

Animation by Adaptation

Tutorial 1: Animation Basics



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Outline

Talk #1: Basics

- ✍ What is character animation?
- ✍ How do we represent motion?
- ✍ Where does motion come from?
- ✍ What is Motion Adaptation about?

Talk #2: Problems in Motion Adaptation

- ✍ Constraint-based Motion Adaptation
- ✍ Spacetime and PFIK+F approaches
- ✍ Lurking Issues
- ✍ Online problems



Objectives

Where's the math?

- ✍ Slides/presentation light on math details
- ✍ My goal is to give you a feeling for the problems we are trying to address.
- ✍ Get you interested/intrigued enough to follow up (discussion, read papers)
- ✍ Enough back
- ✍ Besides, too hard to make slide with equations



What is Animation?

- ✍ Bringing something to life
 - ✍ Making something move
- ✍ A uniquely expressive art form
 - ✍ Independent control over form and movement – both are expressive!
 - ✍ A young, but well evolved, art form (approximately 100 years)



What is Animation? (2)

- ✍ Traditionally “film”
 - ✍ Cartoons, watched passively
- ✍ Beginning to mean new things
 - ✍ Interactive (games, help systems, virtual environments)
 - ✍ Mix into live action
 - ✍ Means of production in more people’s hands



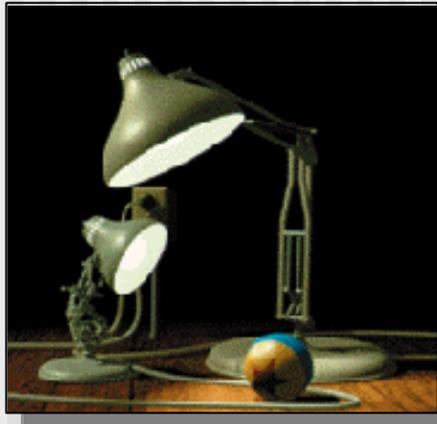
Why Motion?

- ✍ Most unique aspect of animation
- ✍ Heart of animation

- ✍ People have least experience with
- ✍ Hardest to do (art & math)
- ✍ My personal favorite problem
- ✍ High quality standards



Animation Appreciation 101



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)



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



The Dream: Animation Everywhere!

- ✍ Animation is great
 - ✍ Expressive, appealing, ...
 - ✍ Flexibility and control
- ✍ But it is still the realm of experts
 - ✍ Non-experts need different tools
 - ✍ Not the same as making it easier for experts
 - ✍ Need to generate dynamically in response to interaction



What Motion Are we Talking About?

What is a Character?

✍ Roughly: Human-like forms

✍ Or animal-like

✍ Fixed set of parameters

✍ Current pose defined by a vector

$$\mathbf{p} \ ? \ ? \ ^n$$

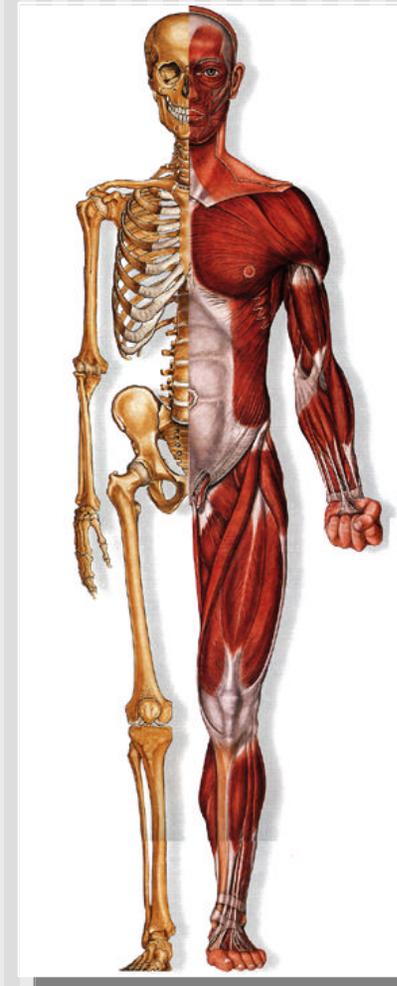
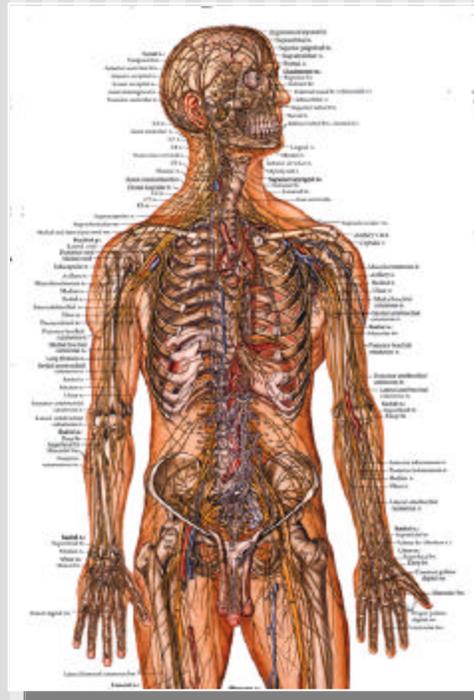
✍ Not continuum (water), large number of parameters (cloth), ...



