WPI

CS 4732:
Computer Animation

Modeling Human Movement

Robert W. Lindeman
Associate Professor
Interactive Media & Game Development
Department of Computer Science
Worcester Polytechnic Institute
gogo@wpi.edu

Modeling Human Movement: It's Hard!

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- We know too well how people move
  - Sometimes they just don't "feel" or "look" right!
- The human body is very complex
  - Many bones -> 200 DOFs!
- Plus
  - Muscles
  - Ligaments
  - Tendons
  - Skin
  - Hair
- Lots of variability too!
  - Genetics, culture, personality, emotional state, ...

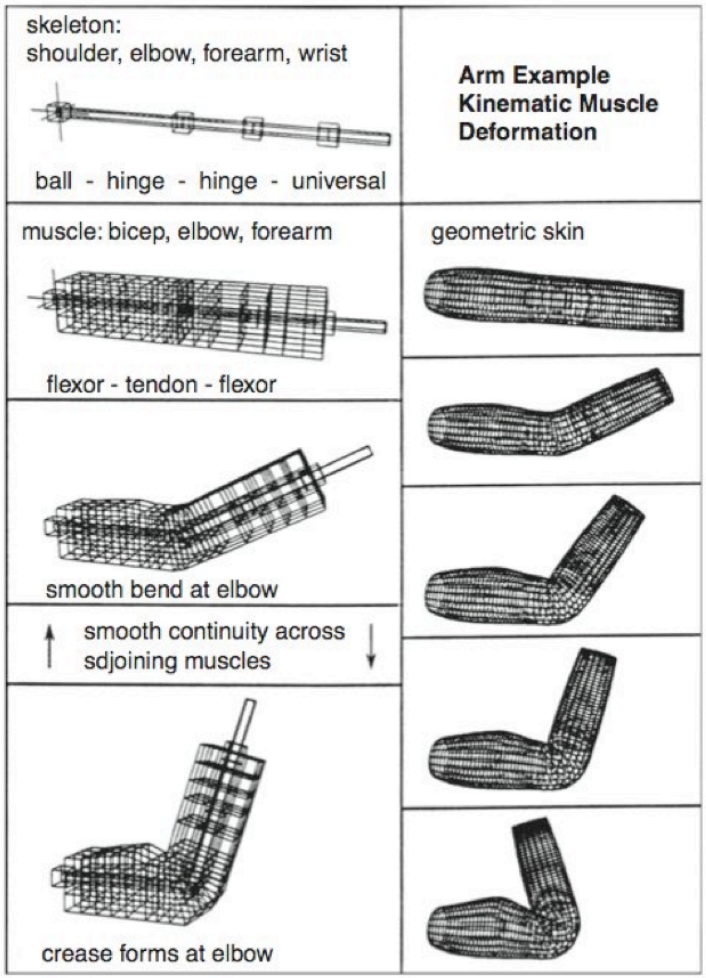
Talking About Humans

- Sagittal Plane
  - Perpendicular to the ground, divides left/right
- Coronal Plane
  - Perpendicular to the ground, divides front/back
- Transverse Plane
  - Parallel to the ground, divides top/bottom
- Distal
  - Away from the body
- Proximal
  - Toward the body
- Flexion
  - Rotation that decreases the angle between bones
- Extension
  - Rotation that increases the angle between bones

