Computer Graphics -Introduction of Animation

Junjie Cao @ DLUT

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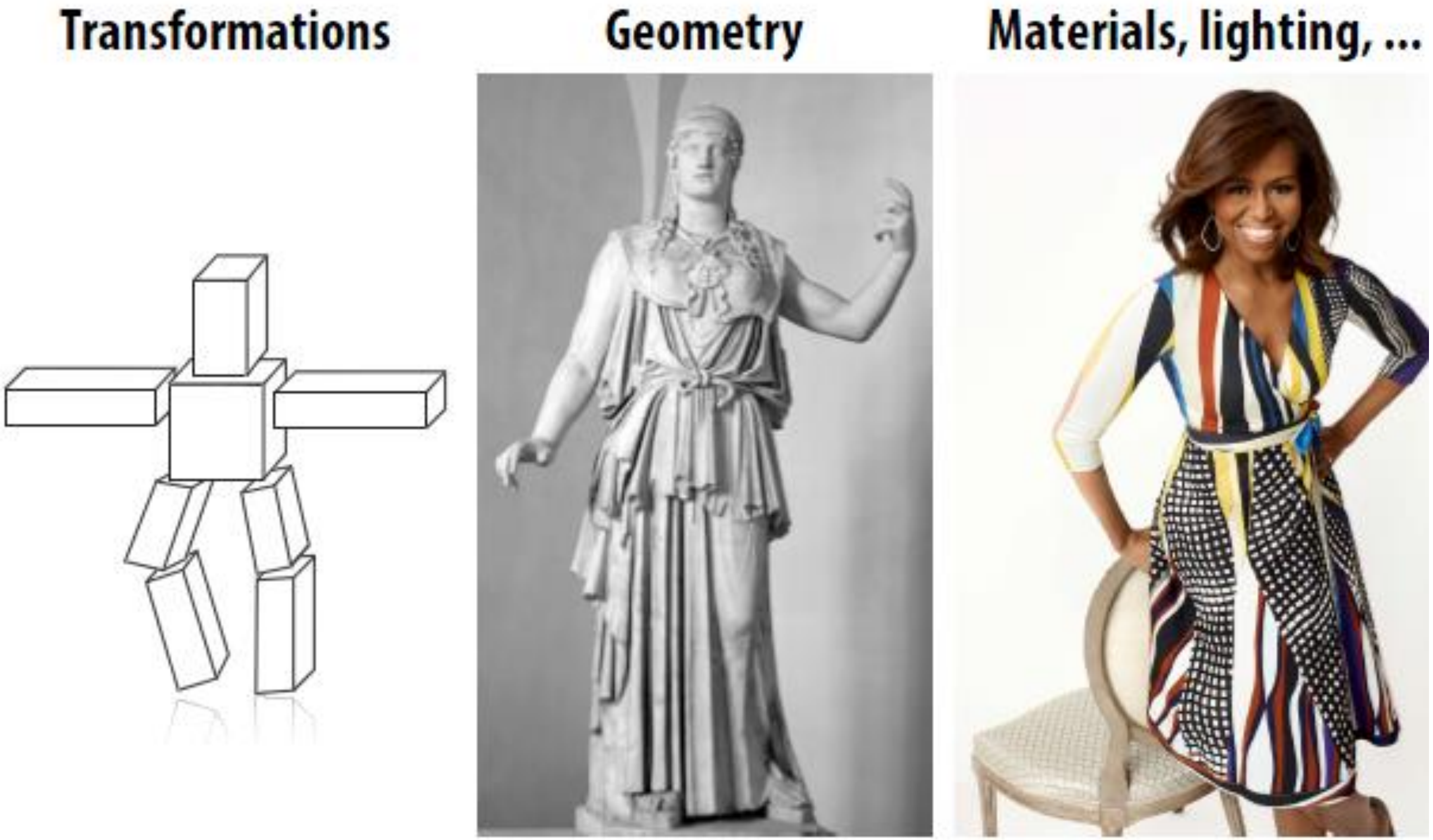
http://jjcao.github.io/ComputerGraphics/