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

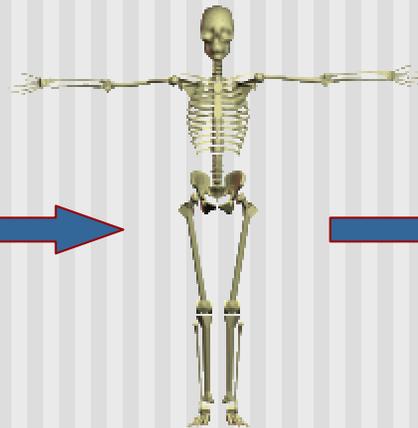
- ✍ Sony Imageworks (effects), 2000
- ✍ Complex human models, terrible dialog



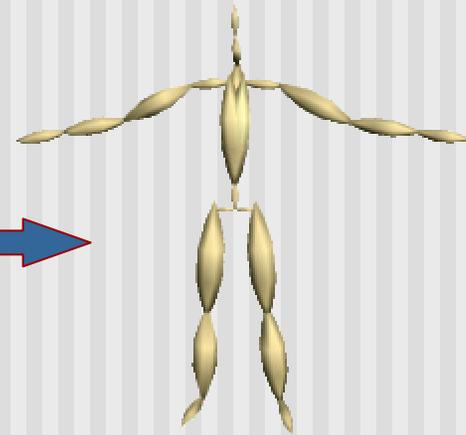
Abstractions



206 bones,
muscles, fat,
organs,
clothing, ...



206 bones,
complex joints

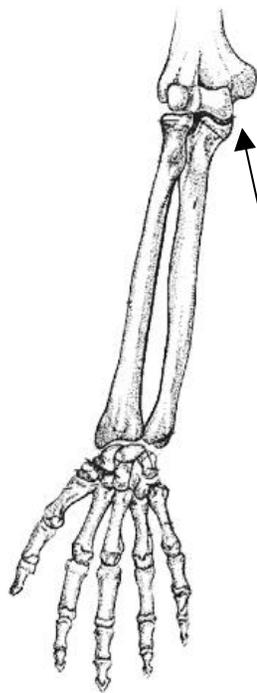


53 bones
Kinematic
joints



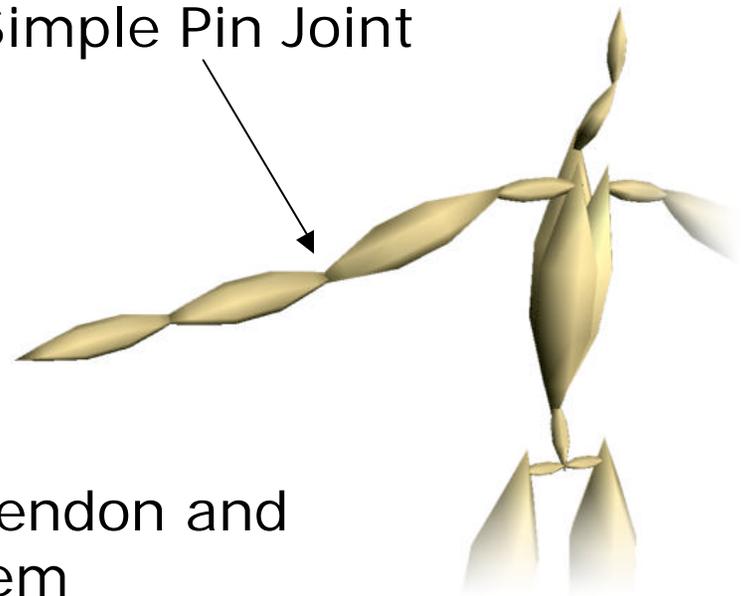
Abstractions vs. Reality (skeletons vs. humans)

Representation of complex human structure
with varying degrees of simplification



Complex tendon and
bone system

Simple Pin Joint



Even the Elbow is complex!