Layered Approach

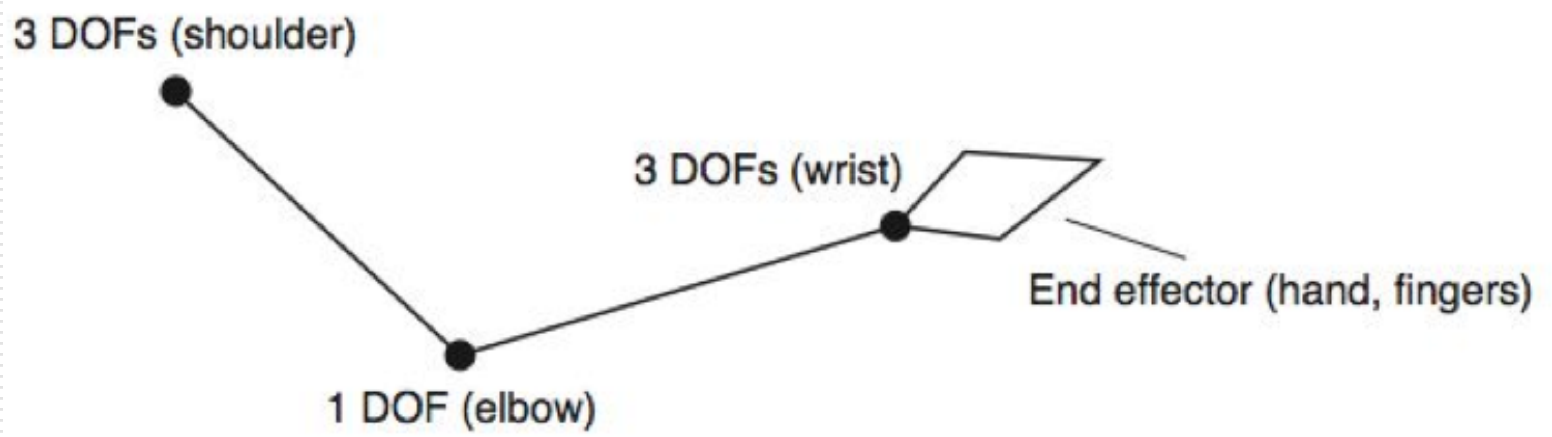
- Model the human like, well, a human
  - Skeleton (bones/rig)
    - Responsible for articulation
    - Rigging:
      - Defining interactive controls for animation
  - Muscles
    - Responsible for deforming the shape, based on bone movement
    - Not anatomically based
    - Defines FFD lattices that deform the skin geometry
  - Skin
    - Carries the appearance of the figure

Muscle FFD


skeleton:
shoulder, elbow, forearm, wrist
ball - hinge - hinge - universal
Arm Example
Kinematic Muscle
Deformation
muscle: bicep, elbow, forearm
flexor - tendon - flexor
geometric skin
smooth bend at elbow
smooth continuity across
sdjoining muscles
crease forms at elbow

Reaching & Grasping

- Arms are often controlled independently from the rest of the body
  - 7 DOFs



  - Forearm roll is faked for simplicity
    - Sometimes wrist, elbow, or other

Reaching & Grasping: Joint Limits

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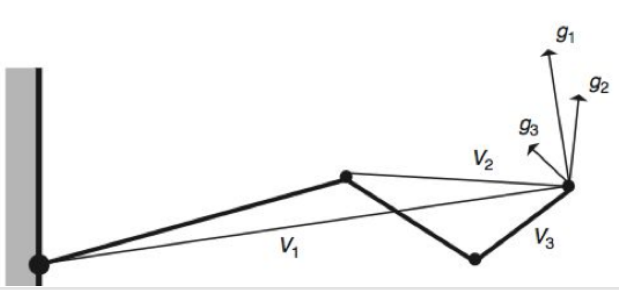
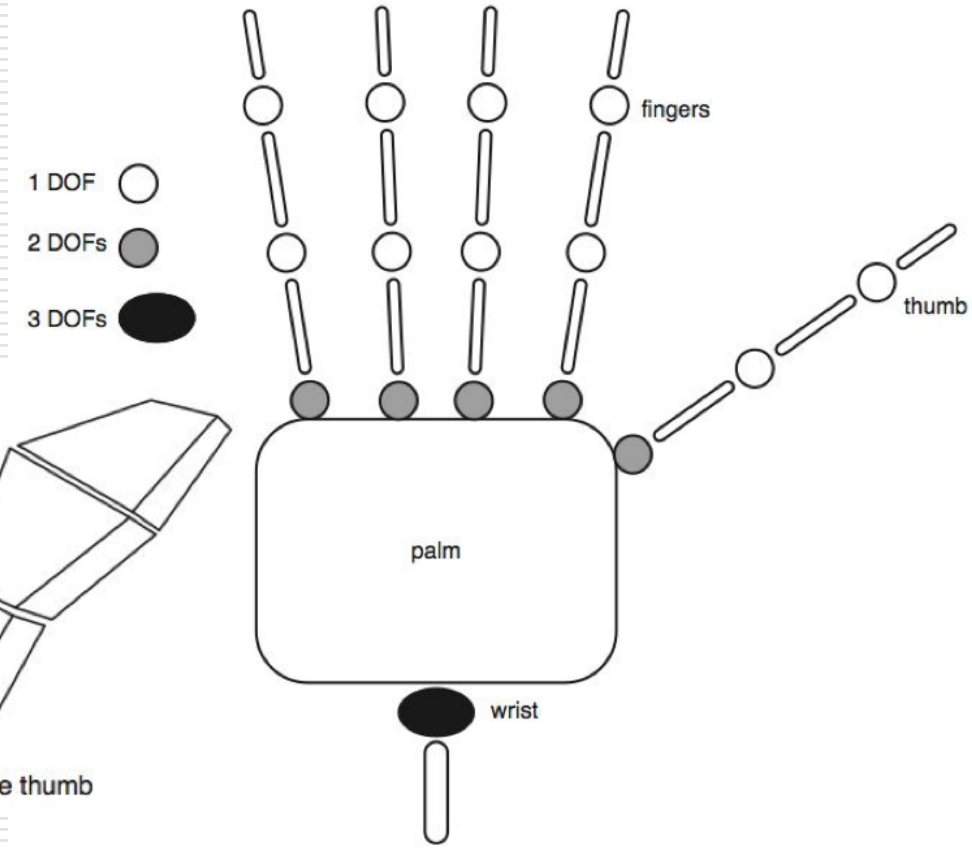
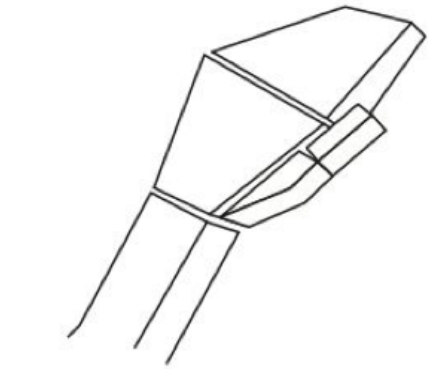
- Movements near/outside of joint limits looks unnatural
  - Some flexion/extension is linked (e.g., touch your toes)
- Enforcing constraints makes forward kinematics more useful
  - Specify several key poses with FK, then interpolate
  - Remember this:



Dexterous Hand

- The hand has MANY DOFs!
- Can simplify



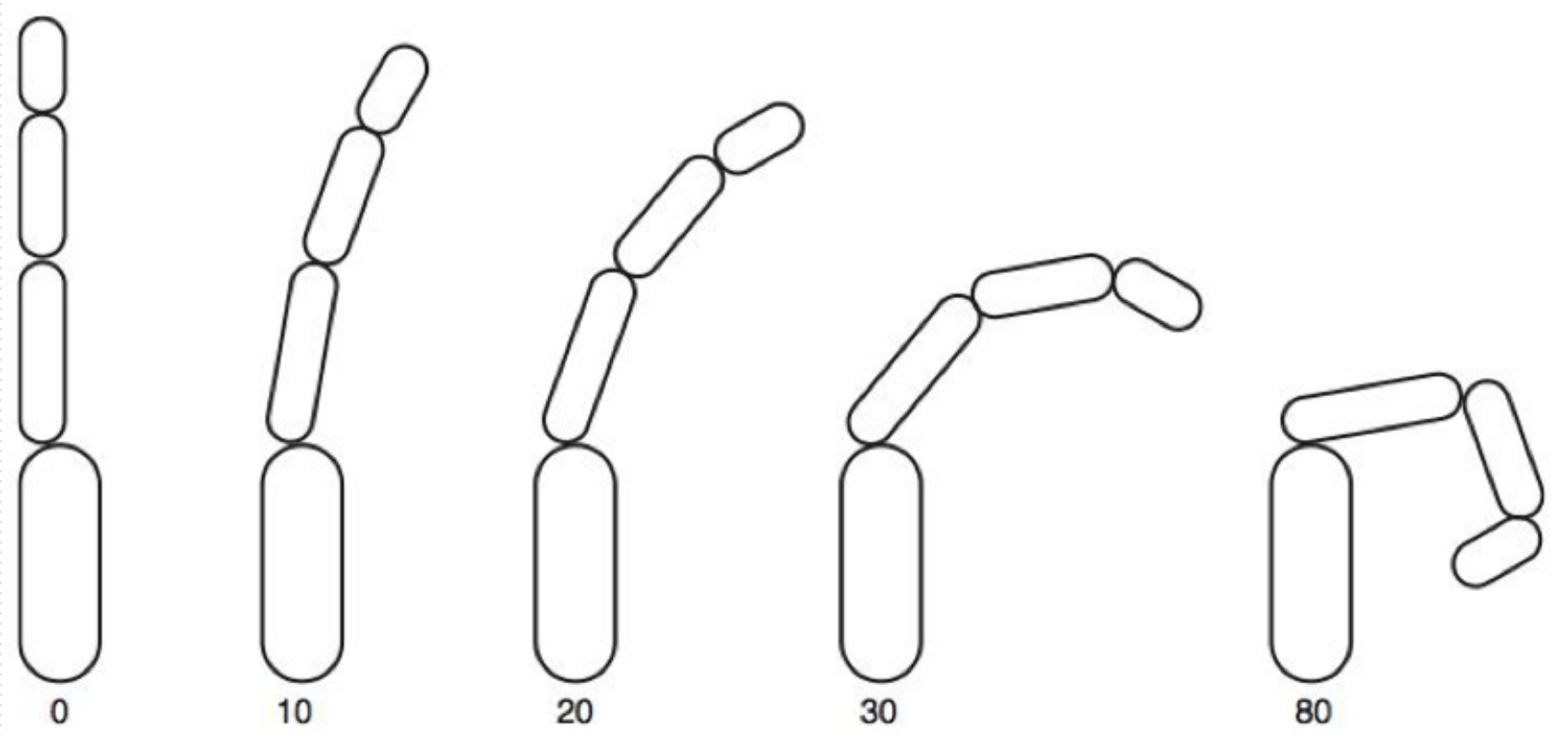


With opposable thumb