Increasing the complexity of our models

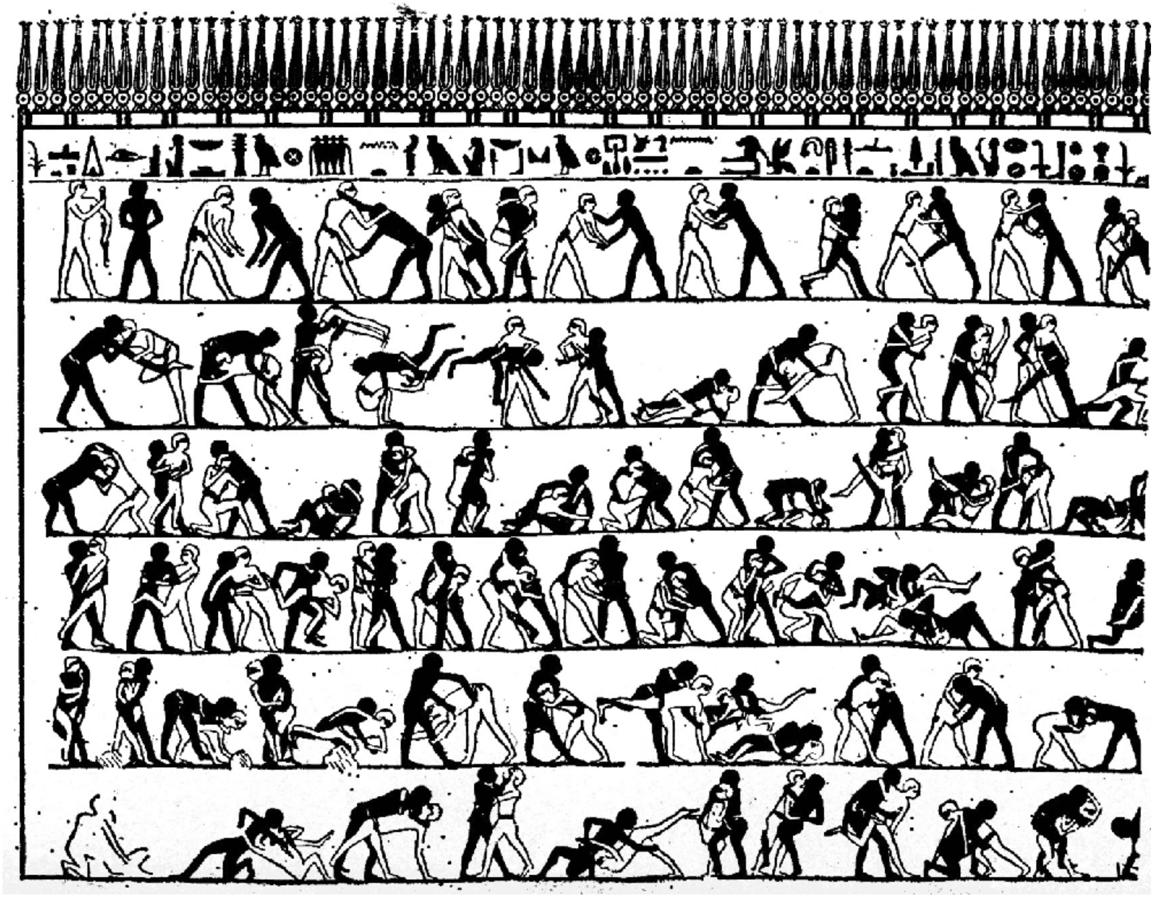


Increasing the complexity of our models

...but what about *motion?*

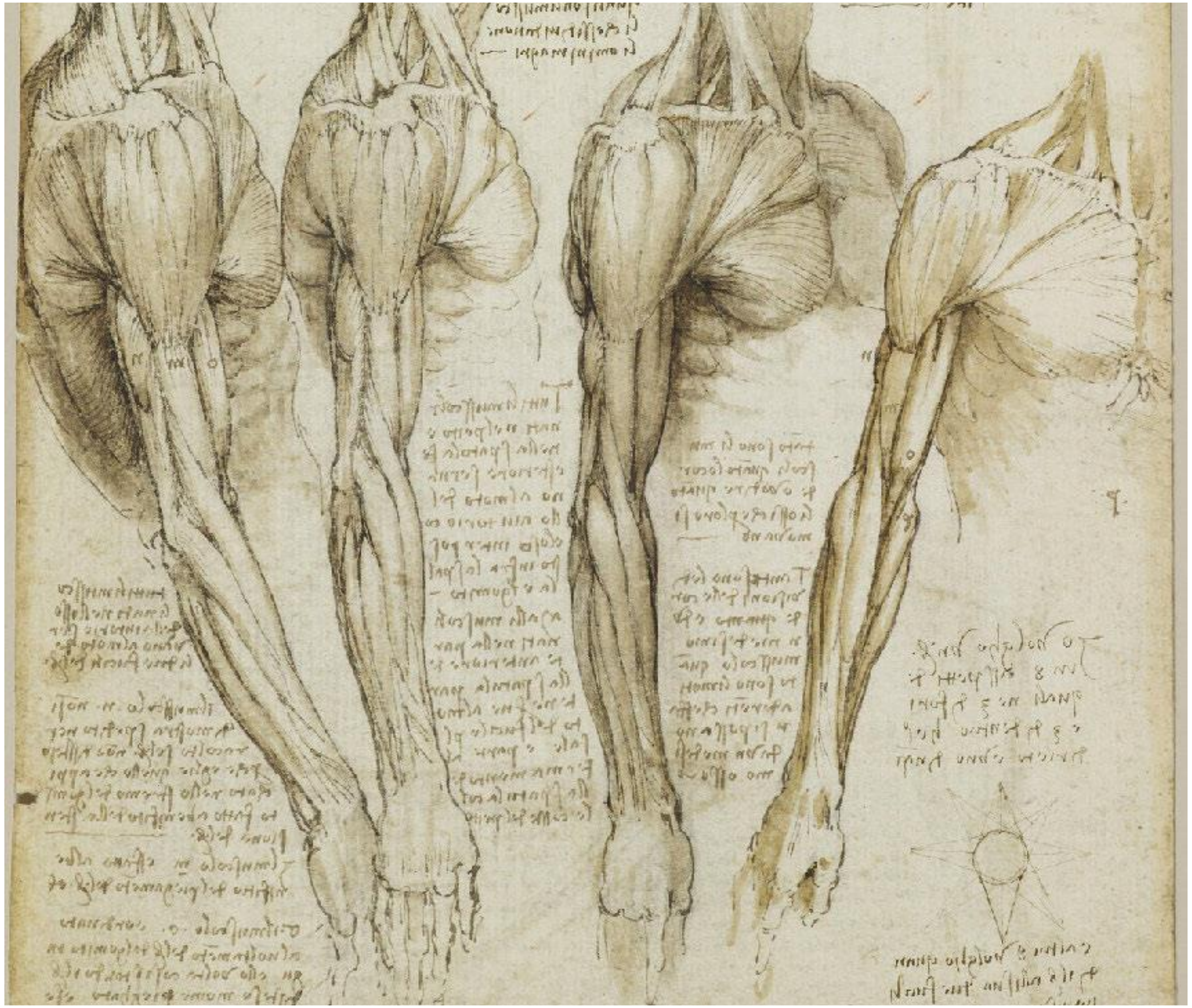
First Animation

(Shahr-e Sukhteh, Iran 3200 BCE)



(tomb of Khnumhotep, Egypt 2400 BCE)

History of Animation



Leonardo da Vinci (1510)

History of Animation

Claude Monet, “Woman with a Parasol” (1875)

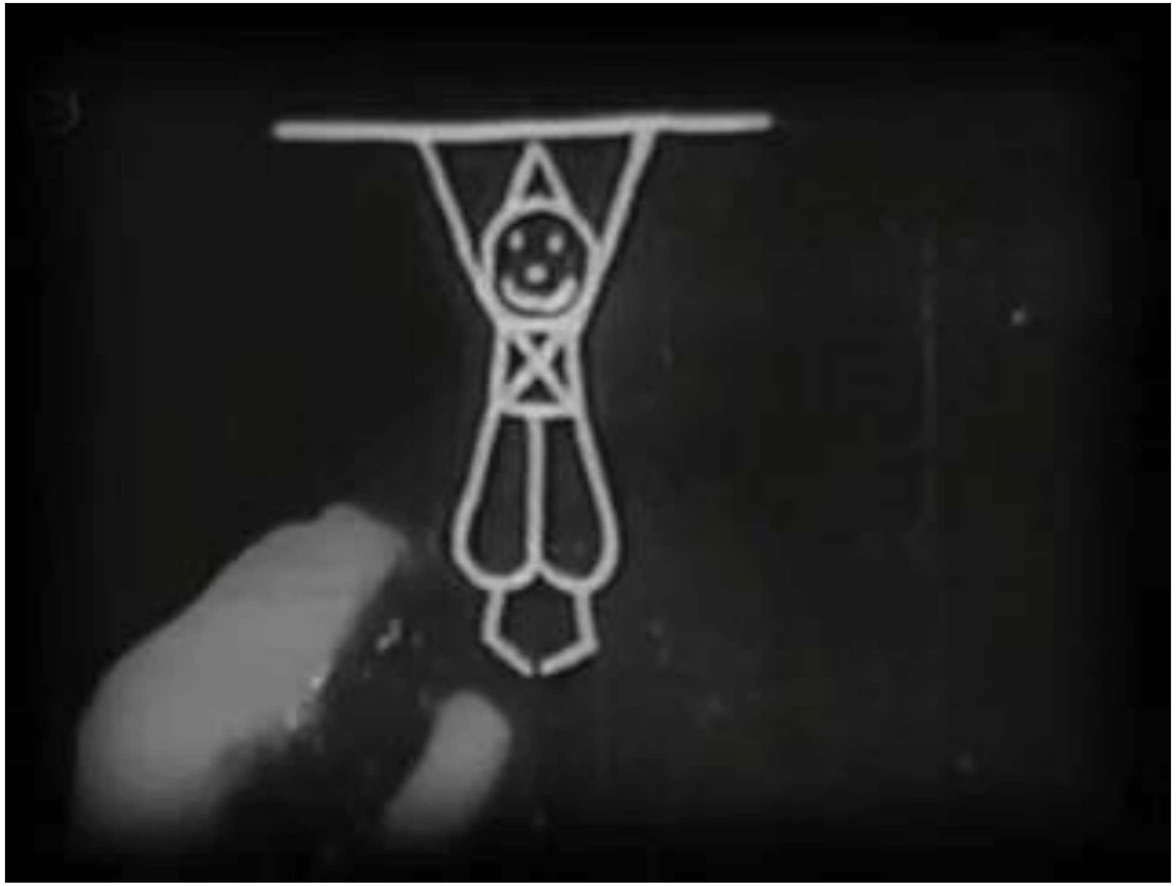
History of Animation

(Phenakistoscope, 1831)

First Film

- **Originally used as scientific tool rather than for entertainment**
- **Critical *technology* that accelerated development of animation**

Eadweard Muybridge, *“Sallie Gardner”* (1878)



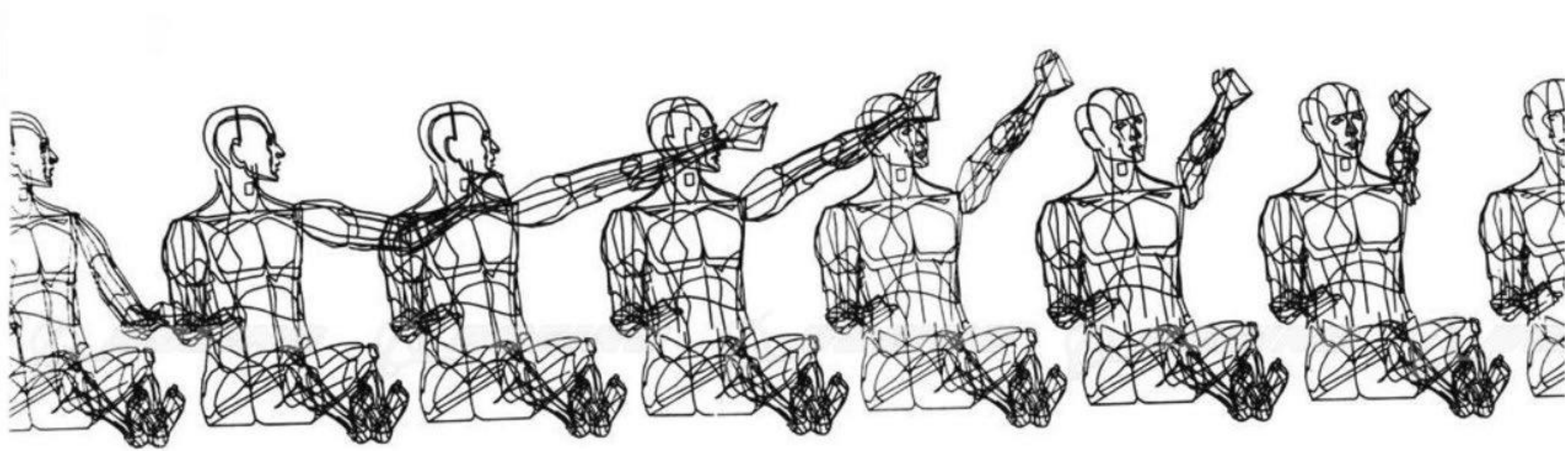
First Animation on Film
Emile Cohl, “Fantasmagorie” (1908)

First Feature-Length Animation
First Feature-Length Animation

First Hand-Drawn Feature-Length Animation

Disney, “Snow White and the Seven Dwarves” (1937)

First 3D Computer Animation



William Fetter, “Boeing Man” (1964)

First CG Feature Film

Pixar, “Toy Story” (1995)

How do we describe motion on a computer?