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Image "3 joints of the elbow"
From the Anatomy Coloring Book

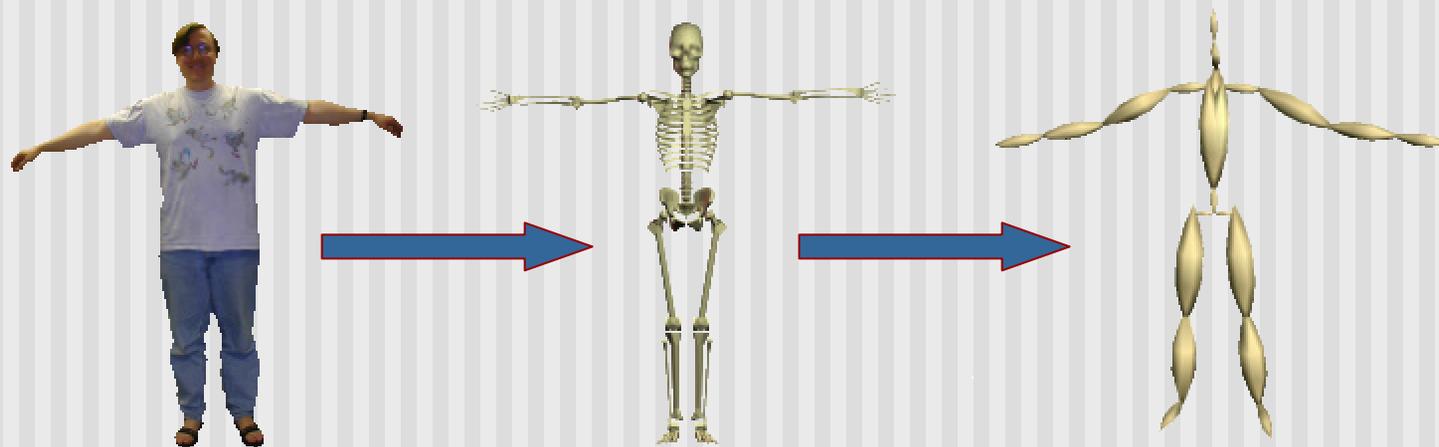


Standard simplified models of humans

- ✍ Small numbers of degrees of freedom for *gross* motion
- ✍ Articulated figures
- ✍ Kinematic joints
- ✍ Why this?



Abstraction of Human Motion



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



Representations of Pose

- ✍ Angle vs. positional data
- ✍ Choices in rotations
- ✍ Global vs. relative
- ✍ Hierarchical vs. non-hierarchical
- ✍ Skeletal vs. Non-Skeletal



Rotations...

