Primer on Final Project - Spring 2019

Today is just to get you thinking

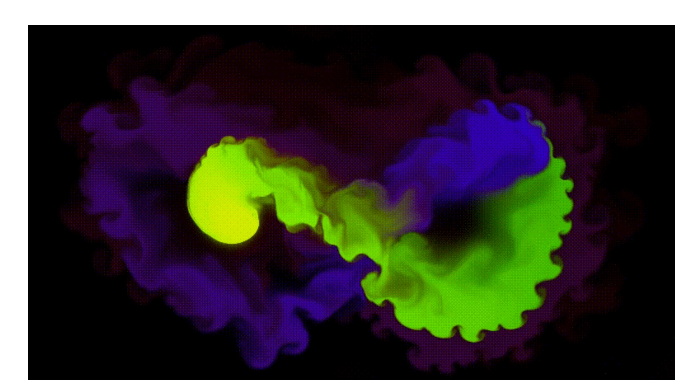
Links on class homepage

Project

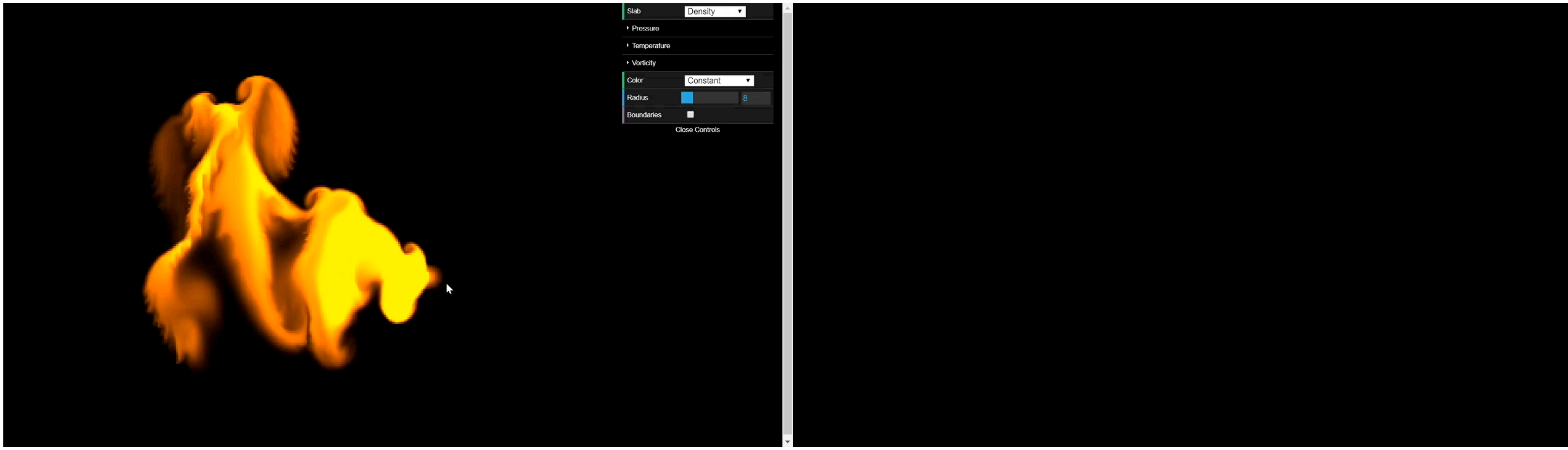
- Build something interesting to you
- Teams of three - choose your team
  - Group matching tomorrow at 5 PM in VCL
- 20% for 184, 40% for 284A

Timeline: 4 weeks

- April 9 Proposals due
  - We will give feedback
- April 30 Graded checkpoint
- May 9 Presentations
- May 14 Final reports due



A few cool projects from previous semesters



Lecture 25:

Intro to Animation

Computer Graphics and Imaging
UC Berkeley CS184/284A

Animation

"Bring things to life"

- Communication tool
- Aesthetic issues often dominate technical issues

Output: sequence of images that when viewed sequentially provide a sense of motion

- Film: 24 frames per second
- Video: 30 fps
- Virtual reality: 90 fps

Topics

History, goals, and principles

Artist-driven animation: rigging, posing, keyframing

Procedural animation: forward and inverse kinematics, physical simulation

Data-driven animation: motion capture, machine learning techniques

Historical Points in Animation

(slides courtesy Keenan Crane)

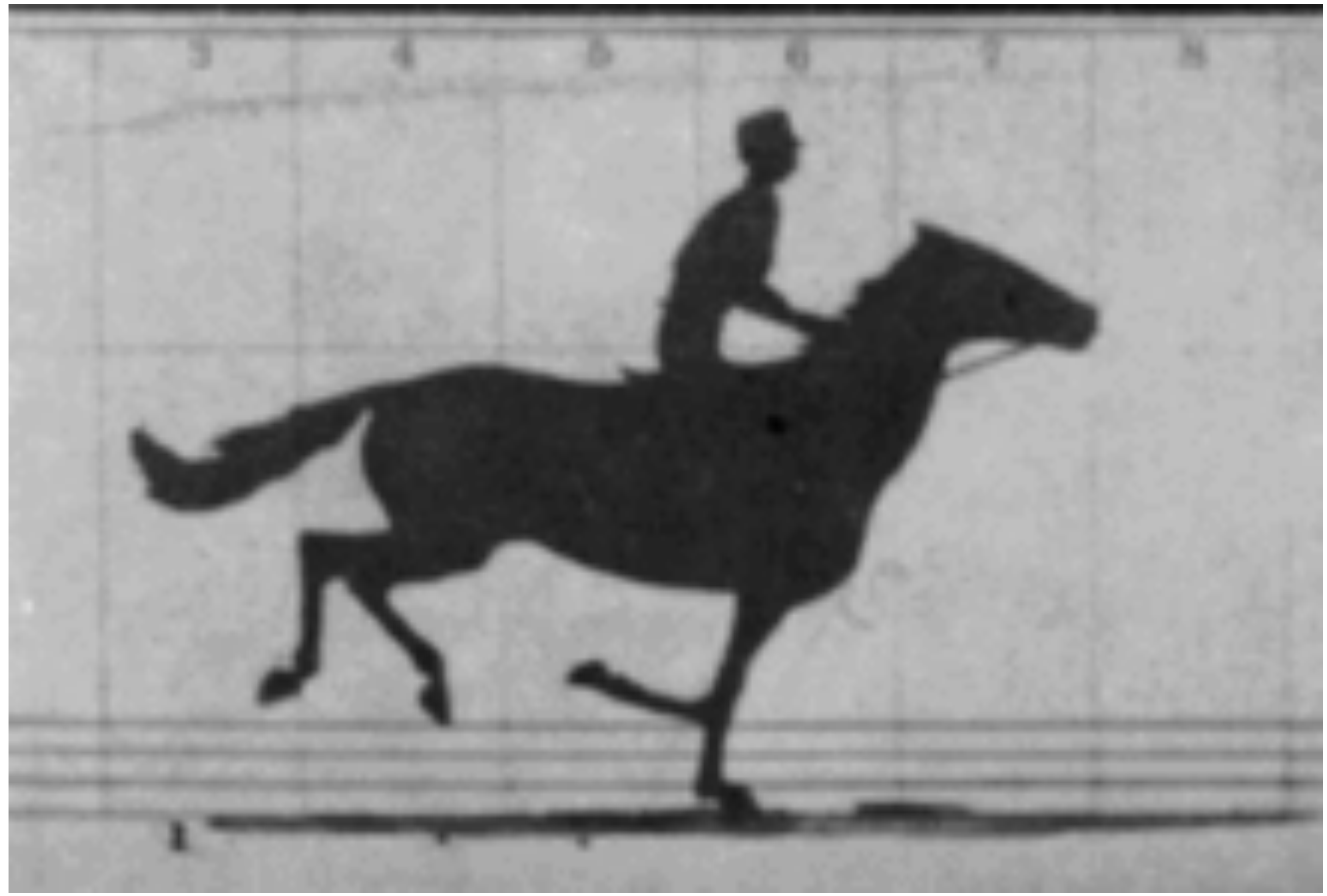
First Animation

(Shahr-e Sukhteh, Iran 3200 BCE)

First Film

Originally used as scientific tool rather than for entertainment

Critical technology that accelerated development of animation

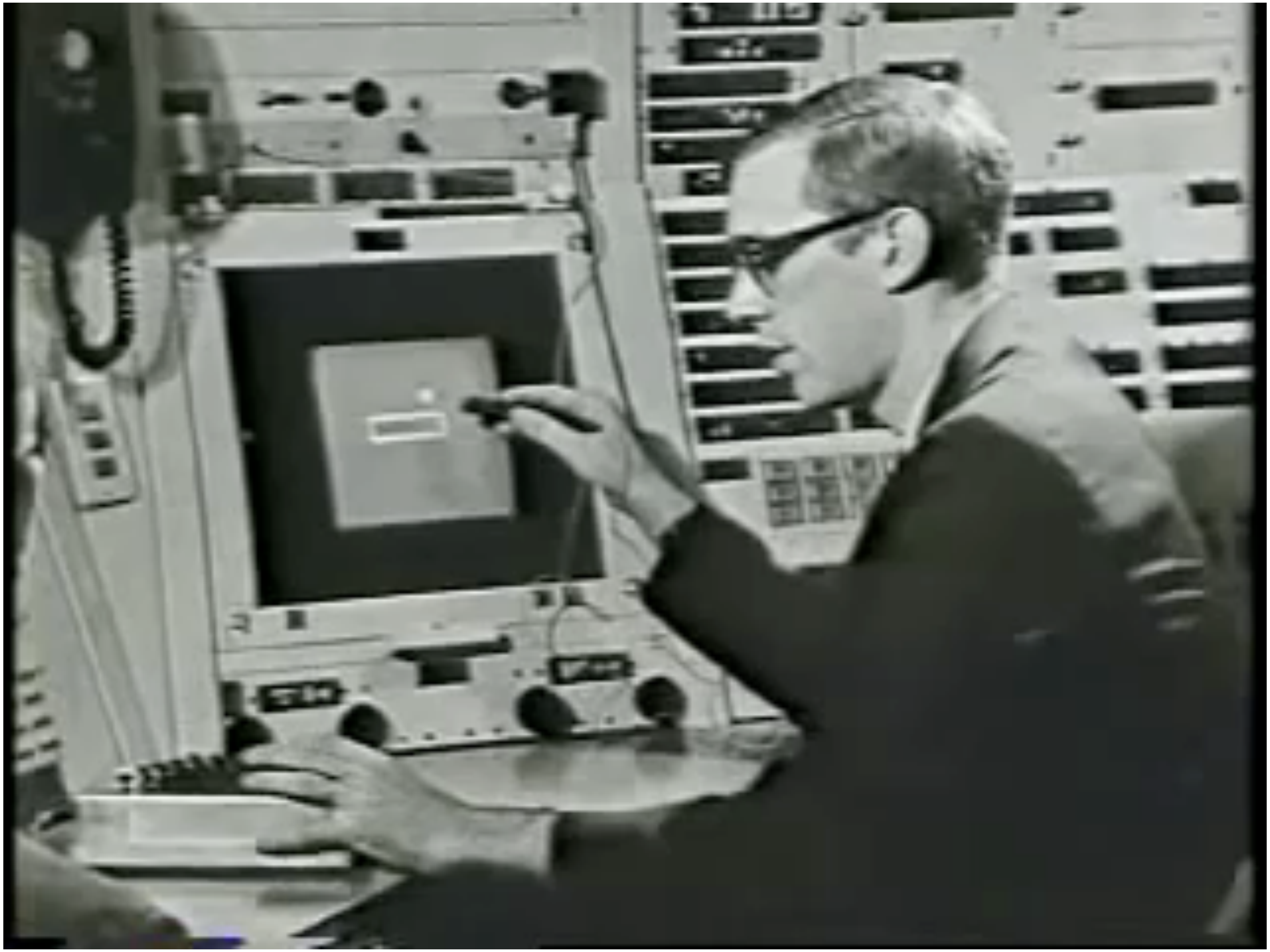


Edward Muybridge, *"Sallie Gardner"* (1878)

First Hand-Drawn Feature-Length Animation

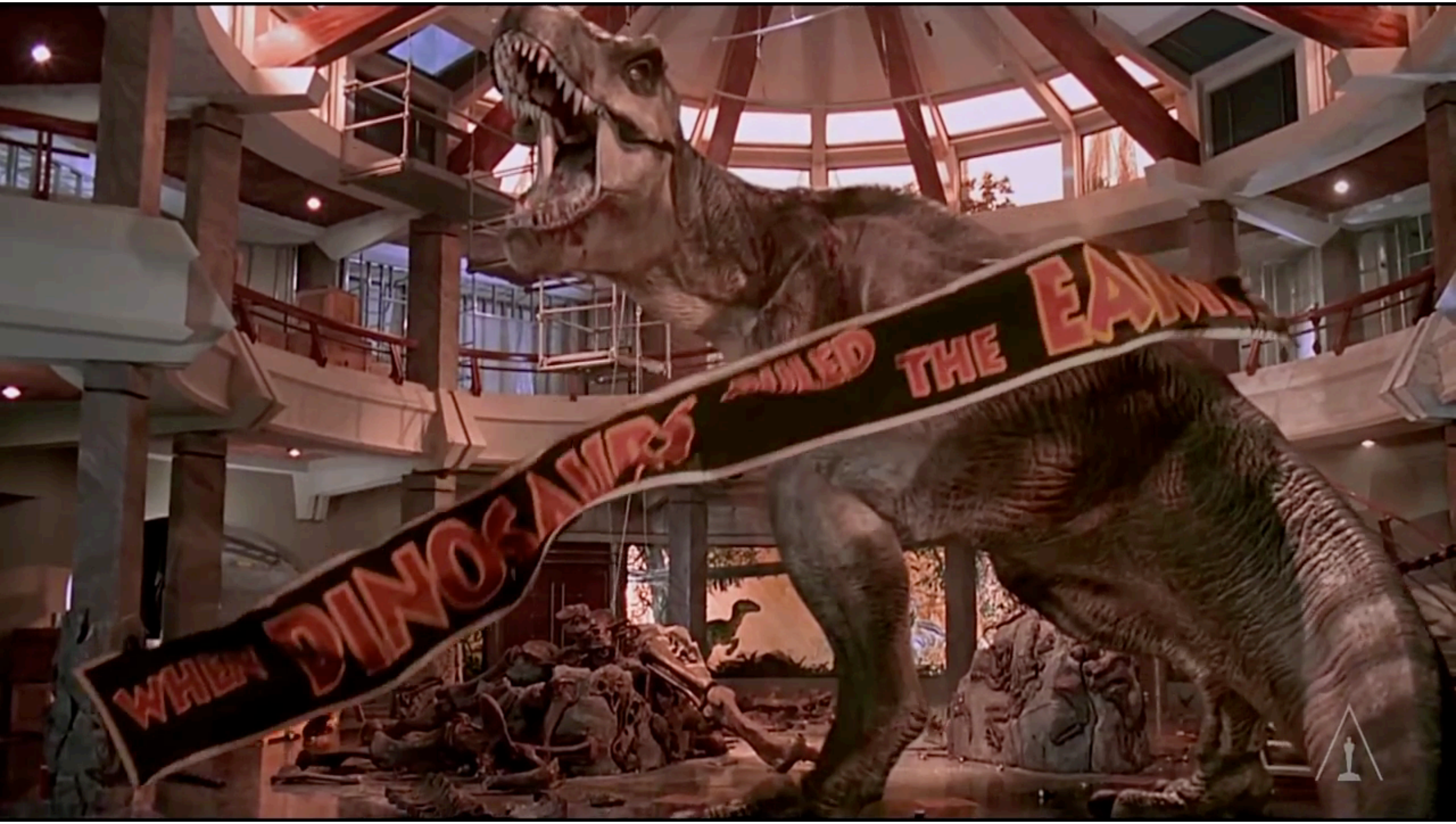
Disney, "Snow White and the Seven Dwarfs" (1937)

First Digital-Computer-Generated Animation



Ivan Sutherland, “Sketchpad” (1963) – Light pen, vector display

Digital Dinosaurs!