Overview

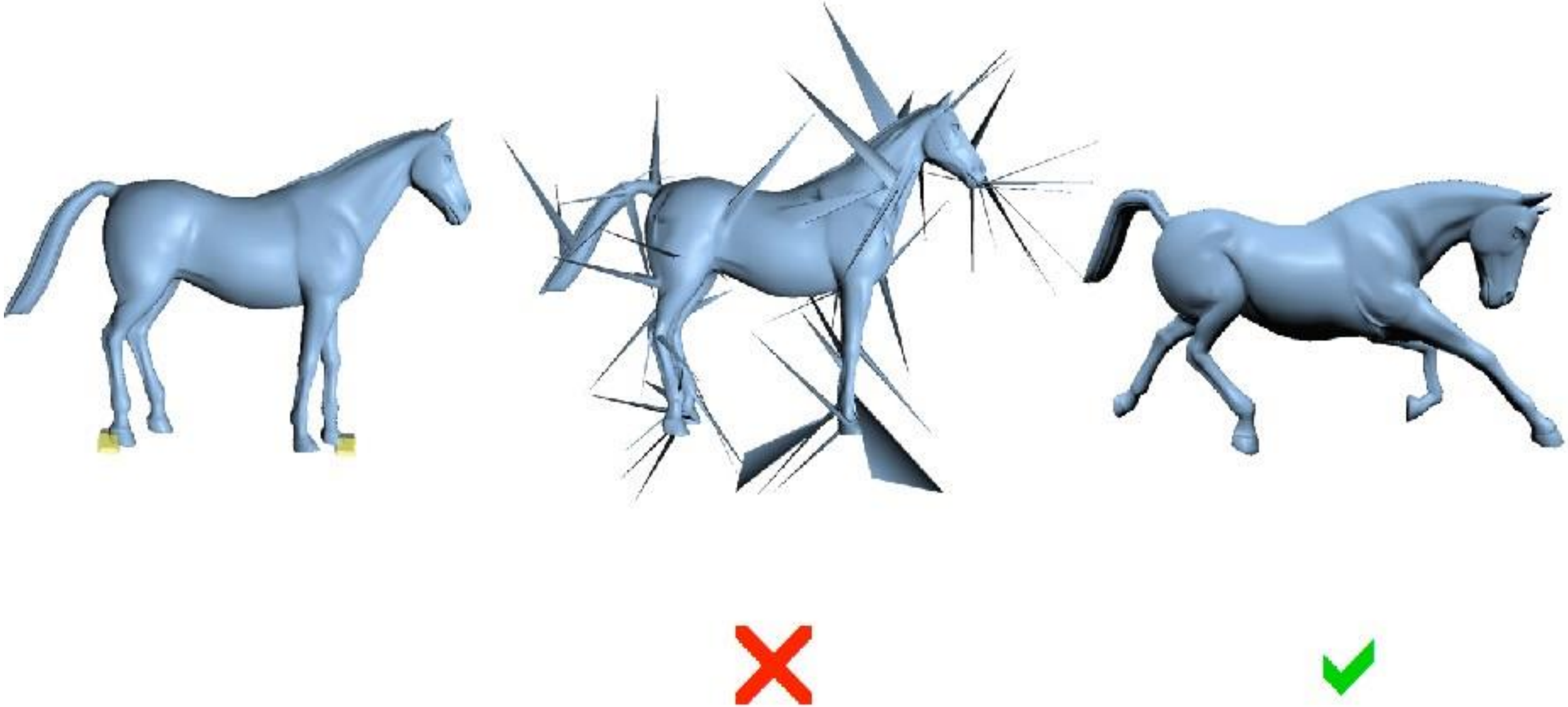
- **Animation Production**
- **Rigging**
  - **Procedural**
  - **Skeletal**
  - **Anatomical**
- **Posing**
  - **Forward Kinematics**
  - **Inverse Kinematics**
  - **Advanced Methods (Style-Based IK + MeshIK)**
- **Animation**
  - **Artist-directed (e.g., keyframing)**
  - **Data-driven (e.g., motion capture)**
  - **Procedural (e.g., physics-based simulation)**

Animation Production

1. Story Board
2. Conceptual Art
3. Recording
4. Modeling
5. Rigging
6. Set Dressing
7. Layout
8. **Animation**
9. Special Effects
10. Shading
11. Lighting
12. Rendering

Rigging

- Parameterize meaningful deformations



Rigging

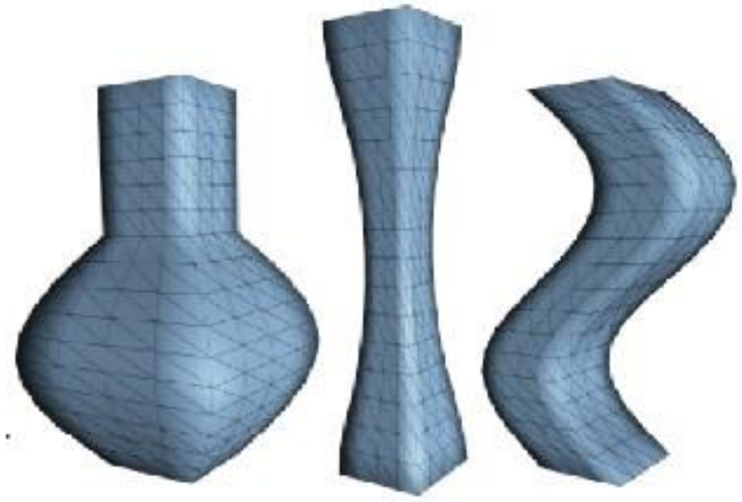
- Augment character with controls to easily change its pose, create facial expressions, bulge muscles, etc.
- Rigging is like the strings on a marionette.
- Capture space of meaningful deformations.
- Varies from character to character.

Rigging

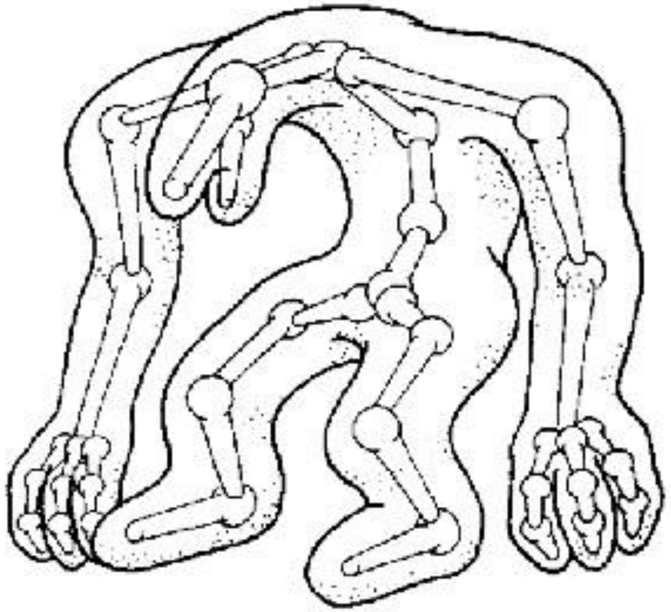
- Extremely important:
  - Determines final shape of the character
  - Quality of rigging deformations has large influence on quality of animation itself
  - Must encode every deformation animator needs to tell the story
- Expensive:
  - Manual effort
  - Both artistic and technical training