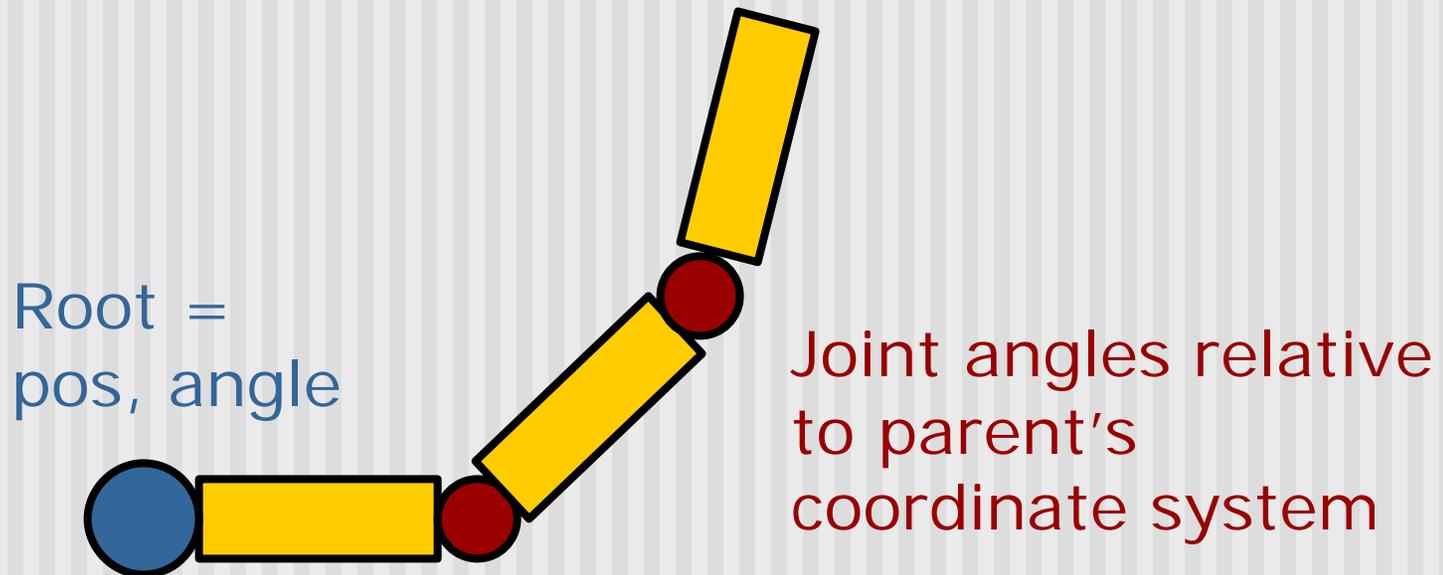
The animation hacker's nemesis

- ✍ 3D rotations are a pain to represent
 - ✍ Have a unique topological structure
 - ✍ Cannot be embedded in R^n without singularity
- ✍ Several methods used for in animation, all have pros and cons
 - ✍ Matrices
 - ✍ Quaternions
 - ✍ Euler Angles
 - ✍ Exponential Coordinates



Hierarchical Representation

- ✍ Common way to represent articulated figures



Good Points of Hierarchical Skeletons

- ✍ Enforce key constraints
 - ✍ Connected segments
 - ✍ Rigid limbs
- ✍ Fewer Dof's
 - ✍ Only store angles between segments
- ✍ Easy for skinning
 - ✍ Local coordinate systems defined



Bad Points of Hierarchical

- ✍ Need 3D rotations
- ✍ Coupled parameters
- ✍ End effector controls require IK
- ✍ Forces rigidity
- ✍ Problems with reference
 - ✍ Different ways of defining things



How to Maximize Good / Minimize Bad

- ✍ Custom character setup (have right DOFs)
- ✍ Well chosen joint sets (placement and type) and controls (IK / FK)
- ✍ Good:
 - ✍ make characters that animator can control
- ✍ Bad: no uniformity/standardization
 - ✍ important if motion from outside source
 - ✍ important if want to build libraries / reuse motions
 - ✍ Everybody has a different skeleton



How do skeletons differ?

Obvious ways?

Topology

- number of bones
- Connectivity of bones

Joint Types

Bone lengths

Anatomical / skin relations

- Is spine in middle of body, or up the back?

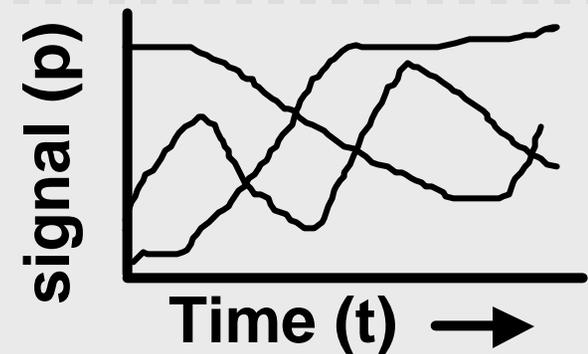
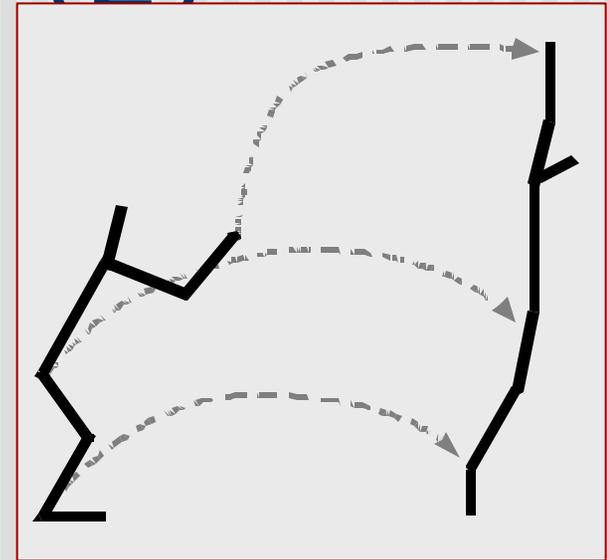