Jurassic Park (1993)

First CG Feature Film

Pixar, “Toy Story” (1995)

Computer Animation - Present Day

Disney, “Big Hero 6” (2014)

Animation Principles

(slides courtesy Mark Pauly)

Goals of Animation

Aesthetic issues as prominent as technical issues

Violation of realism desirable in many contexts

Animation is a communication tool

- Should support desired communication
- There should be something to communicate

Animation Principles

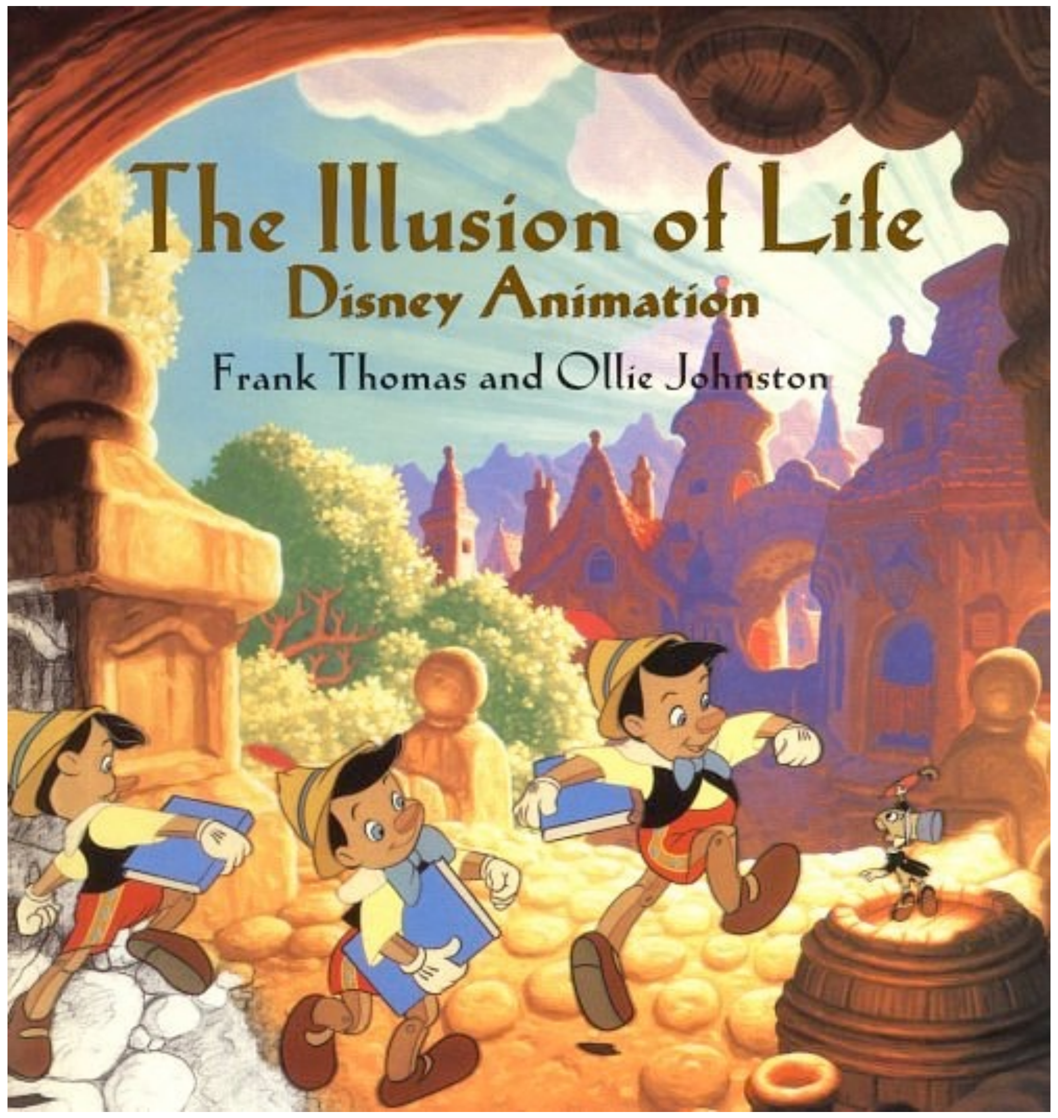
From

- "Principles of Traditional Animation Applied to 3D Computer Animation" - John Lasseter, ACM Computer Graphics, 21(4), 1987

In turn from

- "The Illusion of Life"
  Frank Thomas and Ollie Johnson

Same for 2D and 3D

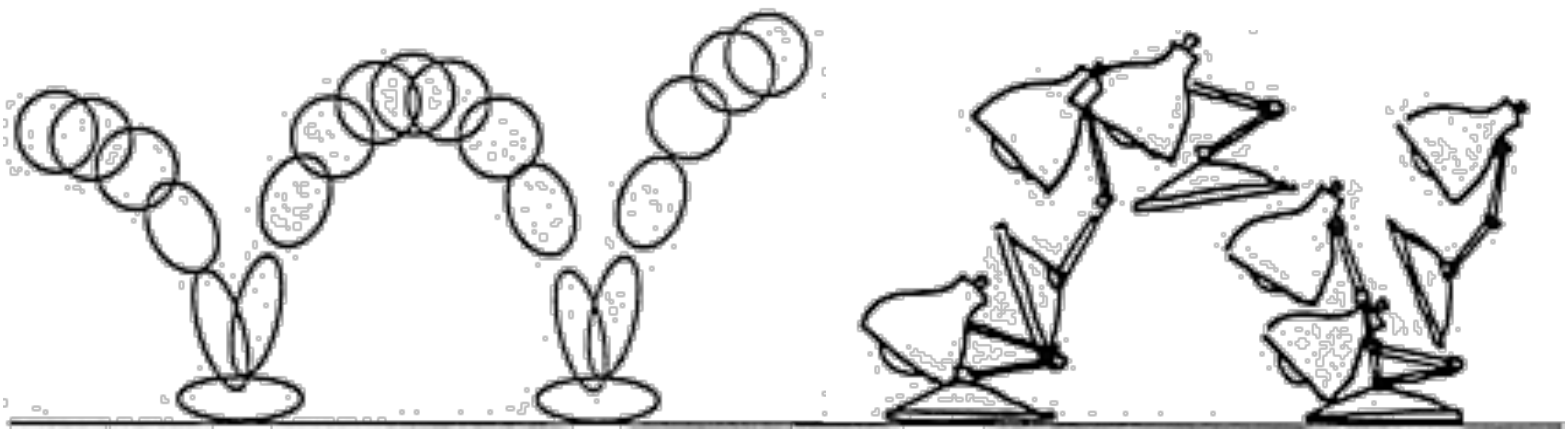


http://www.siggraph.org/education/materials/HyperGraph/animation/character_animation/principles/prin_trad_anim.htm

Squash and Stretch

Refers to defining the rigidity and mass of an object by distorting its shape during an action.

Shape of object changes during movement, but not its volume.

