished lecture this week.