What is a motion (2)

- ✍ A motion maps times to configurations

$$\mathbf{m}(t) \text{ ? ? ? ? }^n$$

- ✍ Vector-valued, time-varying signal
- ✍ But... remember that we have angles! May not be \mathbb{R}^n

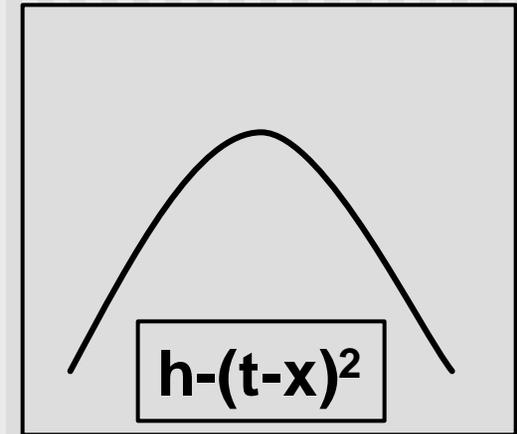
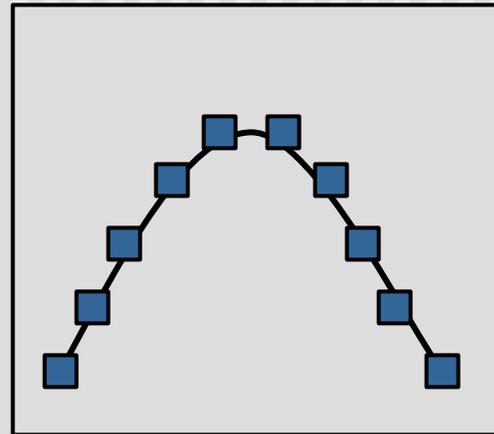
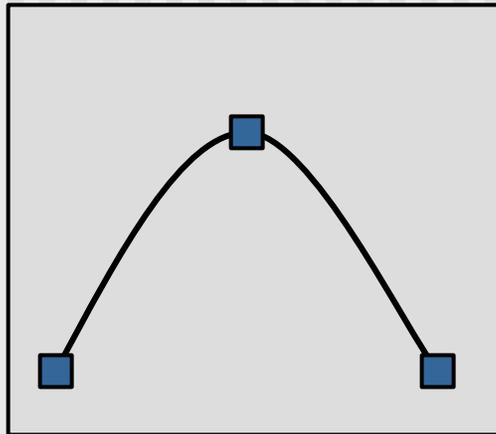


How to represent these functions?

- ✍ Dense samples
- ✍ Key poses and interpolation
 - ✍ How traditional animators do it
 - ✍ Smart interpolation
- ✍ Procedures / Computational methods
- ✍ ???