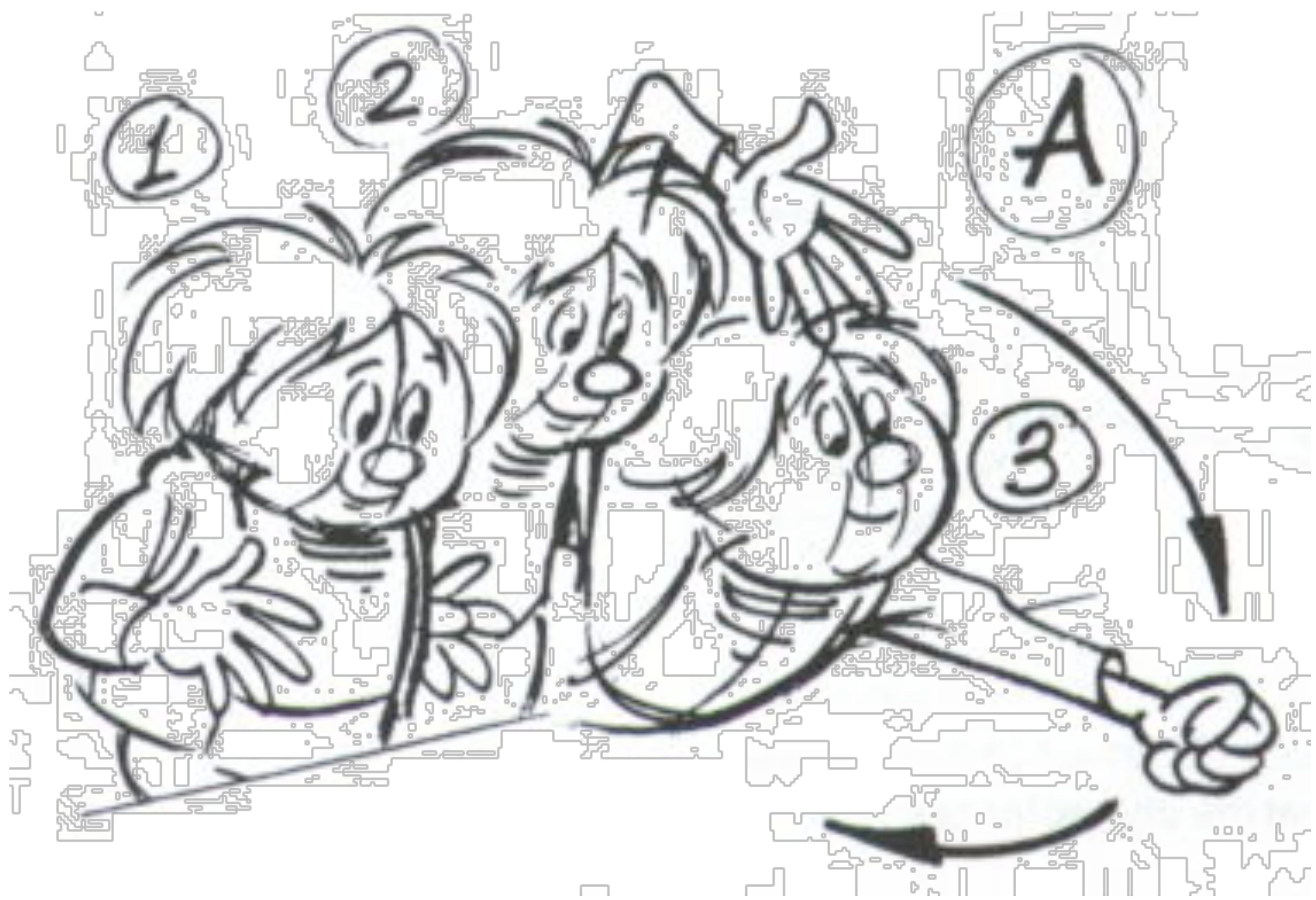


Anticipation

Prepare for each movement

For physical realism

To direct audience's attention



Timing for Animation, Whitaker & Halas

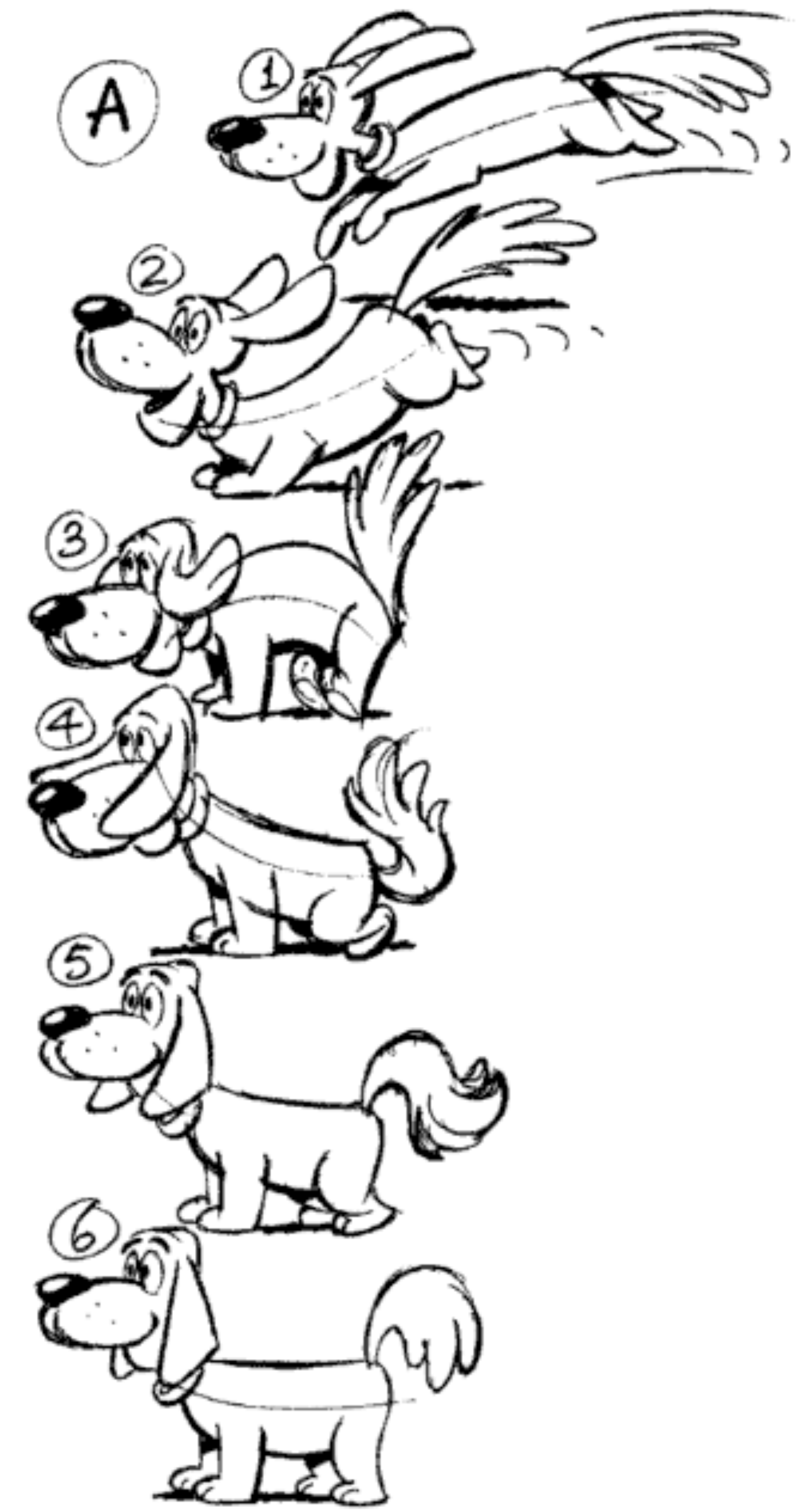
Follow Through

Overlapping motion

Motion doesn't stop suddenly

Pieces continue at different rates

One motion starts while previous is finishing, keeps animation smooth

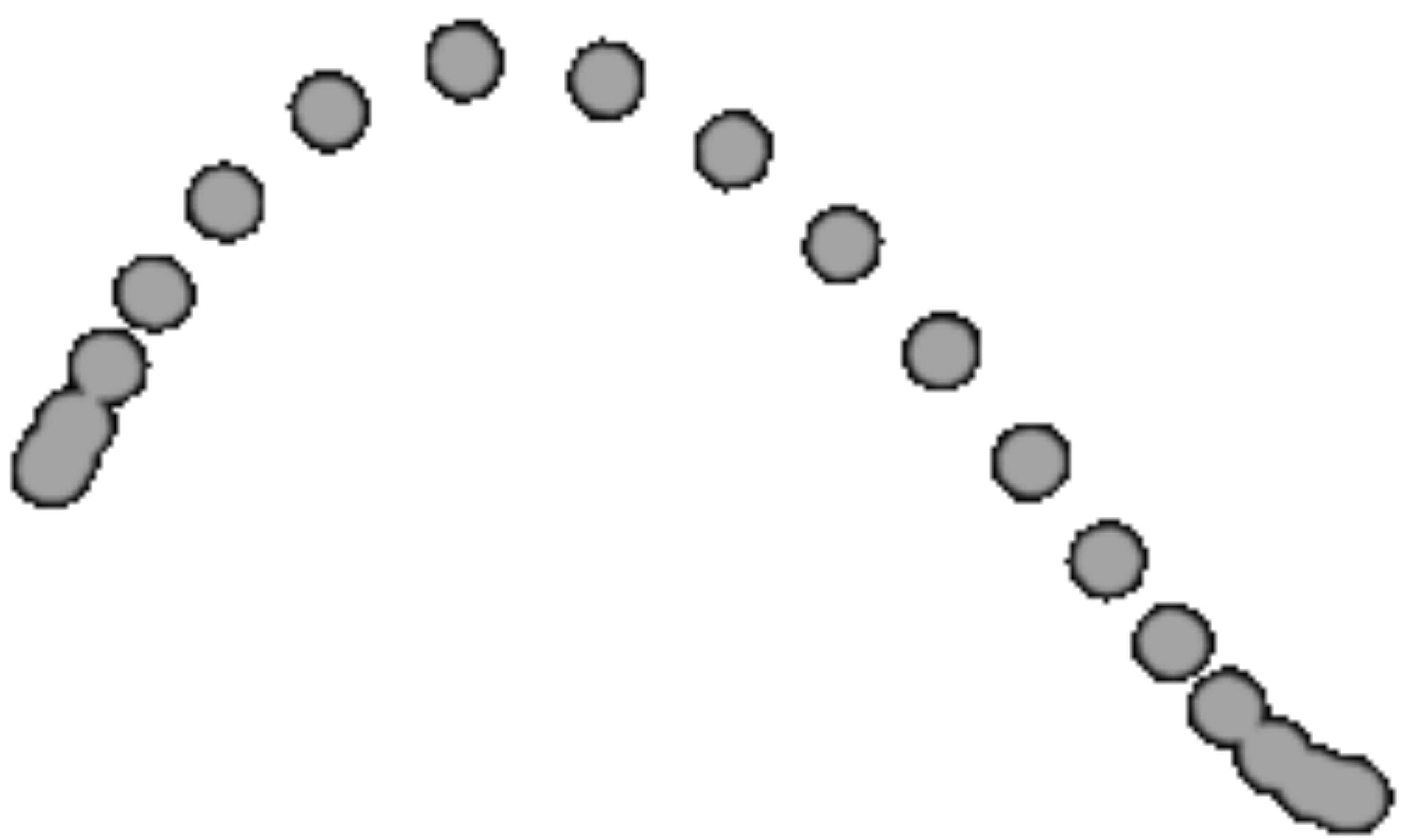


Timing for Animation, Whitaker & Halas

Ease-In and Ease-Out

Movement doesn’t start & stop abruptly.