Types of Rigging

- Procedural Rigging
- Skeletal Rigging
- Anatomical Rigging



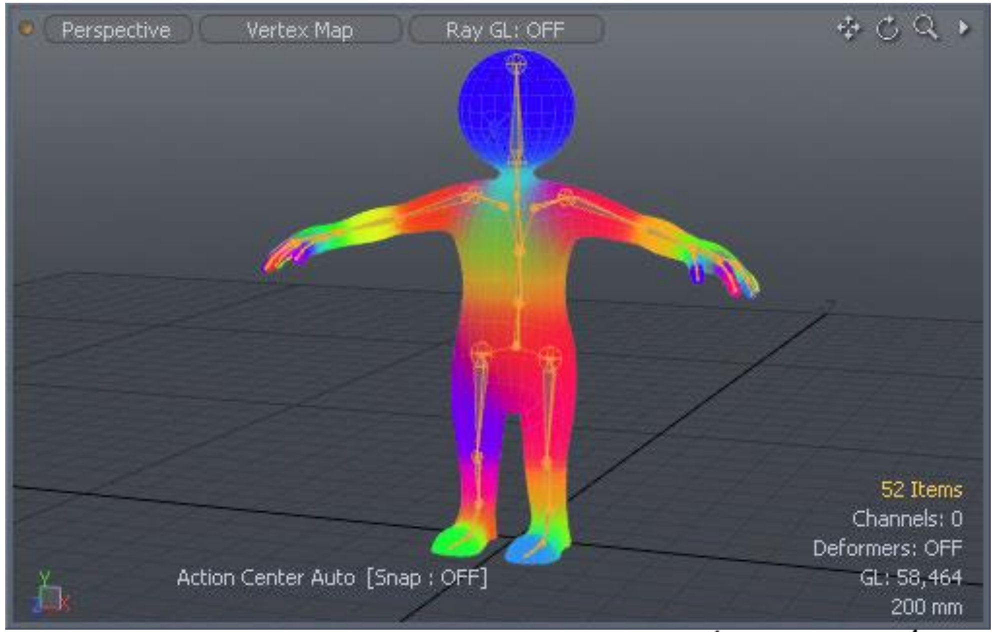
Al Barr. Global and local deformations of solid primitives. SIGGRAPH 1984

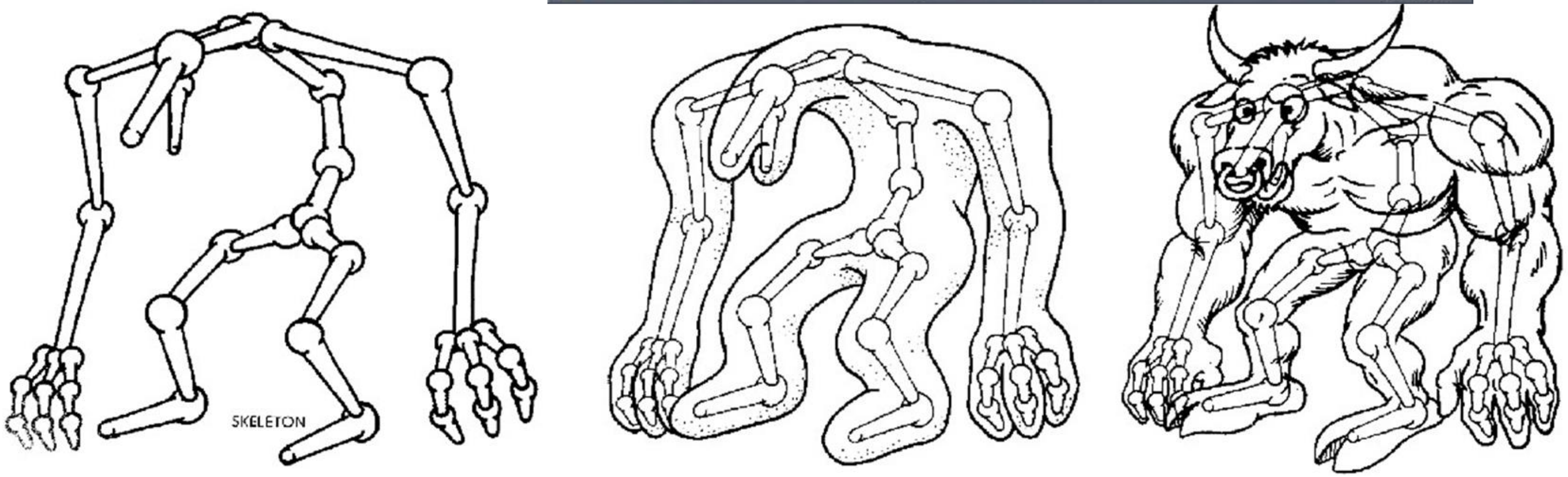


Creating and simulating skeletal muscle from the Visible Human Data Set. TVCG, 2005

Skeletal Rigging

- Parameterize character deformation with a skeleton
- Then add skin on top





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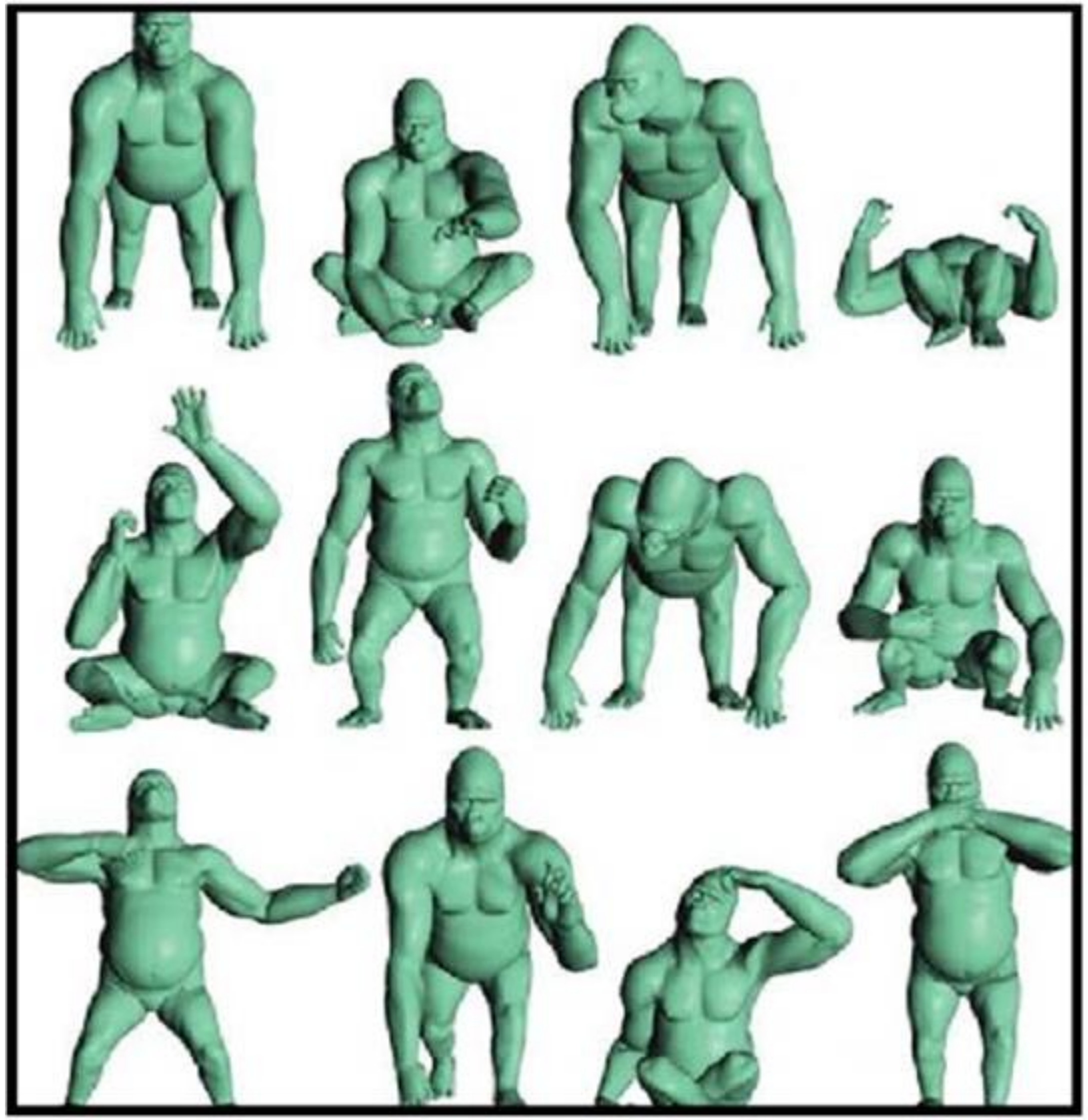
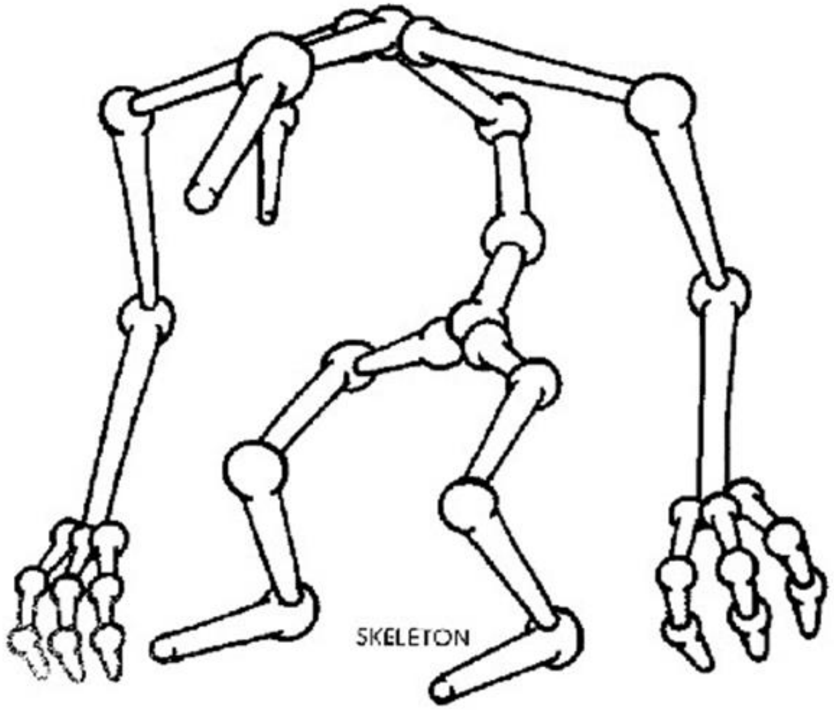
Posing