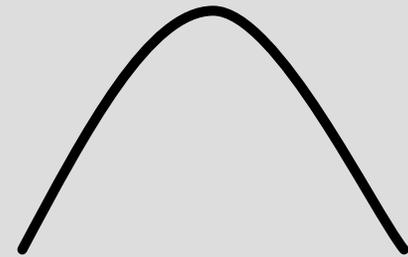
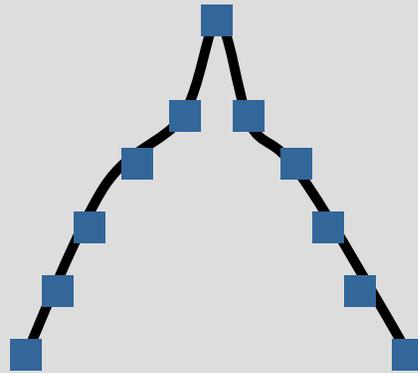
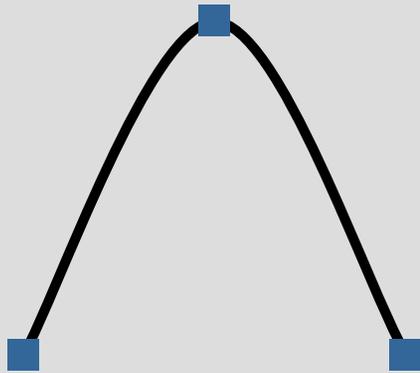
Representation



- ✍ Many ways to represent a motion
- ✍ Different creation methods yield different representations
- ✍ Equivalent (in terms of output)



Representation Matters



$$h-(t-x)^2$$

- ✍ Different representations respond differently to change
- ✍ Different changes are convenient with different representations



Three main ways to make motion

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

And increasingly...

- ✍ 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)



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.



Animation from Observation

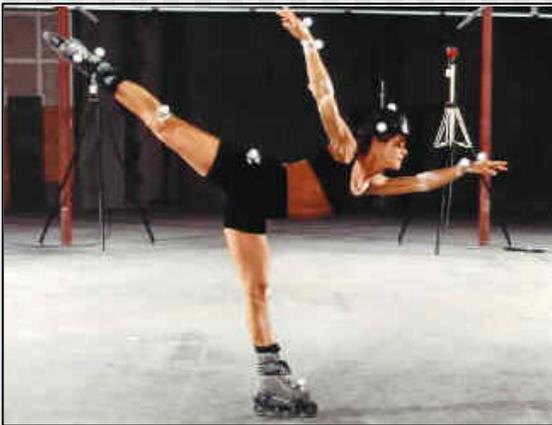
Not (just) Motion Capture

- ✍ Capturing the motion is only one part of the process
- ✍ There are other reasons to capture motions
 - ✍ Medical
 - ✍ Surveillance
 - ✍ Sports performance
- ✍ Don't look at capture as a silver bullet



Motion Capture Technology: Optical Tracking

- ✍ User markers and special cameras
- ✍ Tracking + Math



Animation Appreciation 101

- ✍ Michael Jackson's Ghost
 - ✍ Digital Domain, 1997 (?)
 - ✍ Detailed Motion Capture
 - ✍ Recognizable motion
 - ✍ Skeleton is OK



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



Motion is tough

And it's not just motion capture's problem

Motion Capture

Sample every frame

- ✂ No structure.
- ✂ No intent.
- ✂ lots of data!

Dense samples can represent rich frequency content

Noise, sensor errors

Hand Animation

Data at Keyframes

- ✂ Structured?
- ✂ Remember why?
- ✂ Maybe lots of data.

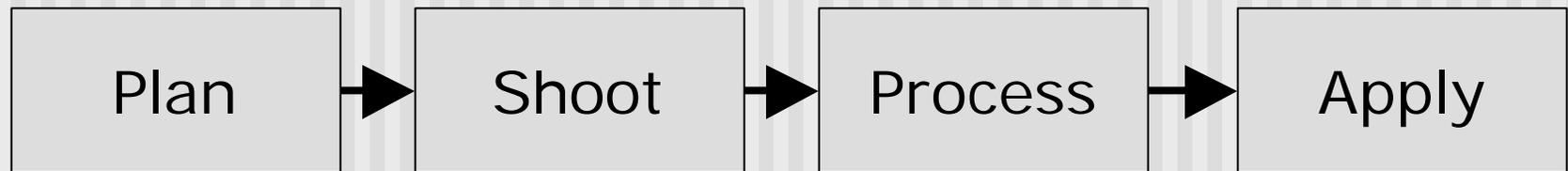
Good animators create complex frequency content