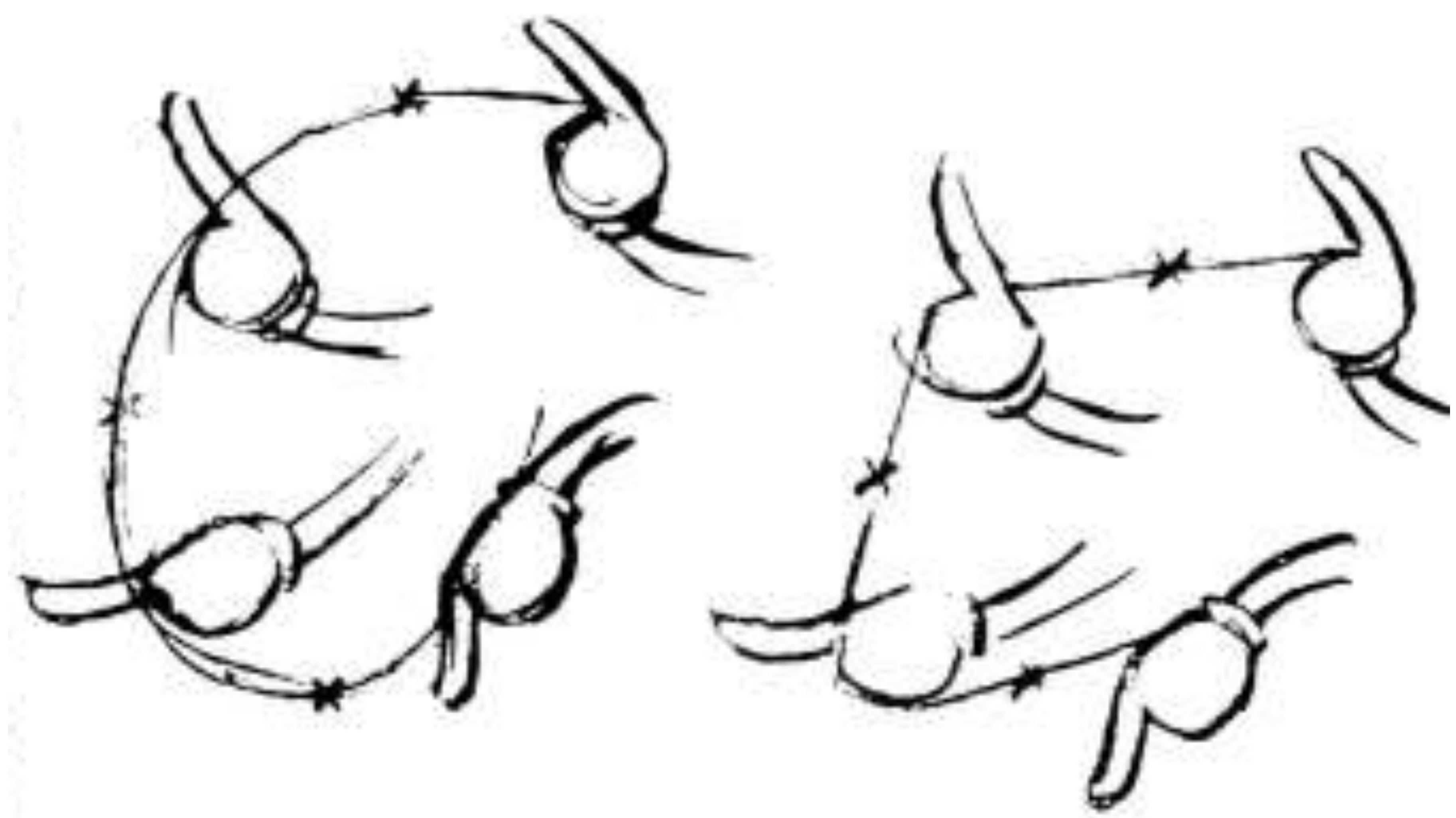
Also contributes to weight and emotion



Arcs

Move in curves, not in straight lines

This is how living creatures move



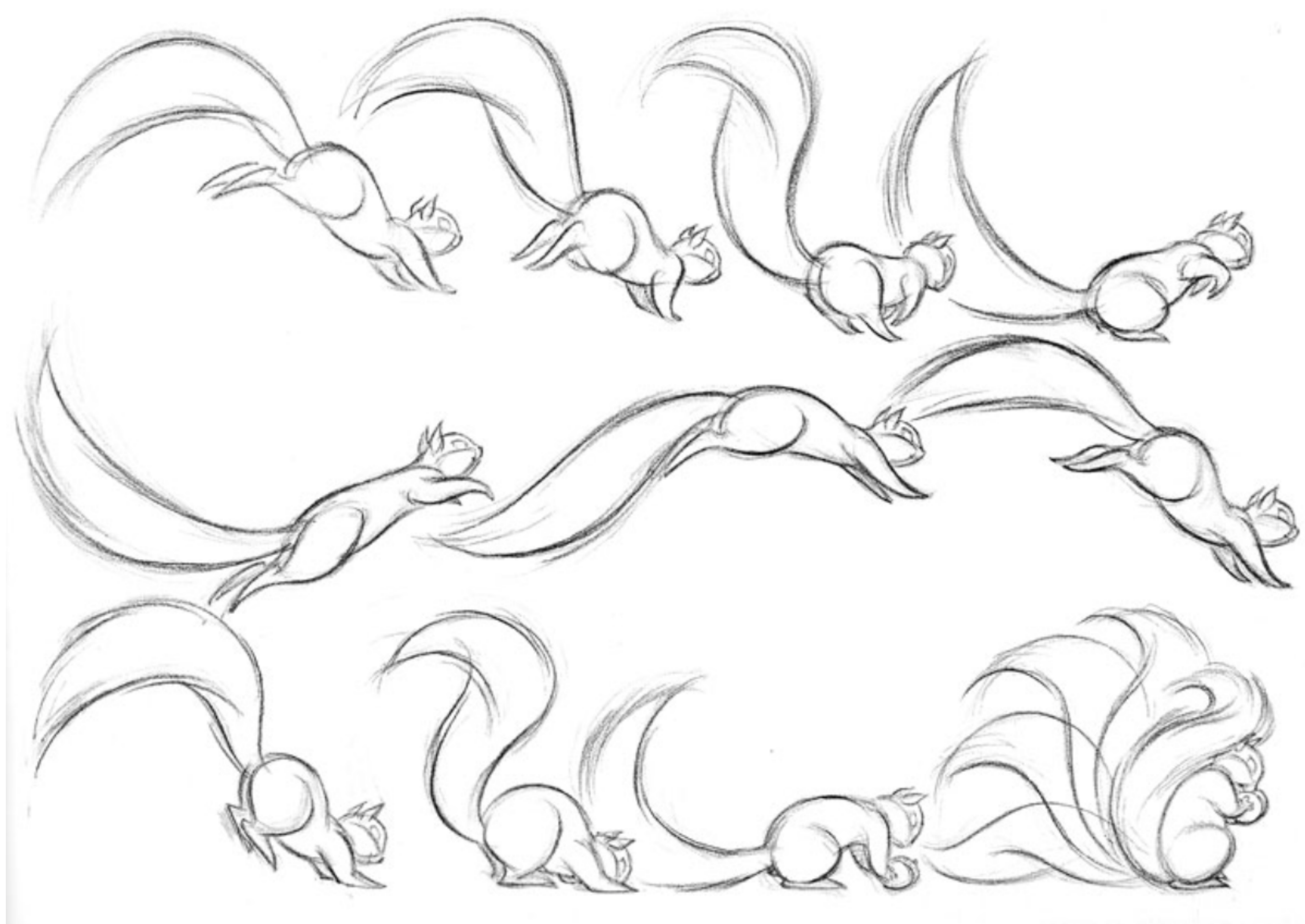
Disney Animation: The Illusion of Life

Secondary Action

Motion that results from some other action

Needed for interest and realism

Shouldn't distract from primary motion



Cartoon Animation, Preston Blair

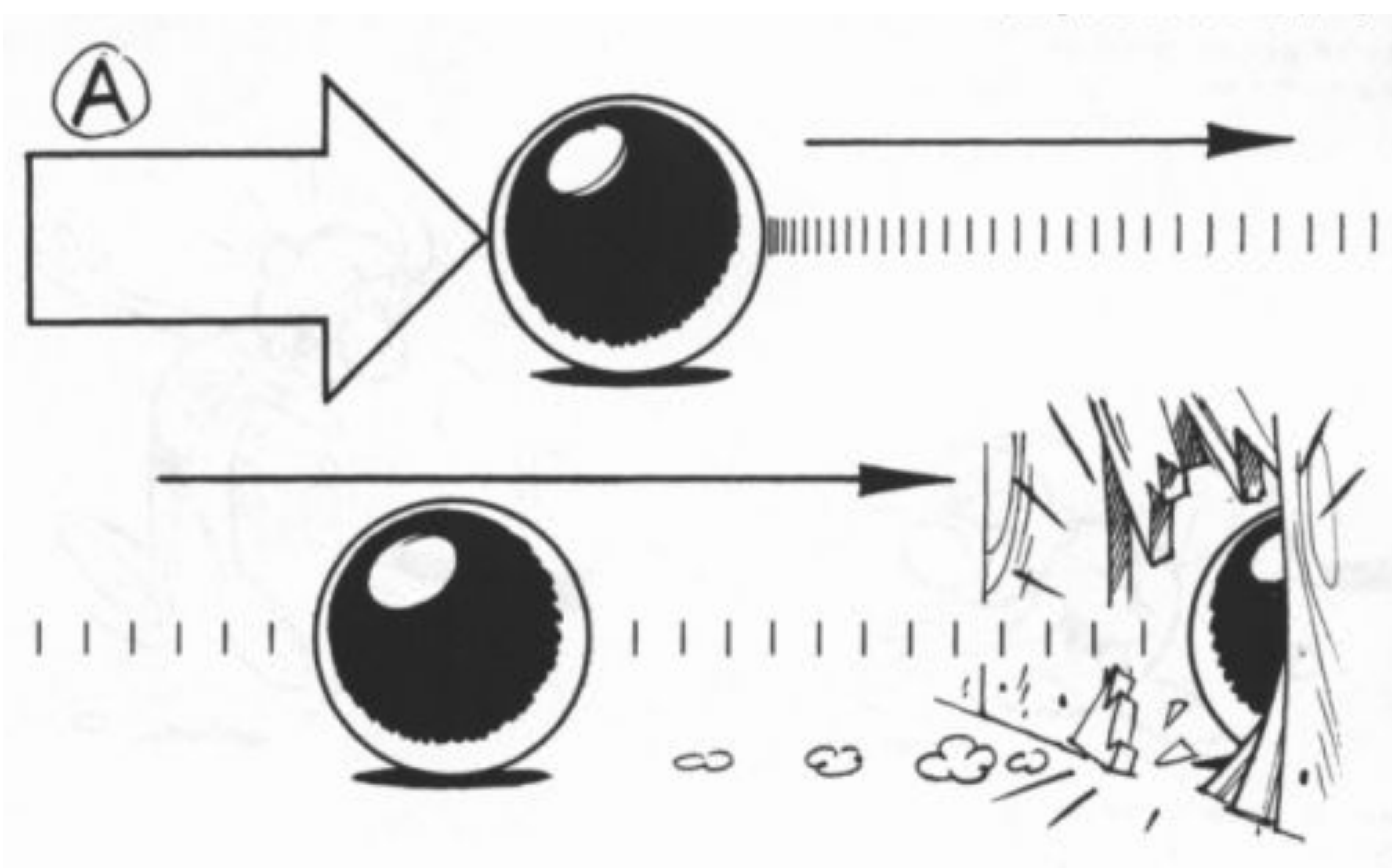
Secondary Action

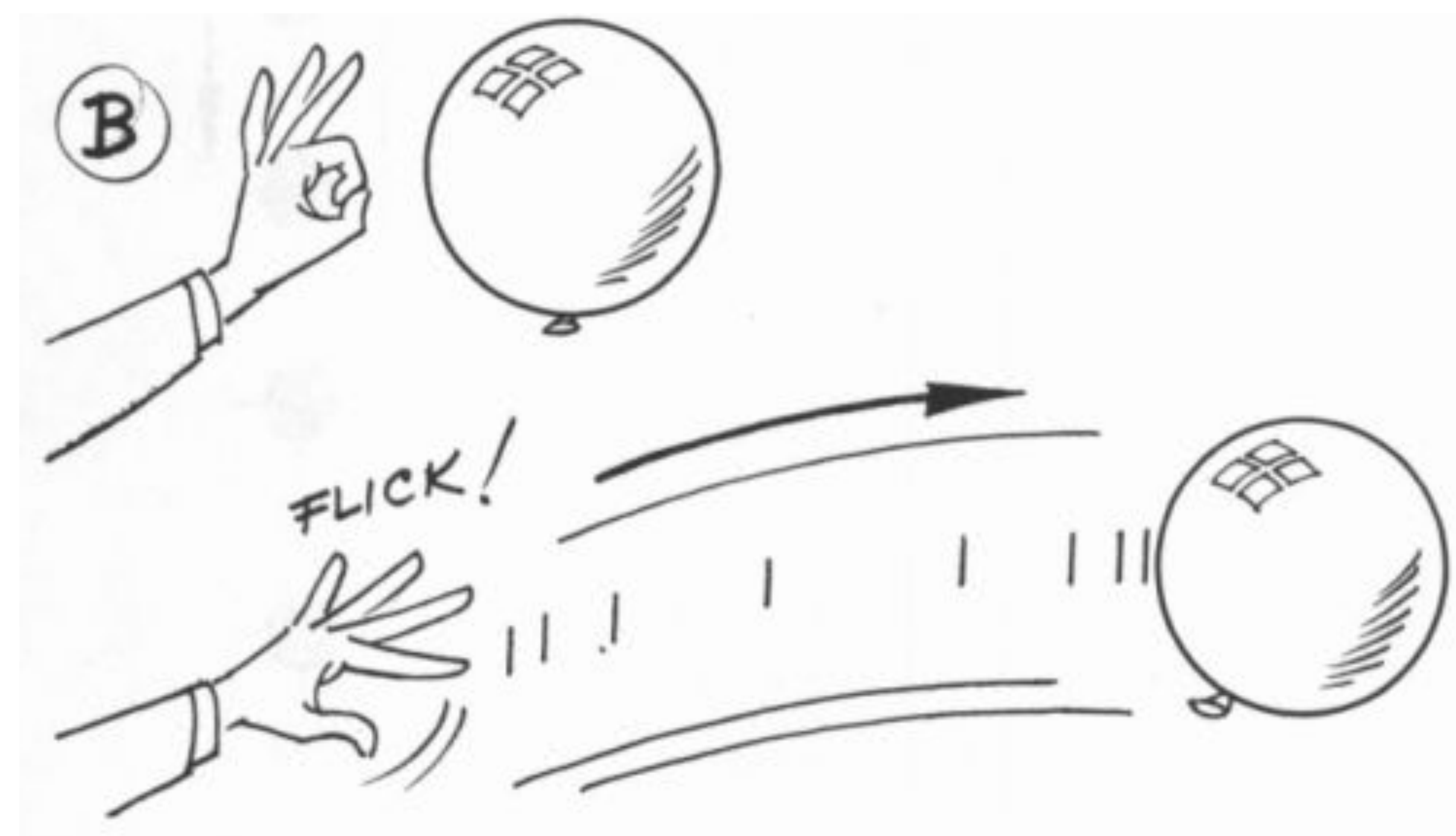
Today: often use simulation to compute secondary motion of hair, clothing, etc

Timing

Rate of acceleration conveys weight

Speed and acceleration of character's movements convey emotion





Timing for Animation, Whitaker & Halas

Exaggeration

Helps make actions clear

Helps emphasize story points and emotion

Must balance with non-exaggerated parts

Timing for Animation, Whitaker & Halas

Personality

Action of character is result of its thoughts

Know purpose & mood before animating each action

No two characters move the same way

12 Animation Principles

1. Squash and stretch
2. Anticipation
3. Staging
4. Straight ahead and pose-to-pose
5. Follow through
6. Ease-in and ease-out
7. Arcs
8. Secondary action
9. Timing
10. Exaggeration
11. Solid drawings
12. Appeal

Computer Animation

Keyframe Animation

Keyframes

“Tweens”

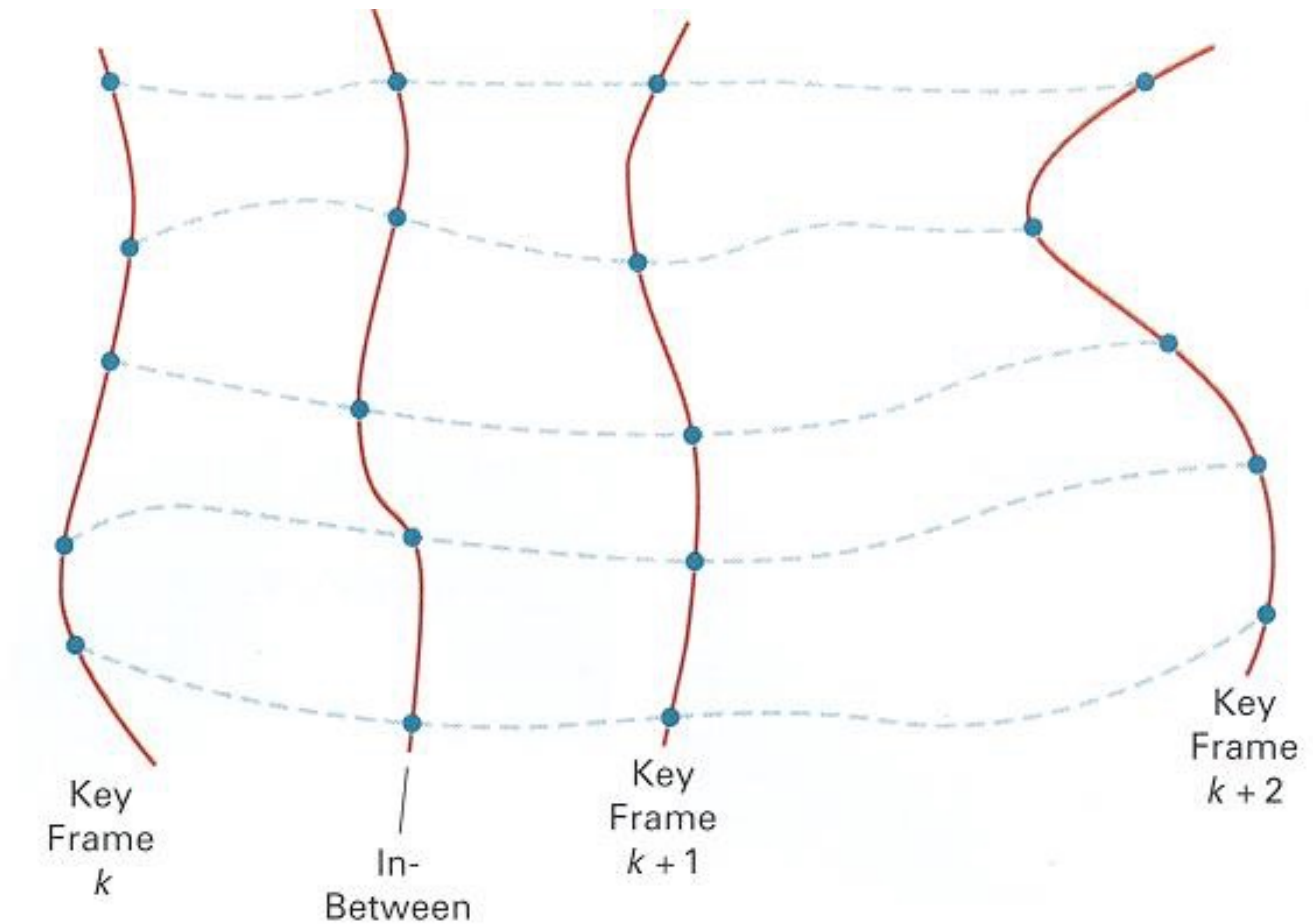
Animator (e.g. lead animator) creates keyframes

Assistant (person or computer) creates in-between frames (“tweening”)

Jonathan Ragan-Kelley & Ren Ng

Keyframe Interpolation

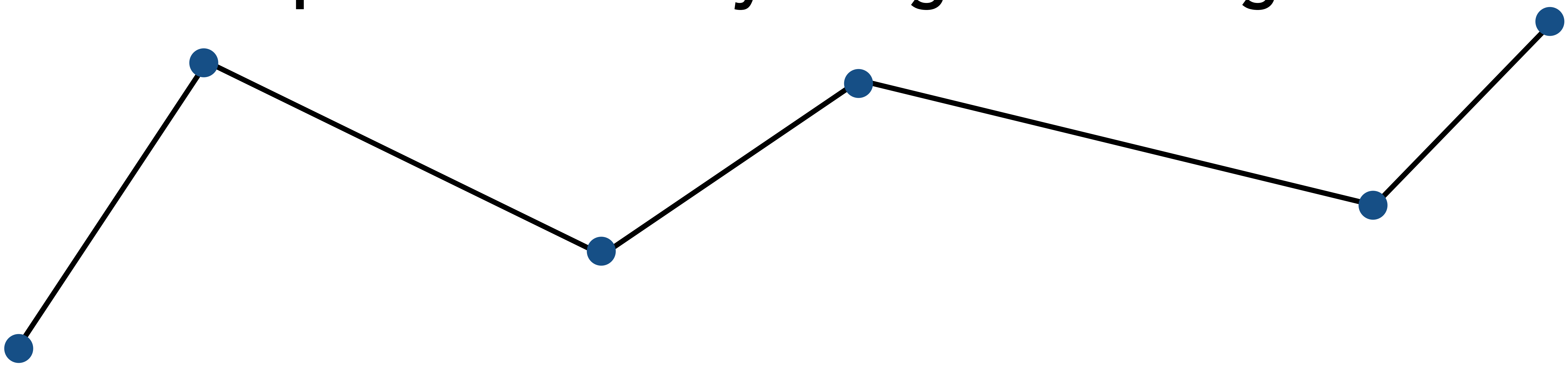
Think of each frame as a vector of parameter values



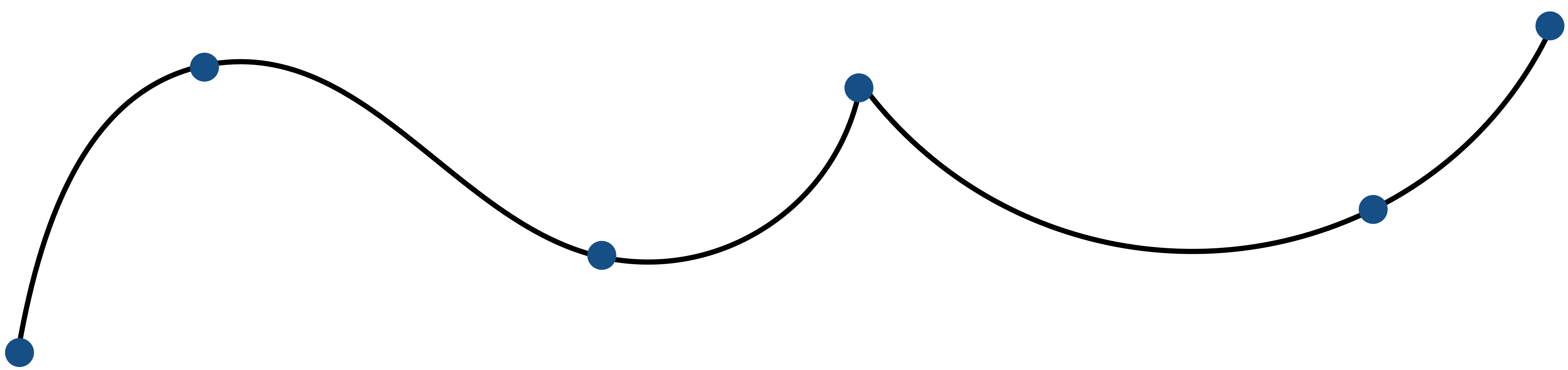
Hearn, Baker and Carithers, Figure 16.11