- Use the rigging controls to put the character into a given pose



Forward Kinematics

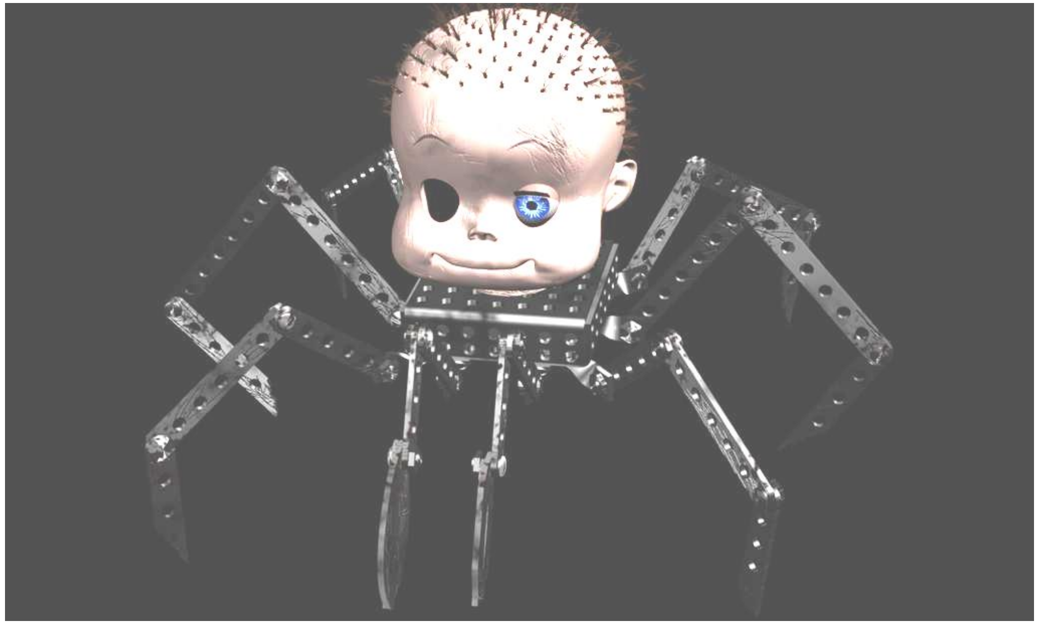
- Given the joint angles, find the position of the “end effector” (i.e. hand)
- Problem: unintuitive



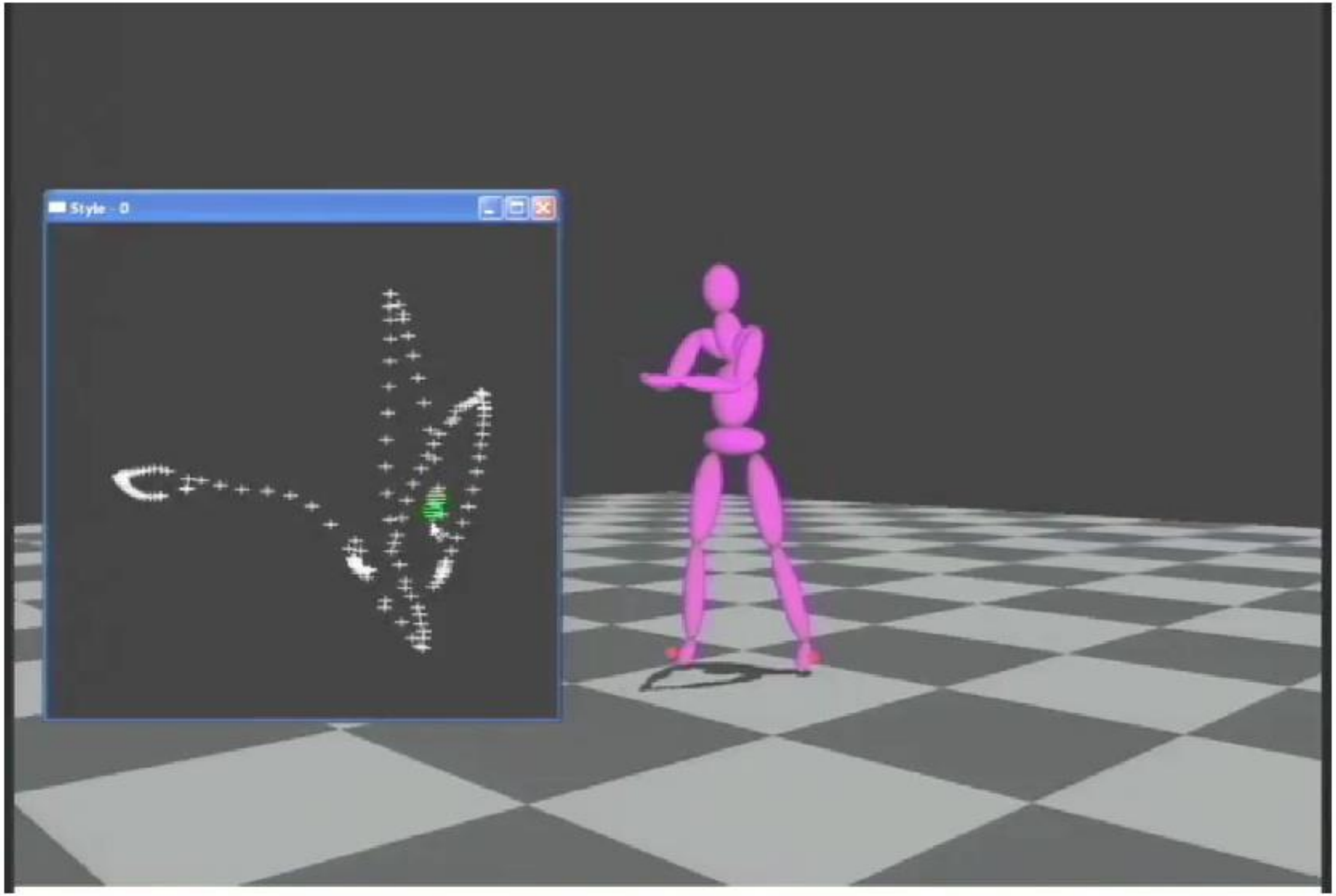
Inverse Kinematics

- Given the end effector position, find the joint angles

- Goals
  - Keep end of limb fixed while body moves
  - Position end of limb by direct manipulation
  - More general: arbitrary constraints