Quality takes work



Hard for academics to obtain quality hand animation

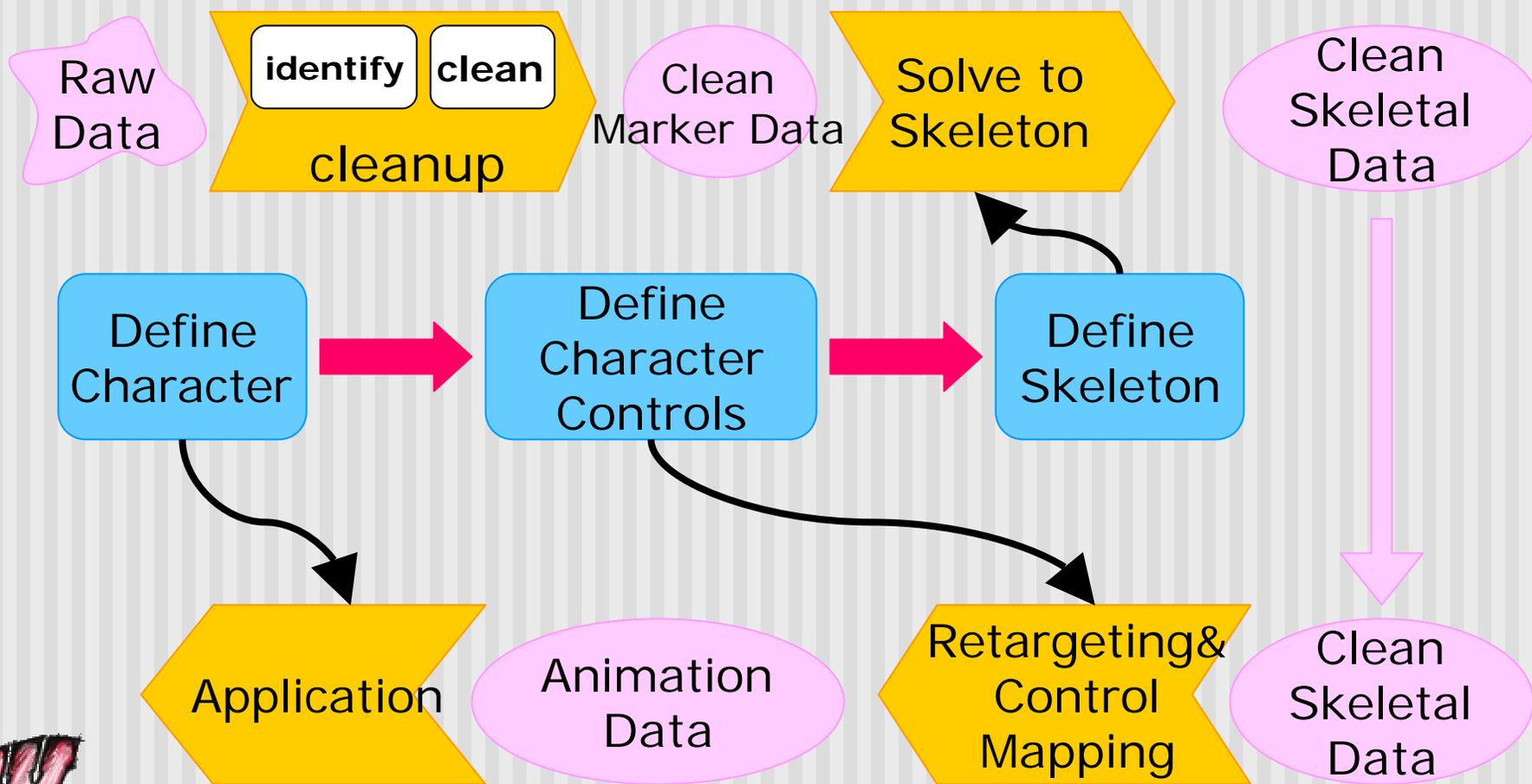
Mocap Pipeline



- ✍ Motion Capture is a misunderstood technology
- ✍ Good for what its good for
- ✍ Not necessarily easy or cheap
- ✍ Must be done with great care



Processing Pipeline



What is performed is almost never what we want

- ✍ Animation: bring something to life
 - ✍ means we want to change *something* about the performance
- ✍ Actor vs. character
- ✍ Restrictions of realism
- ✍ Performers aren't perfect
- ✍ Need for usable data (loops, reference poses, ...)
- ✍ Studio is not virtual world
- ✍ Motion re-use
 - ✍ sometimes we are stuck with what we have



A Teaser...

Coming Attractions