Keyframe Interpolation of Each Parameter

Linear interpolation usually not good enough



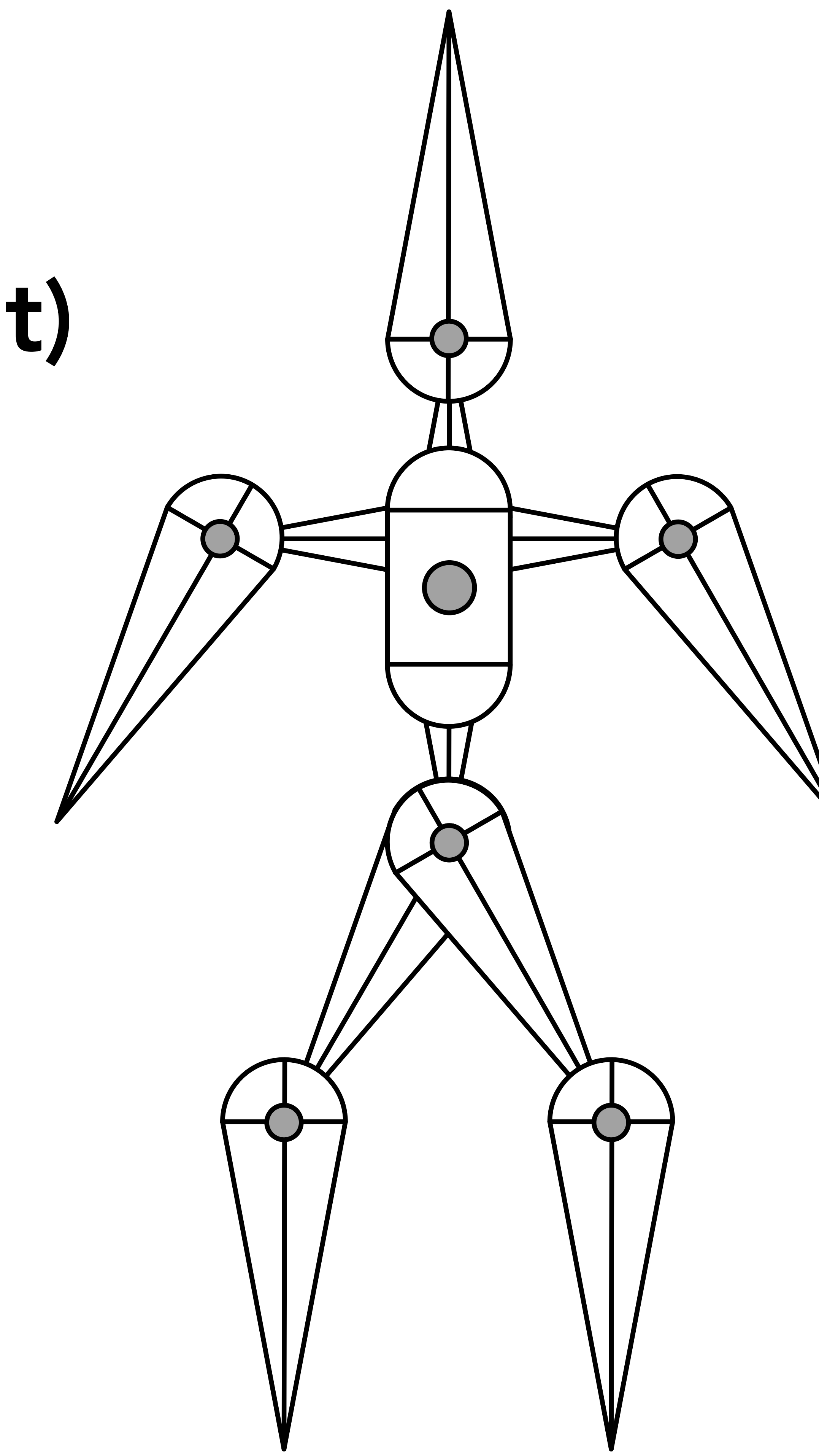
Recall splines for smooth / controllable interpolation



Forward Kinematics: Artist-specified animation with skeletons

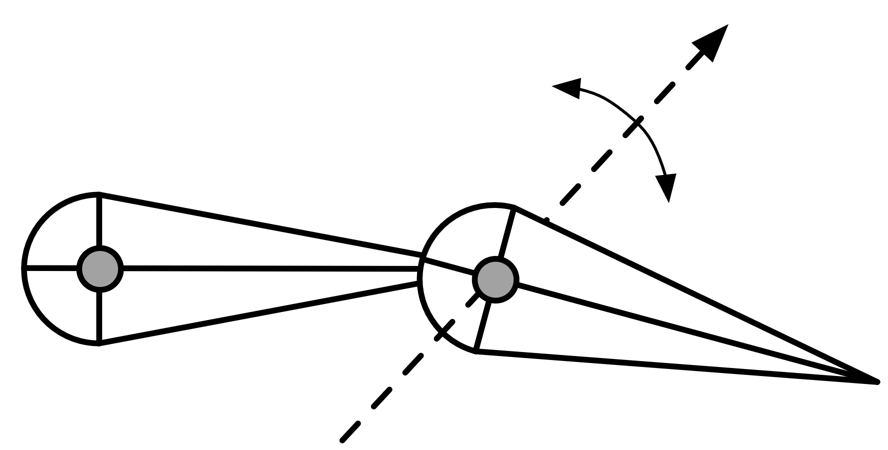
Articulated skeleton

- Topology (what's connected to what)
- Geometric relations from joints
- Tree structure (in absence of loops)

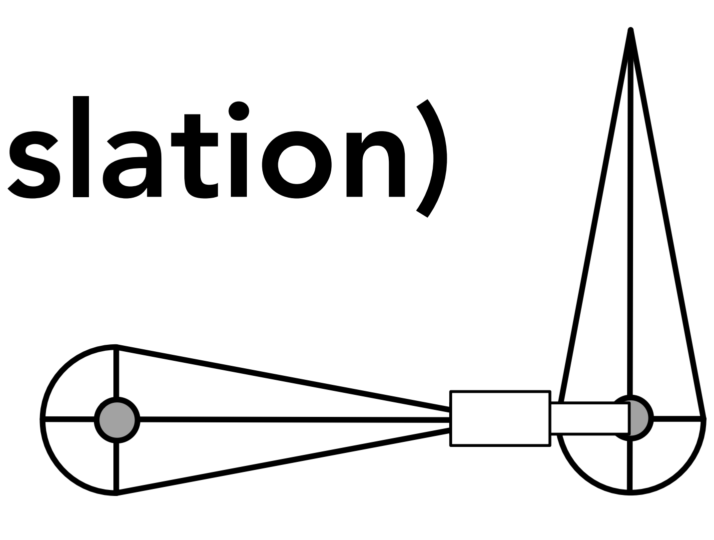


Joint types

- Pin (1D rotation)

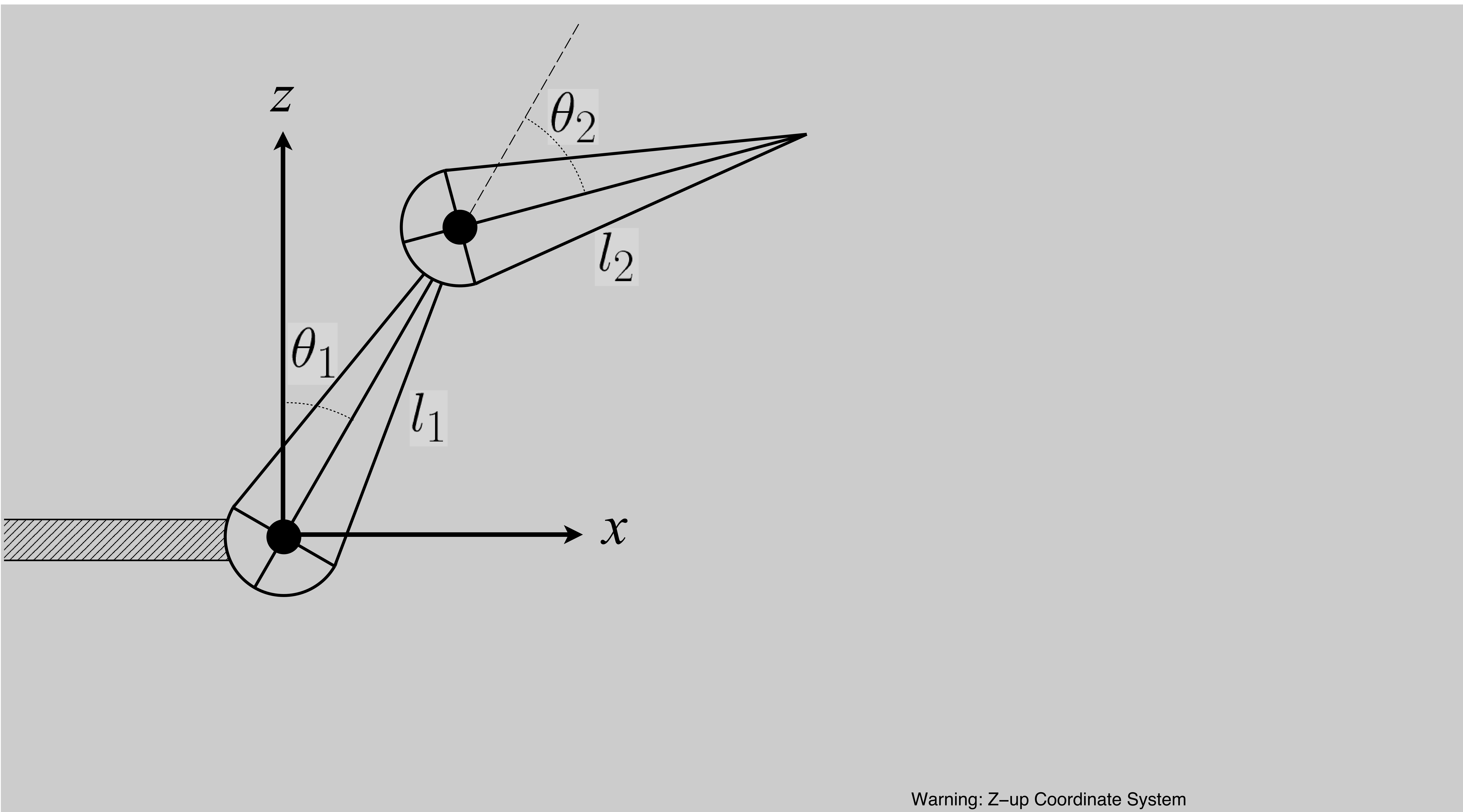


- Ball (2D rotation)
- Prismatic joint (translation)