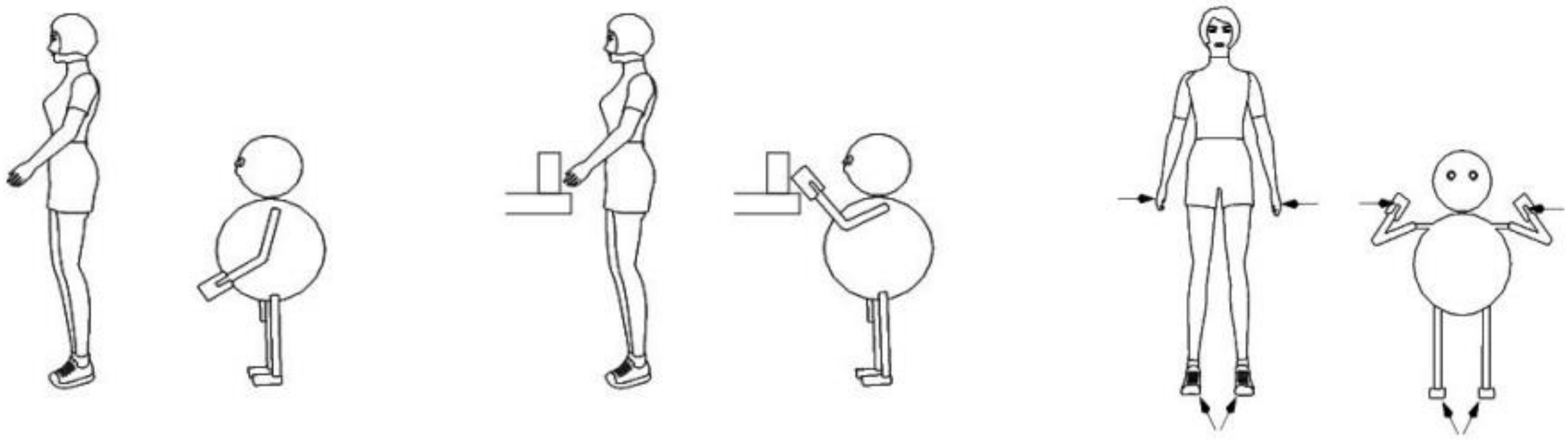


Style-Based IK



Motion Retrageting

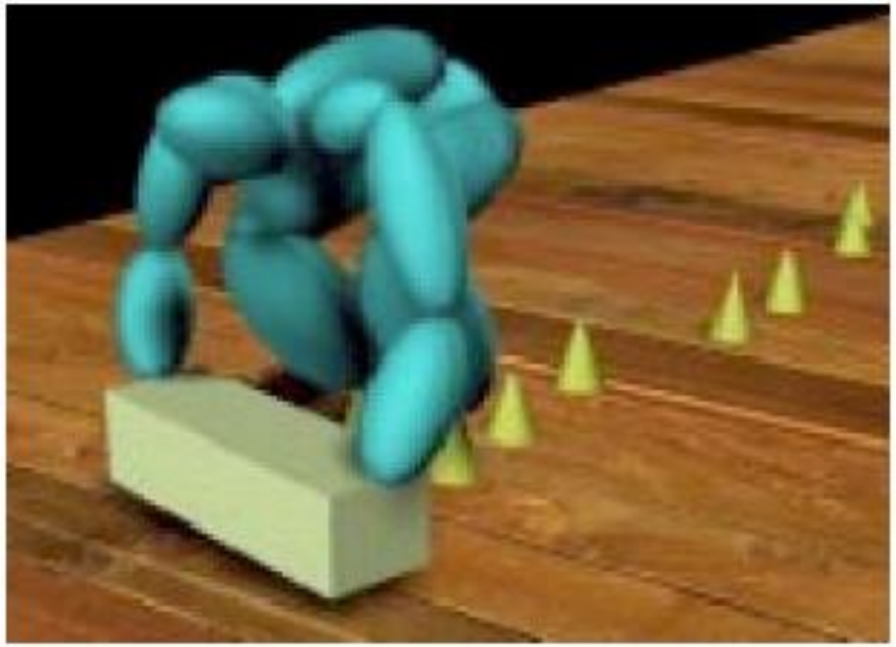
- instance of motion re-use
  - adapting an animated motion from one character to another
- What's the problem? **preserving the essence of motion**
  - Preserve angles or end-effector positions?
  - foot-floor probs. (flying, penetrating, skating)

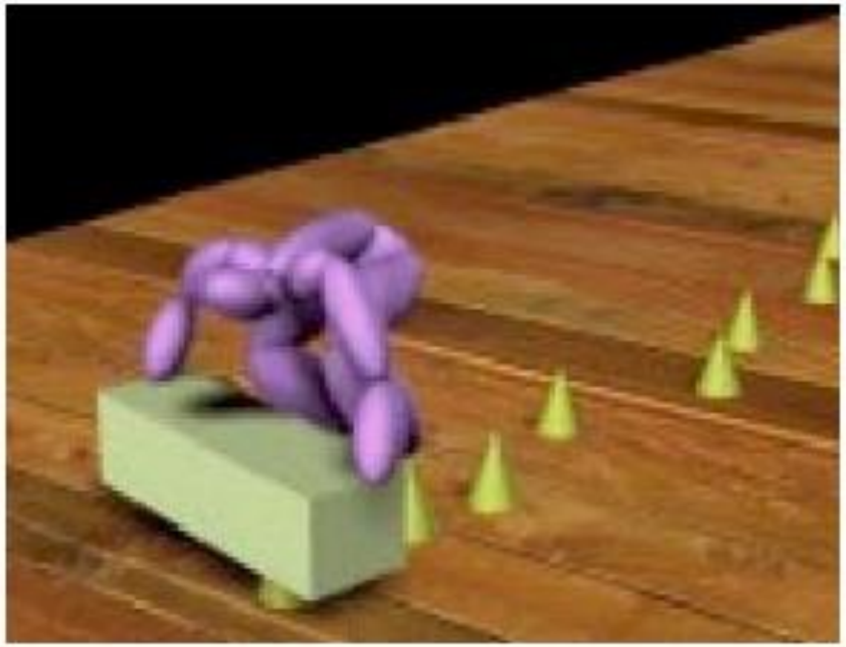


Michael Gleicher, "Retargetting motion to new characters ", SIGGRAPH '98

Task Definition

- identical structure, different bone lengths
- preserve important aspects,
- alter the less important ones
- constraints





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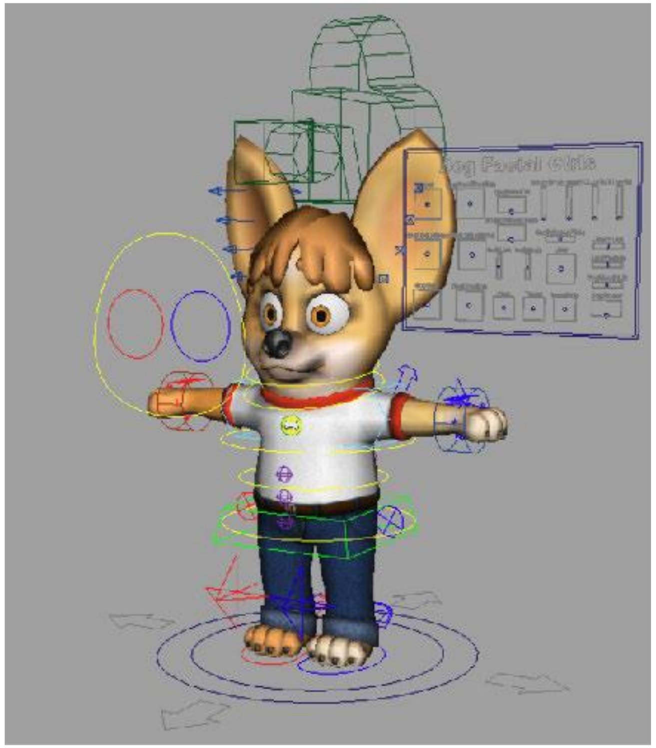
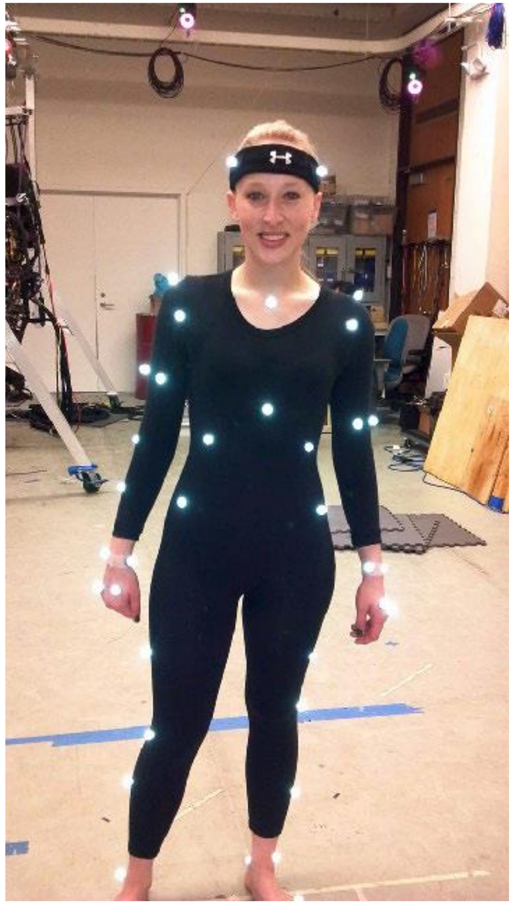
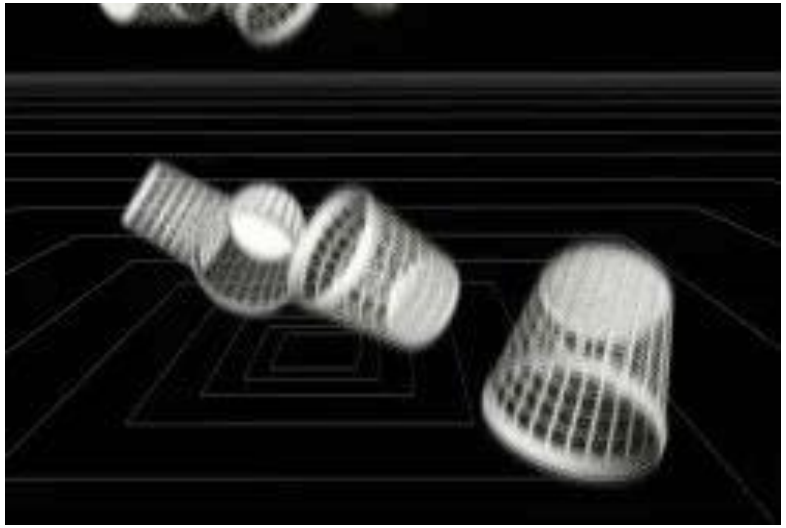
Animation