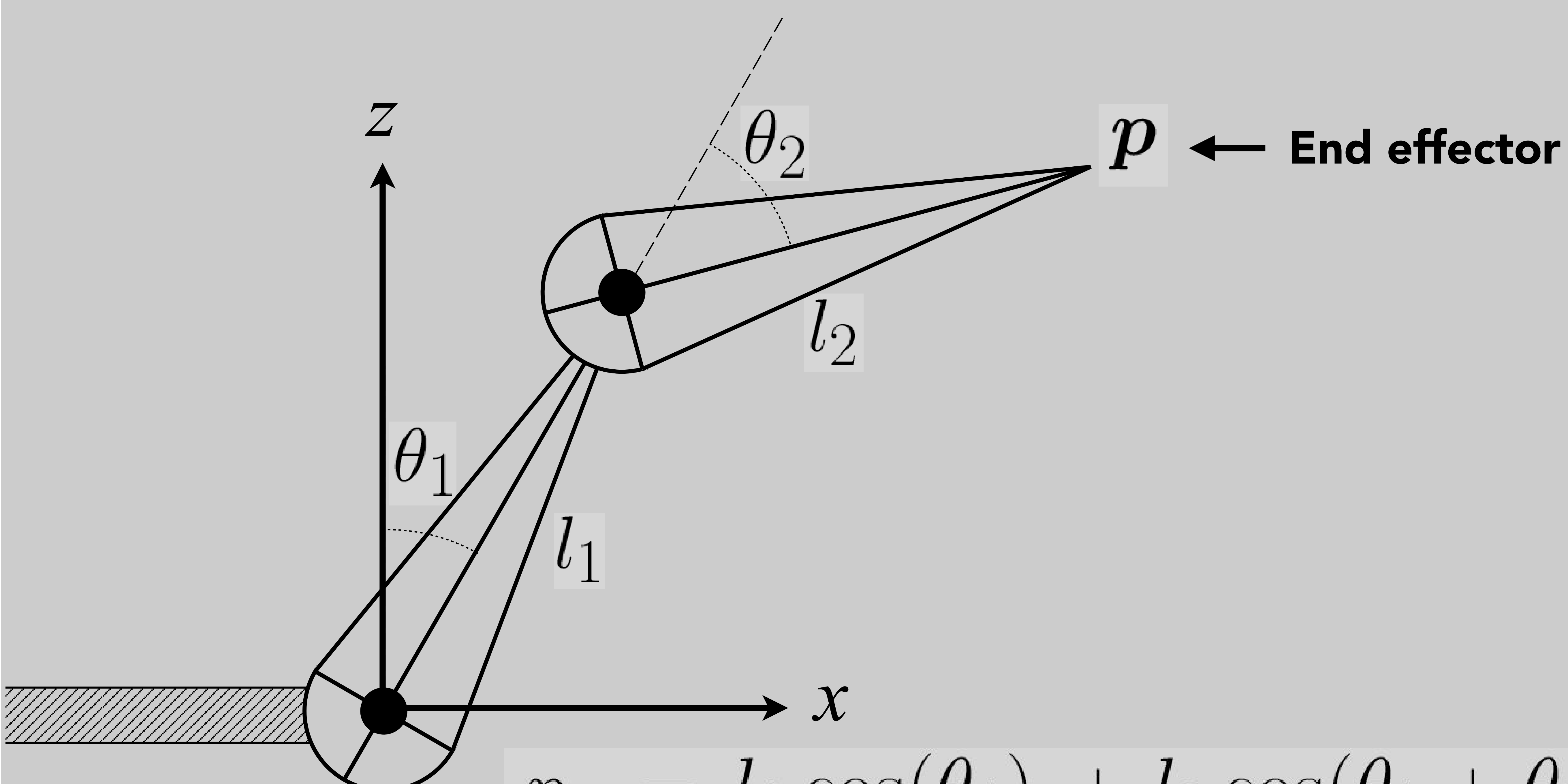
Forward Kinematics

Example: simple two segment arm in 2D



Forward Kinematics

Animator provides angles, and computer determines position *p* of end-effector



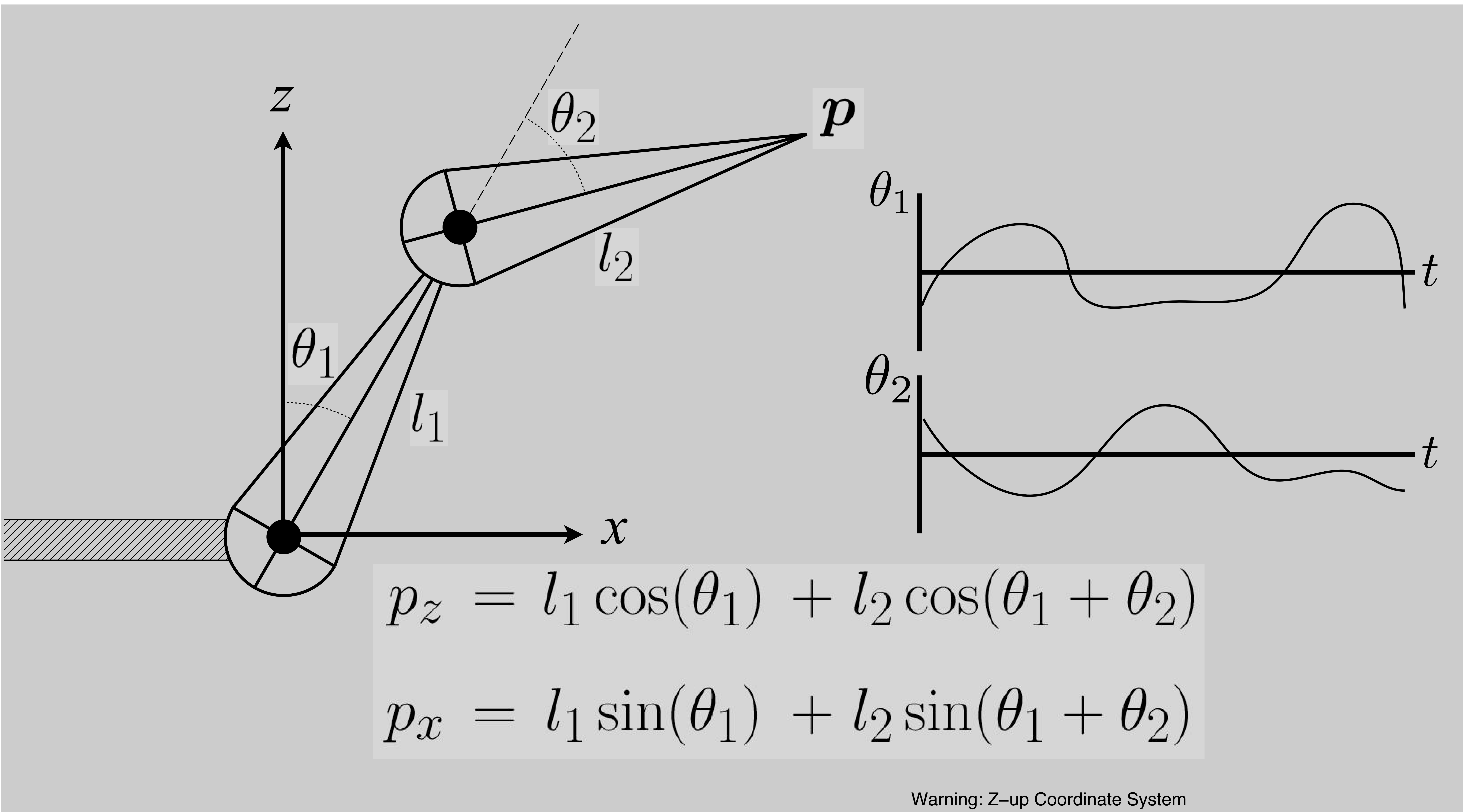
$$p_z = l_1 \cos(\theta_1) + l_2 \cos(\theta_1 + \theta_2)$$

$$p_x = l_1 \sin(\theta_1) + l_2 \sin(\theta_1 + \theta_2)$$

Warning: Z–up Coordinate System

Forward Kinematics

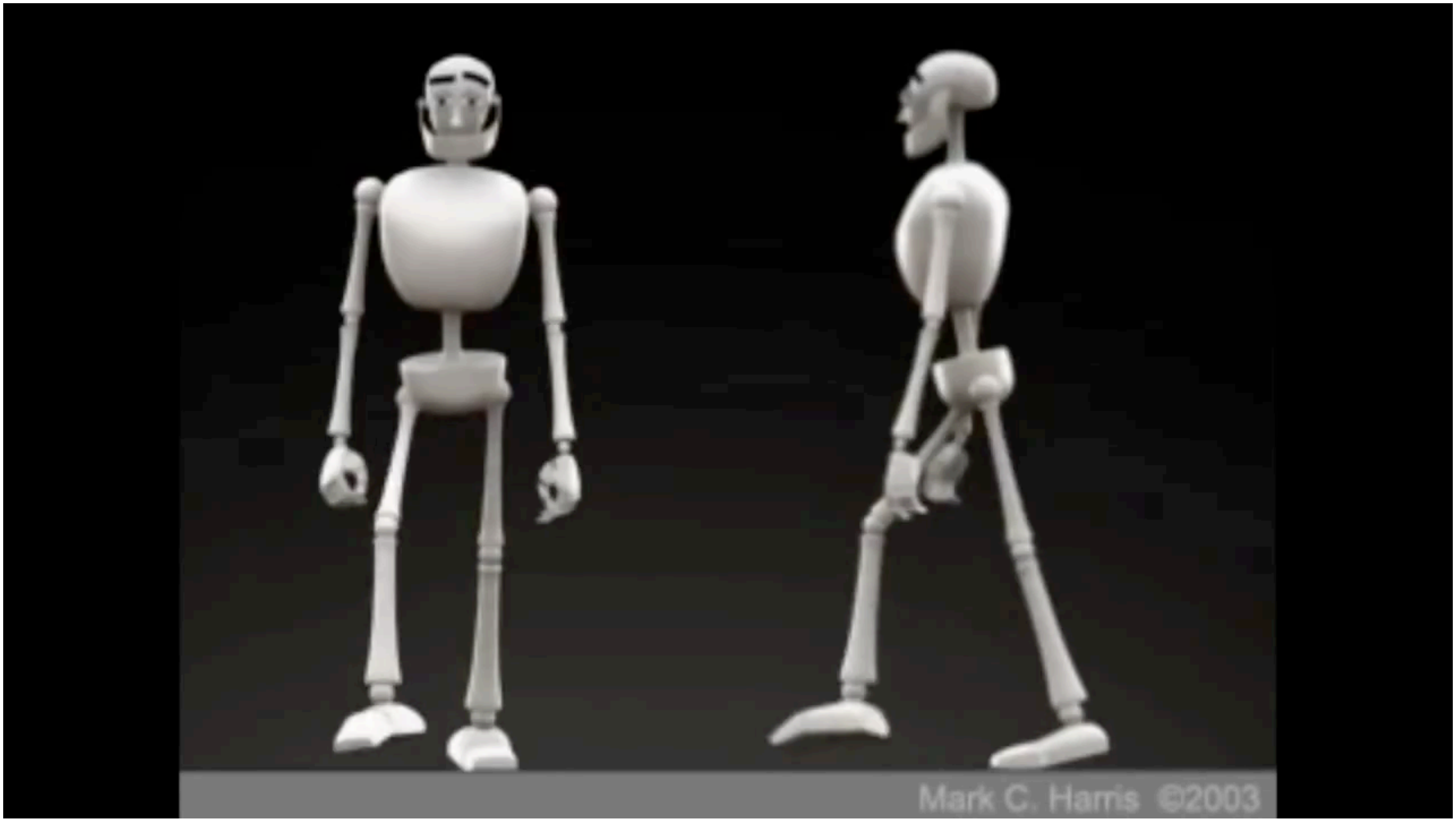
Animation is described as angle parameter values as a function of time



$$p_z = l_1 \cos(\theta_1) + l_2 \cos(\theta_1 + \theta_2)$$

$$p_x = l_1 \sin(\theta_1) + l_2 \sin(\theta_1 + \theta_2)$$

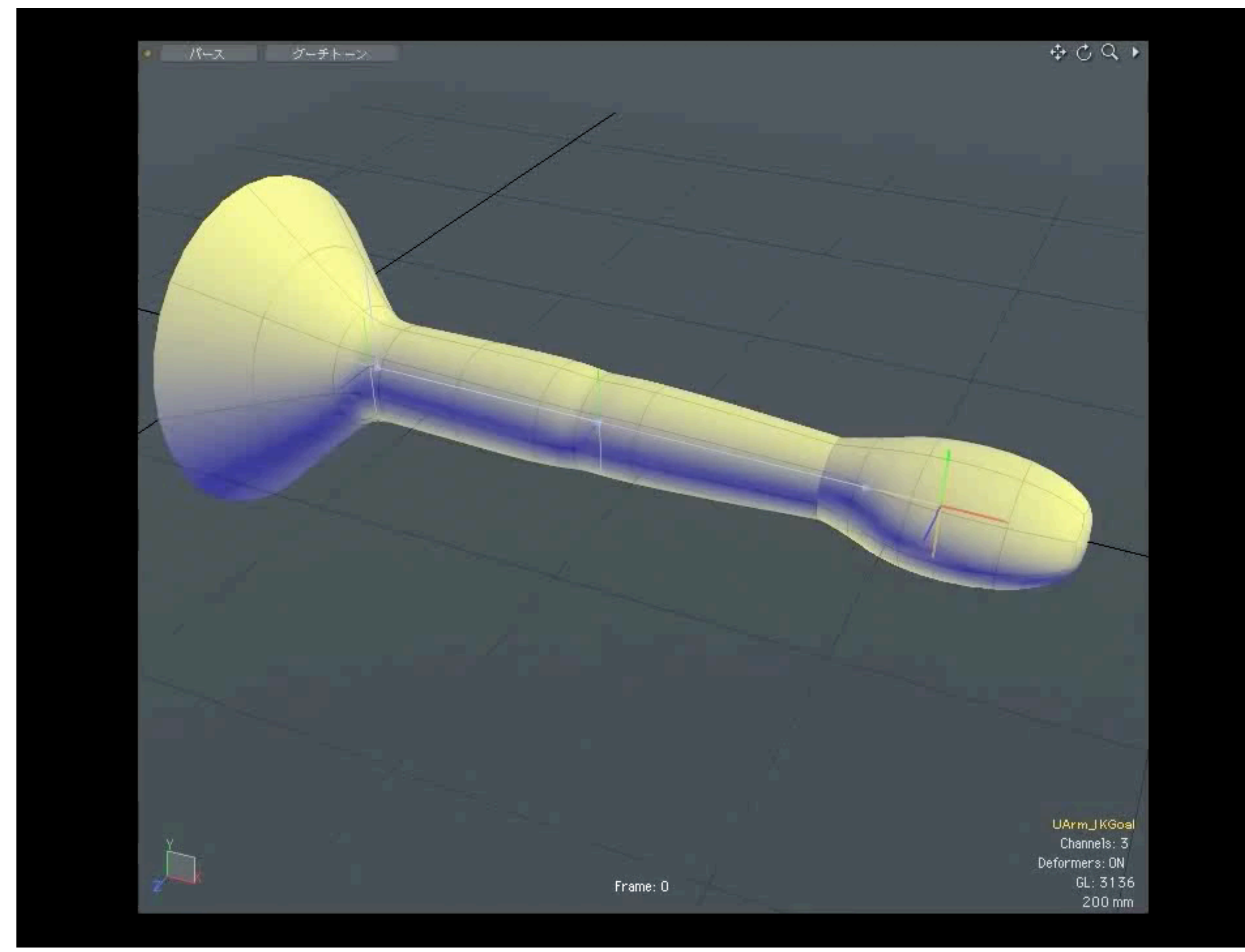
Example Walk Cycle



Inverse Kinematics

Inverse Kinematics: Artist just specifies end positions

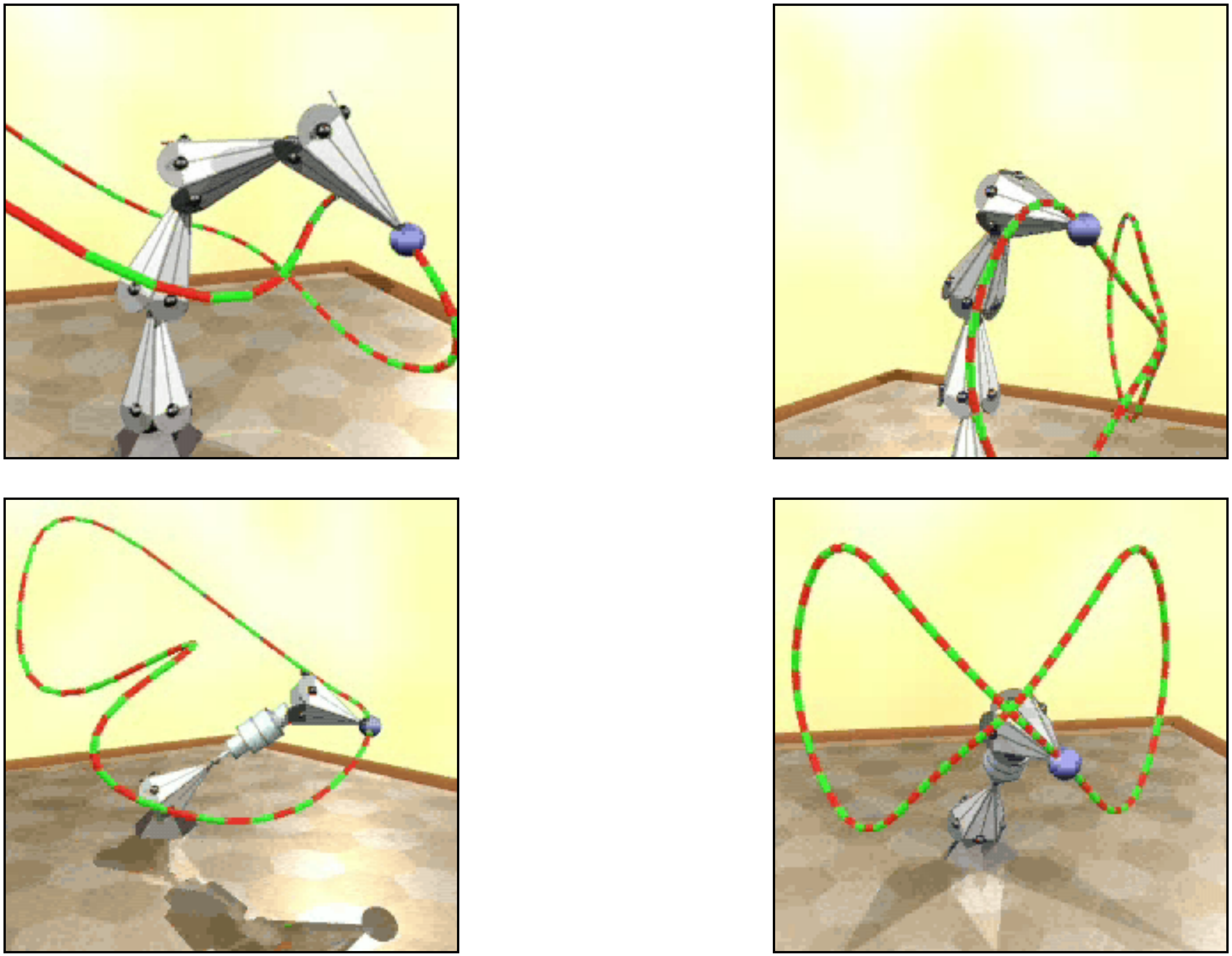
Given the end effector position, find the joint angles.