- Change the rigging parameters over time to generate continuous movement.
  - Artist-directed (e.g., keyframing)
  - Data-driven (e.g., motion capture)
  - Procedural (e.g., simulation)

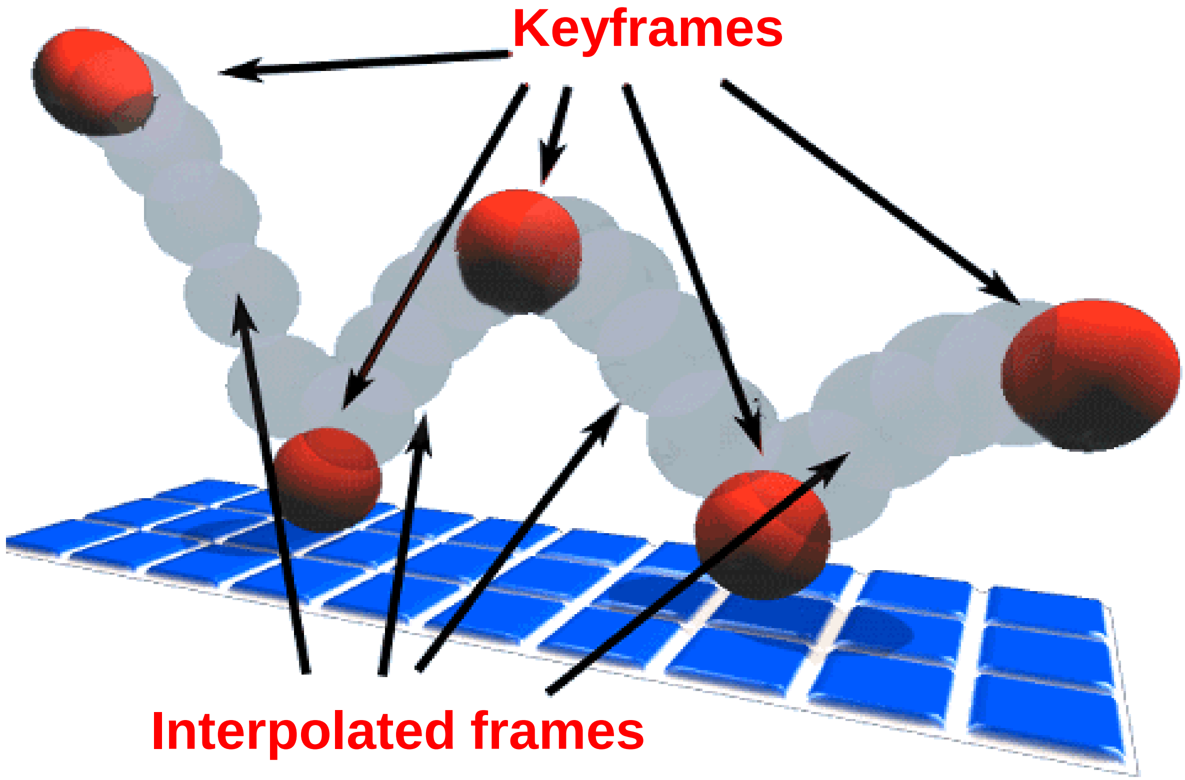






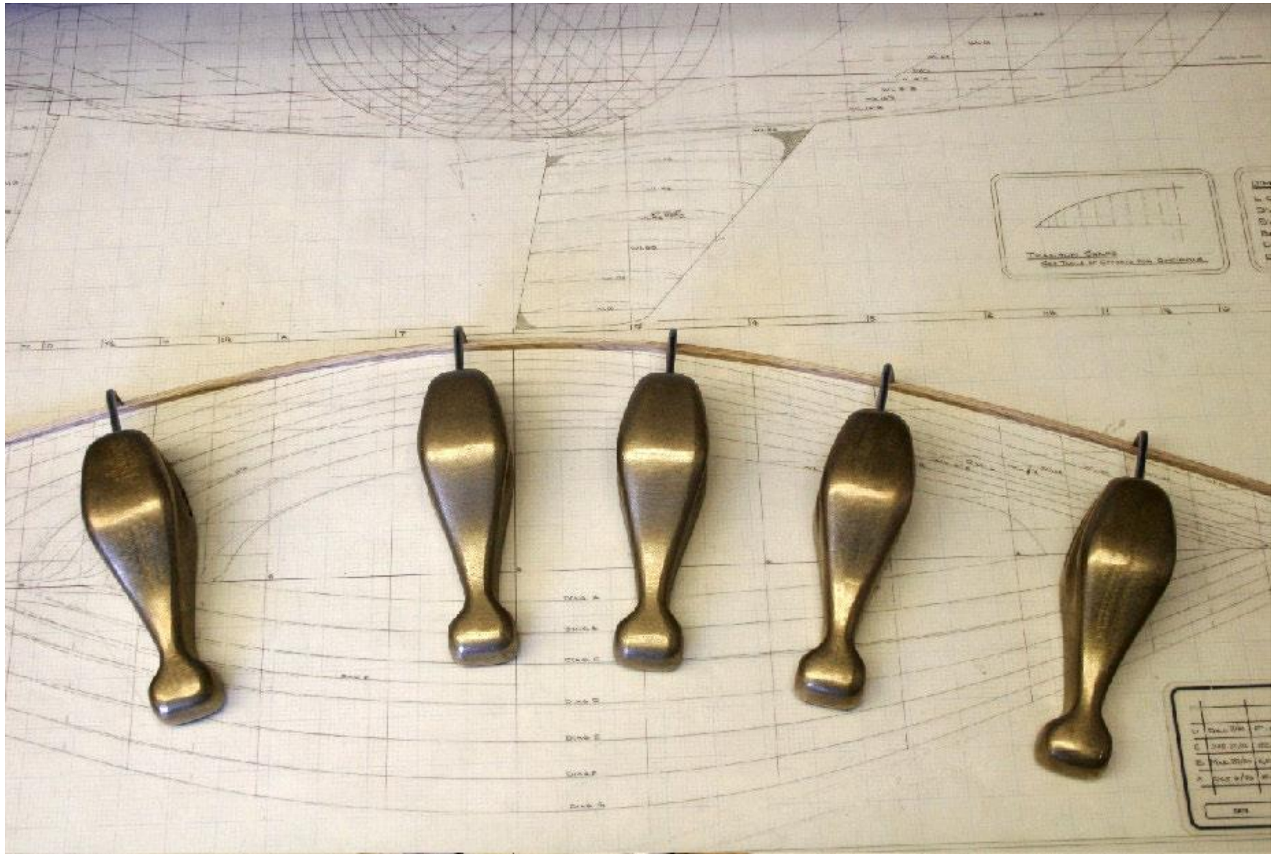
Keyframing

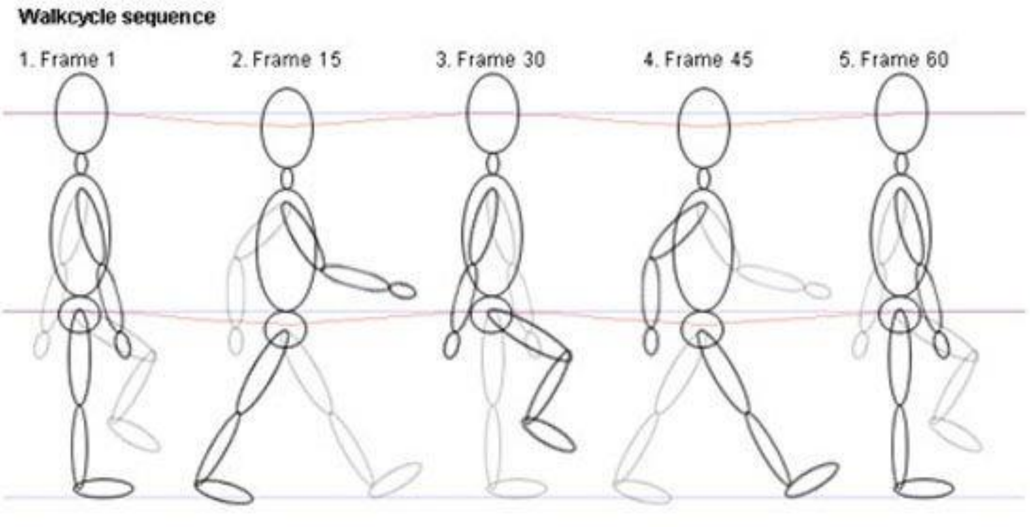
- Basic idea:
  - specify important events only
  - computer fills in the rest via interpolation/approximation
- “Events” don’t have to be position
- Could be color, light intensity, camera zoom, ...



Spline Interpolation

- **Mathematical theory of interpolation arose from study of thin strips of wood or metal ("splines") under various forces**
- **Good summary in Levin, "The Elastica: A Mathematical History"**



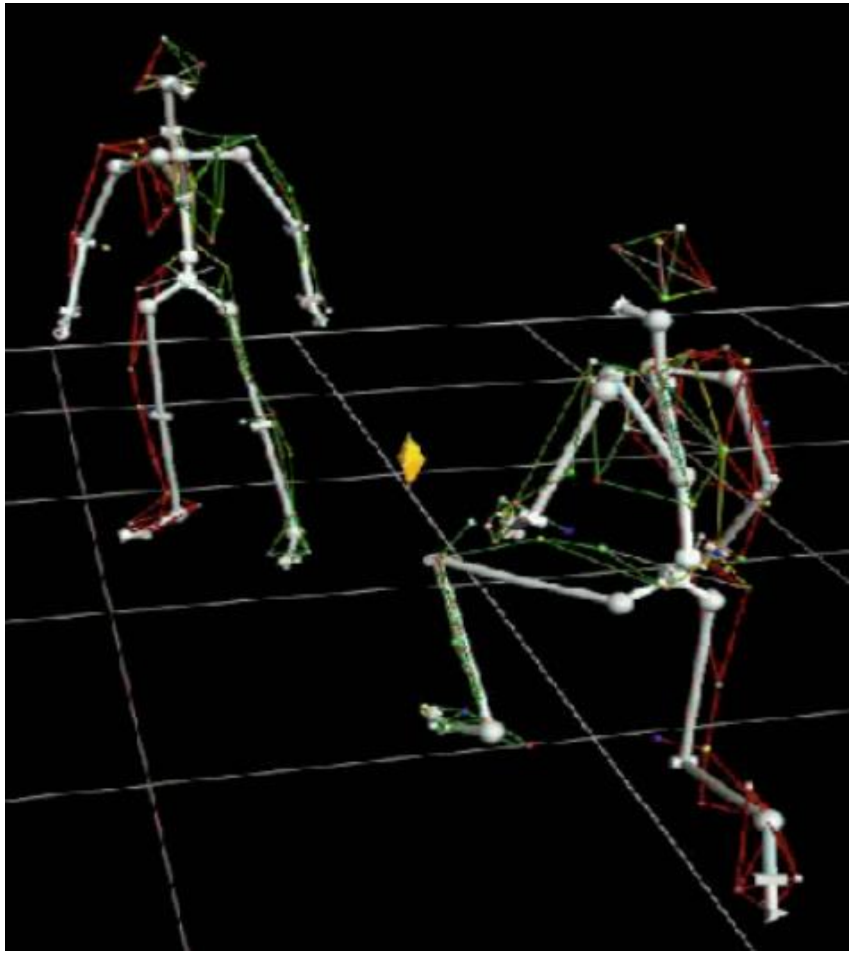


- **Motivation is perhaps pragmatic: e.g., simple closed form, decent continuity**
- **Plenty of good reasons to choose alternatives (e.g., NURBS for exact conics, ...)**

Motion Capture

- More realistic motion sequences can be generated by Motion Capture