Goals

- Position end of limb by direct manipulation
- (More general: arbitrary constraints)

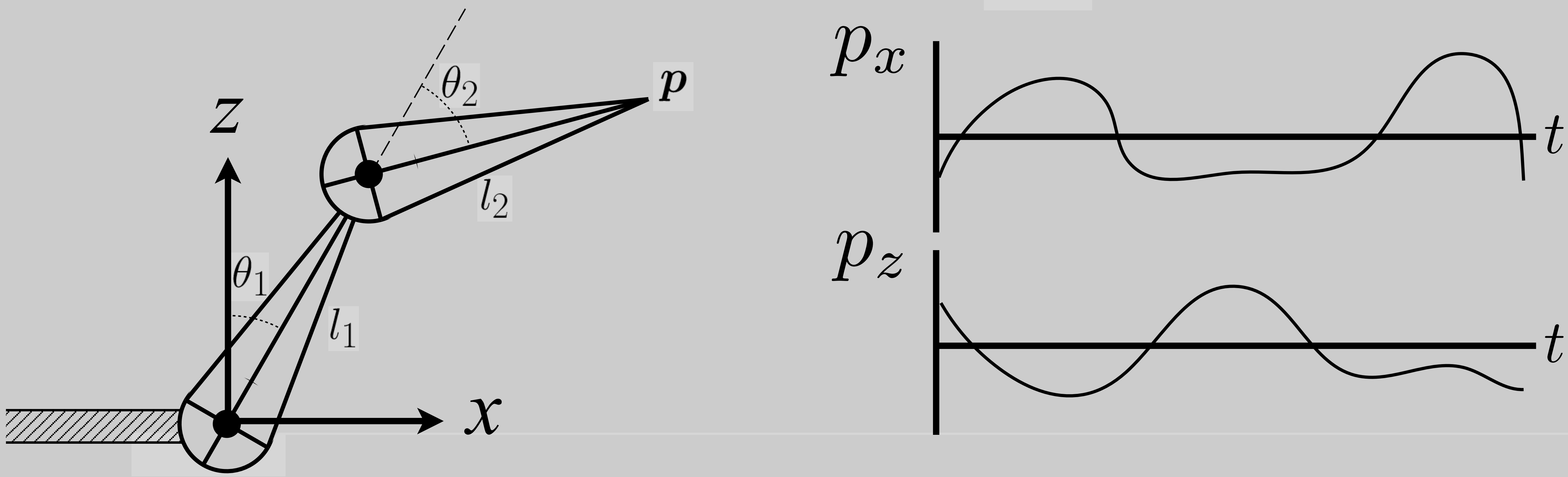
Inverse Kinematics



Egon Pasztor

Inverse Kinematics

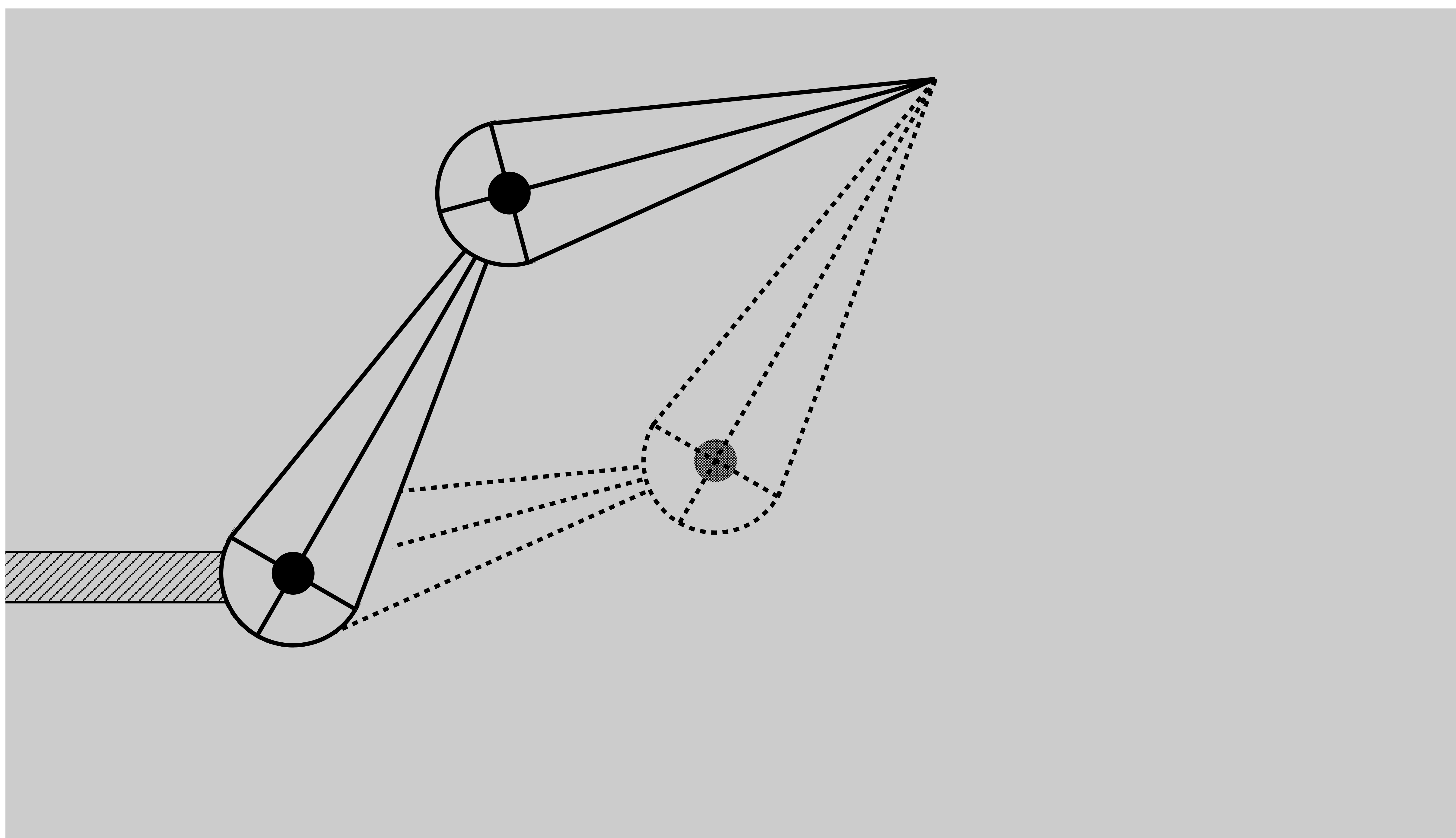
Animator provides position of end-effector, and computer must determine joint angles that satisfy constraints



Inverse Kinematics

Why is the problem hard?

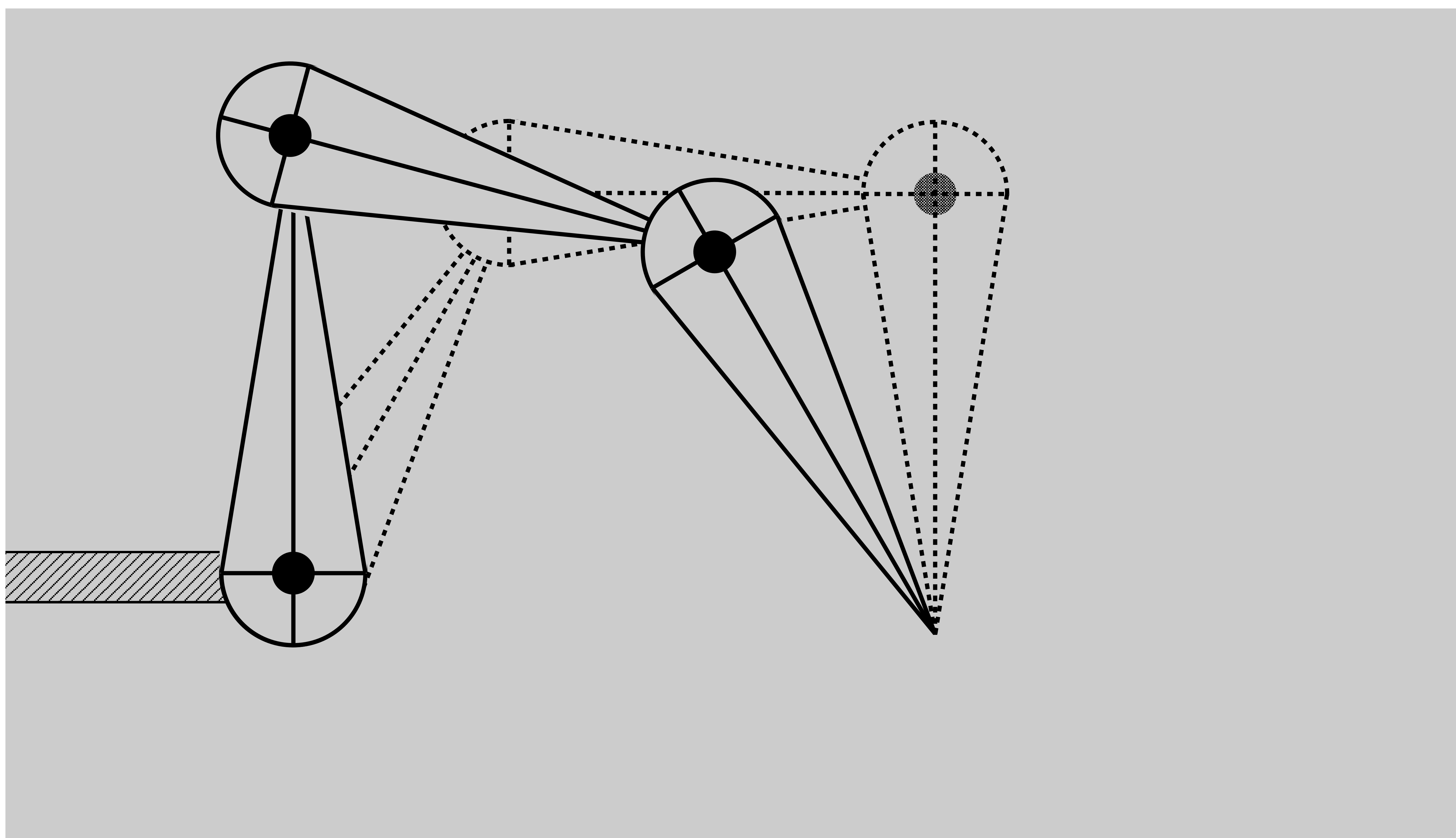
- Multiple solutions separated in configuration space



Inverse Kinematics

Why is the problem hard?

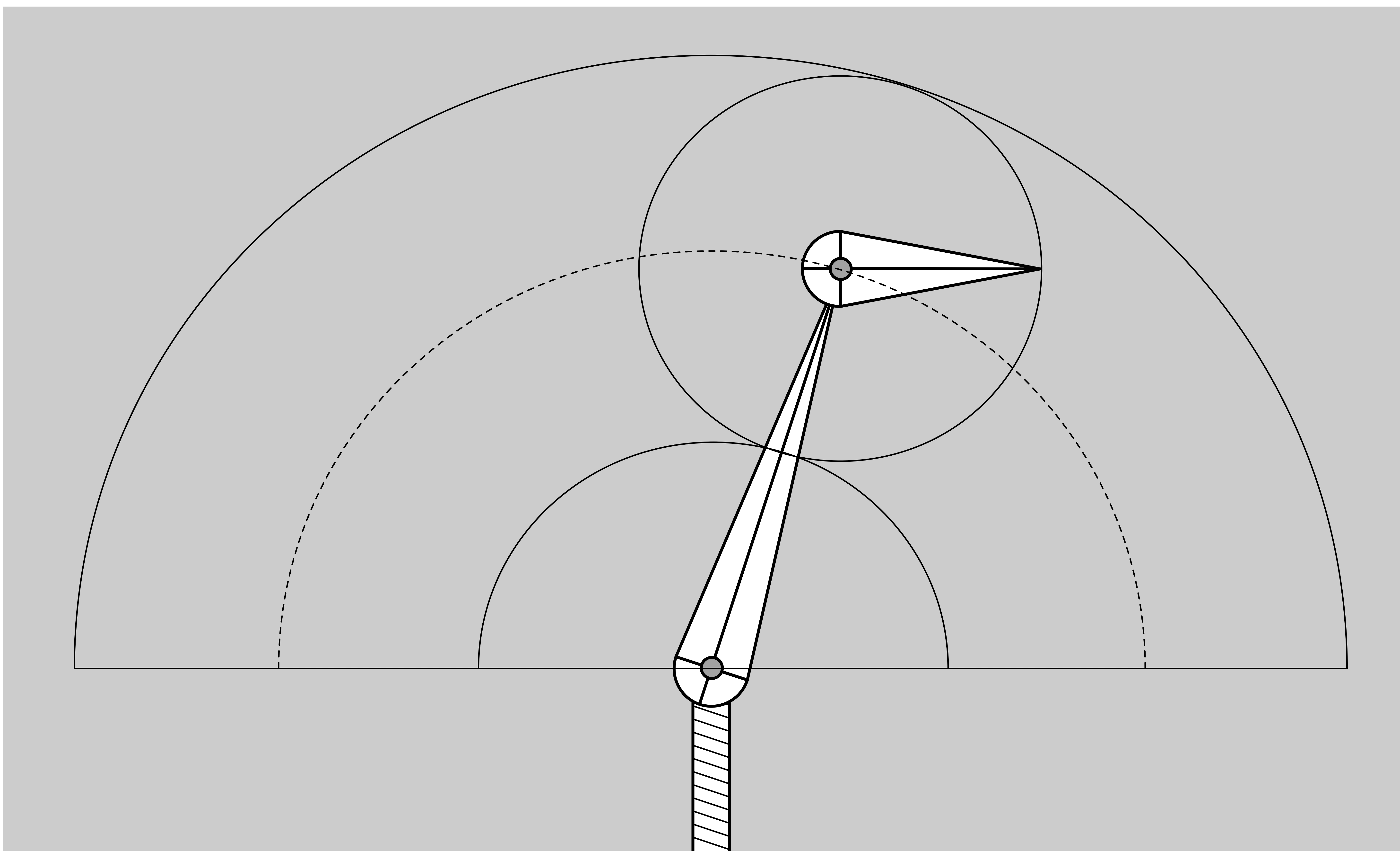
- Multiple solutions connected in configuration space



Inverse Kinematics

Why is the problem hard?

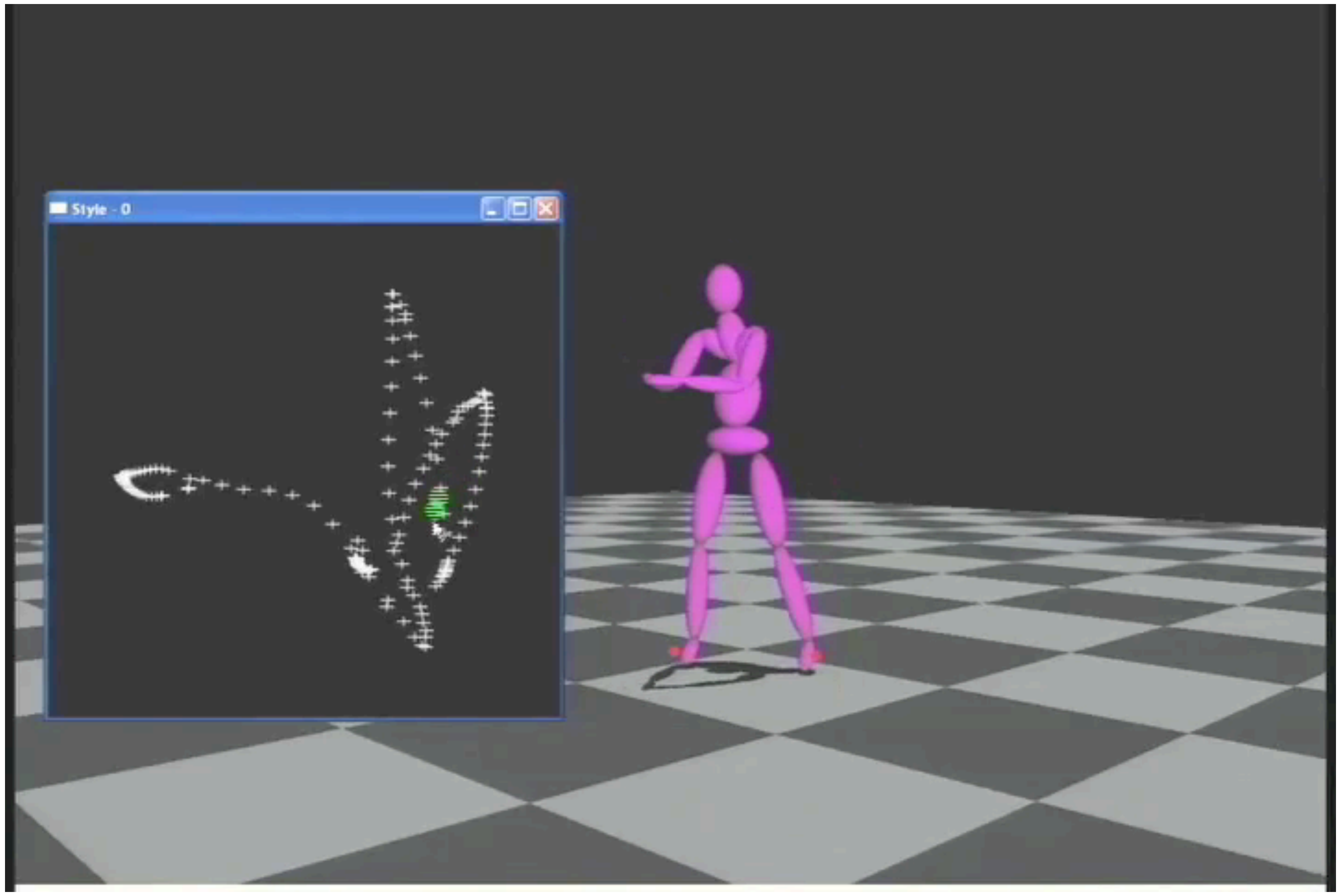
- Solutions may not always exist



Inverse Kinematics

Why is the problem hard?

- We may not care for the most accurate solution
  - Balance other desires: motion style, smoothness, robustness to external forces



Attendance Time

If you are seated in class, go to this form and sign in:

- https://tinyurl.com/184lecture

Notes:

- Time-stamp will be taken when you submit form.
  Do it now, won't count later.
- Don't tell friends outside class to fill it out now, because we will audit at some point in semester.
- Failing audit will have large negative consequence. You don't need to, because you have an alternative!

Rigging

Rigging is a set of higher level controls on a character that allow more rapid & intuitive modification of pose, deformations, expression, etc.

Important

- Like strings on a puppet
- Captures all meaningful character changes
- Varies from character to character

Expensive to create

- Manual effort
- Requires both artistic and technical training

Rigging Example

Courtesy Matthew Lailler via Keenan Crane

Blend Shapes: Interpolate shape instead of skeleton

Courtesy Félix Ferrand

Motion Capture

Data-driven approach to creating animation sequences

- Record real-world performances (e.g. person executing an activity)
- Extract pose as a function of time from the data collected

Motion capture room for ShaqFu

Motion Capture Pros and Cons

Strengths

- Can capture large amounts of real data quickly
- Realism can be high

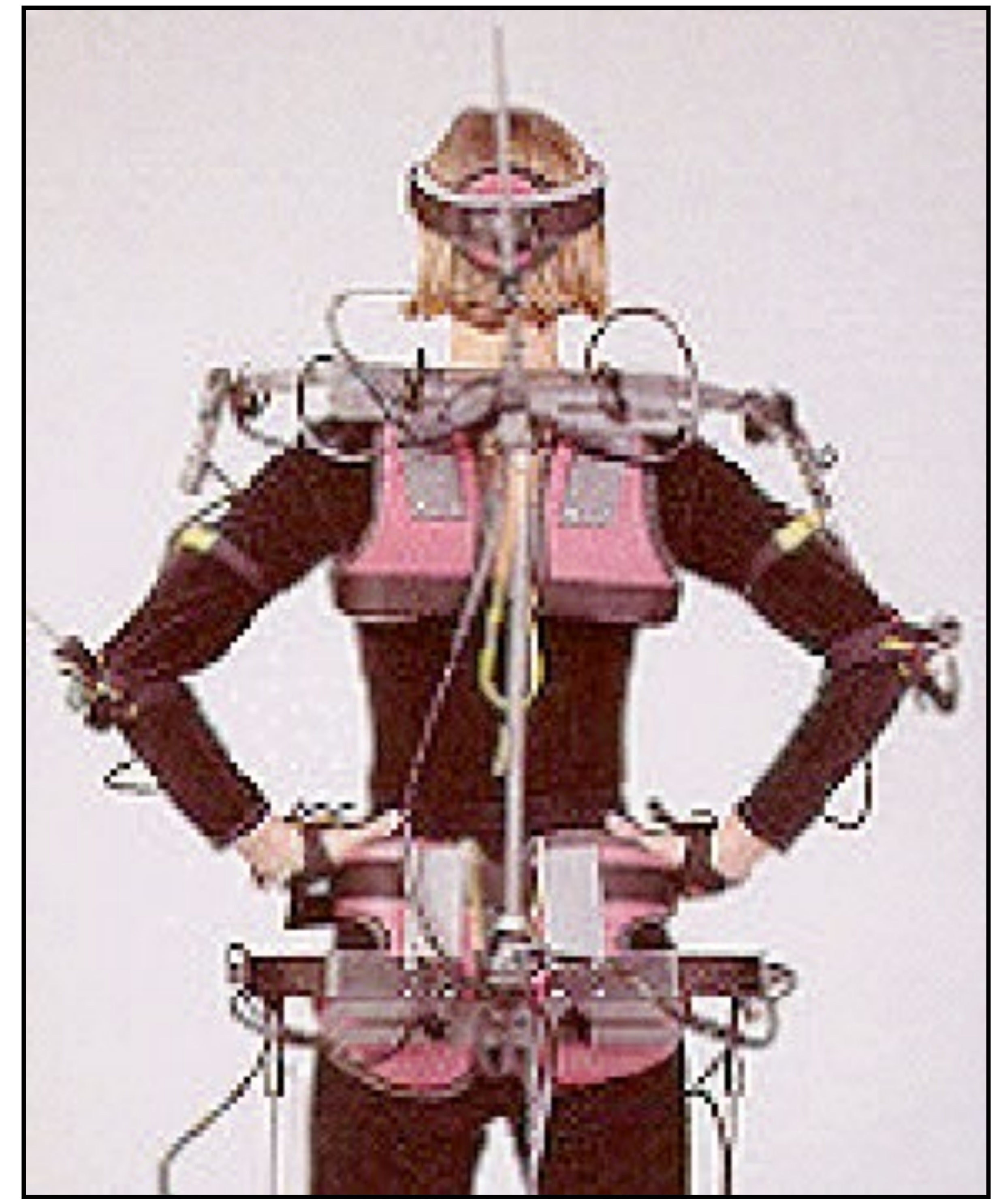
Weaknesses

- Complex and costly set-ups
- Captured animation may not meet artistic needs, requiring alterations

Motion Capture Equipment

Optical
Use reflective markers or special illumination

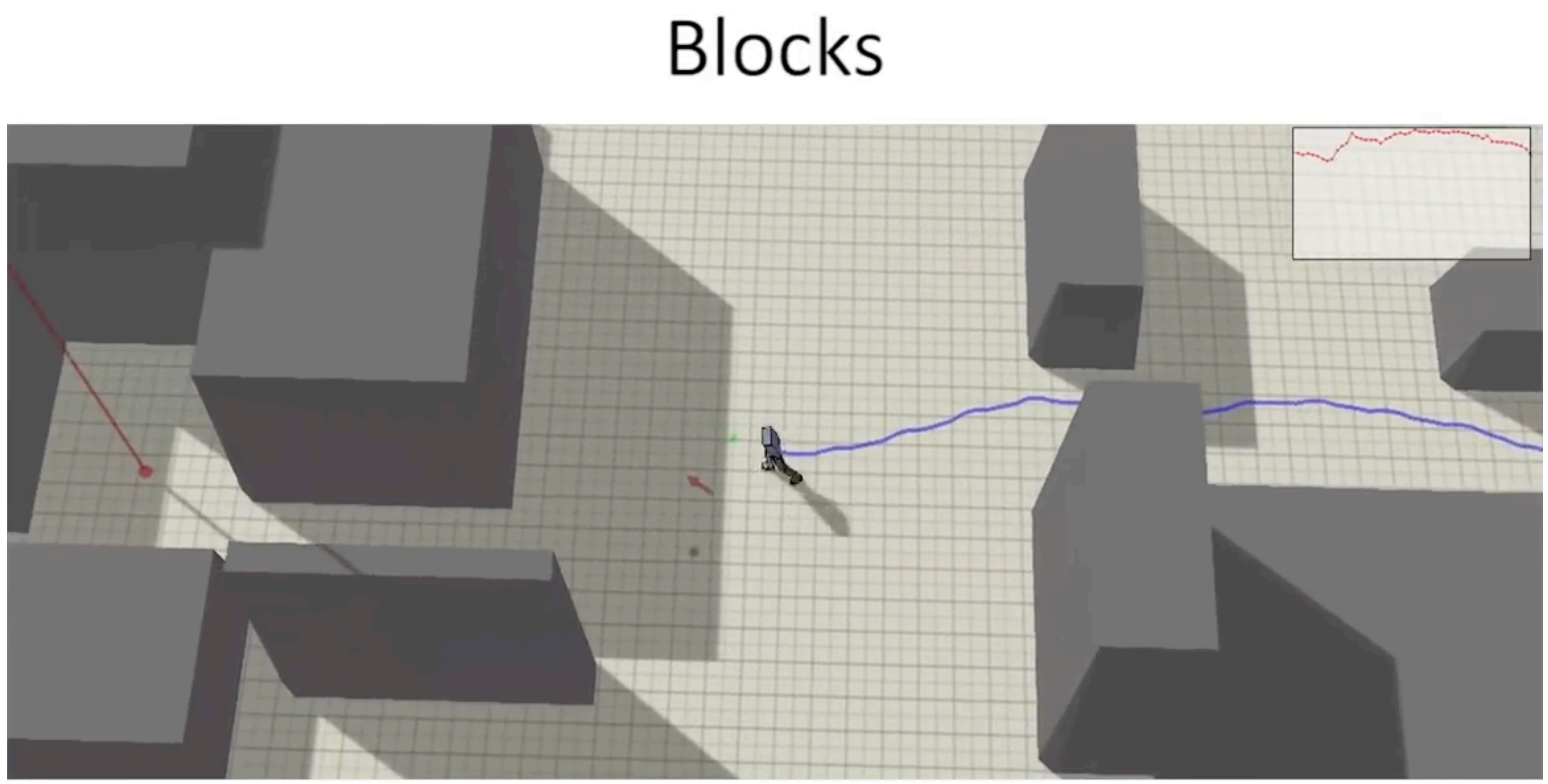
Magnetic
Sense magnetic fields to infer position / orientation. Tethered.



Mechanical
Measure joint angles directly. Restricts motion.

Animation as Controls and Machine Learning

Sequential decision making: given my current state (joint positions, joint angles, etc.), how should I move to maximize reward (following motion path, motion style, etc.)?



https://www.cs.ubc.ca/~van/papers/2017-TOG-deepLoco/index.html

Next Time: Physical Simulation

Acknowledgments

Thanks to Keenan Crane, Mark Pauly, James O'Brien, Steve Marschner and Tom Funkhouser for presentation resources.