- Extract data from real-world people acting out a scene
- Record live action

Becomes Mocap Data



[Images from NYU and UW]

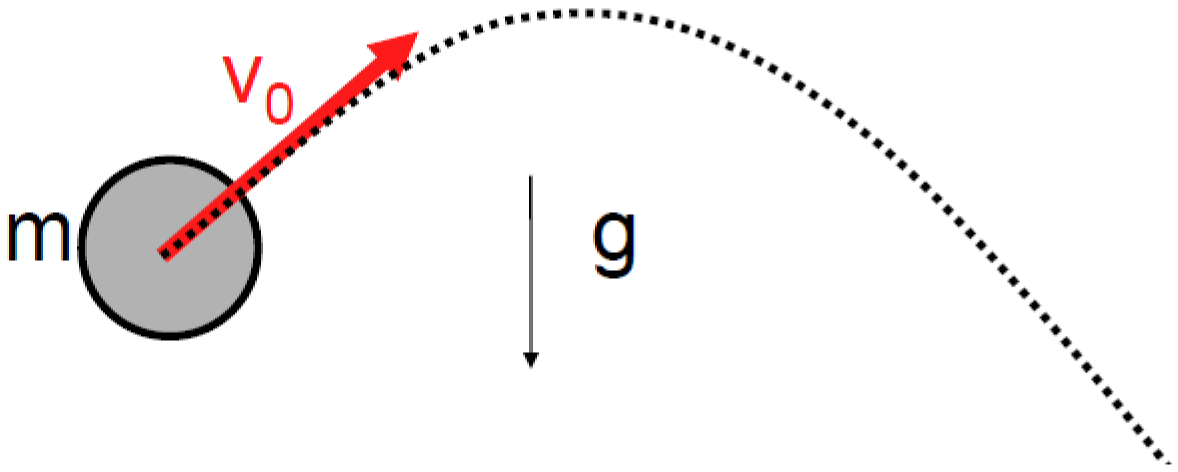
IMocap

- A new technique developed for Pirates of the Caribbean 2 that enabled ILM to capture performance on location while maintaining a relatively small footprint.

Performance Capture

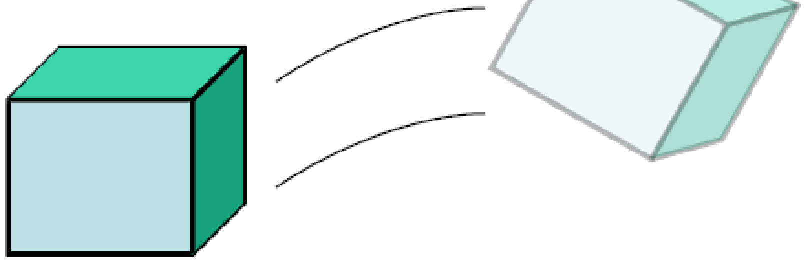
Types of Animation: Physically-Based

- Assign physical properties to objects
  - Masses, forces, etc.
- Also procedural forces (like wind)
- Simulate physics by solving equations of motion
  - Rigid bodies, fluids, plastic deformation, etc.
- Realistic but difficult to control



Types of Dynamics

- Point



- Rigid body
- Deformable body (include clothes, fluids, smoke, etc.)
  - Particle Systems:
    - Smoke, water, fire, sparks, etc.
    - Usually heuristic as opposed to simulation, but not always
    - Mass-Spring Models (Cloth)
  - Continuum Mechanics (fluids, etc.)

Sig02 Melting and Flowing, by Mark Carlson, etc.