Without opposable thumb

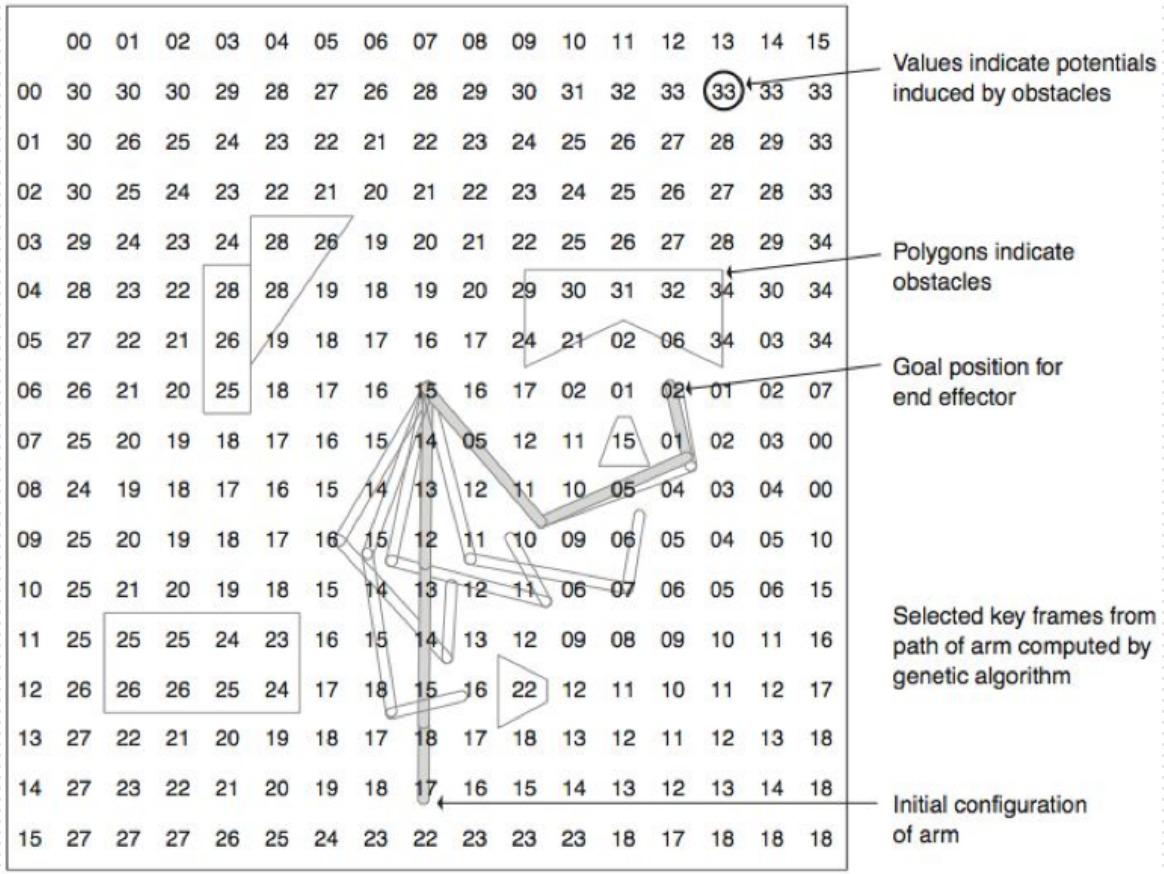
Dexterous Hand (cont.)

- Or coordinate movements



Handling Obstacles

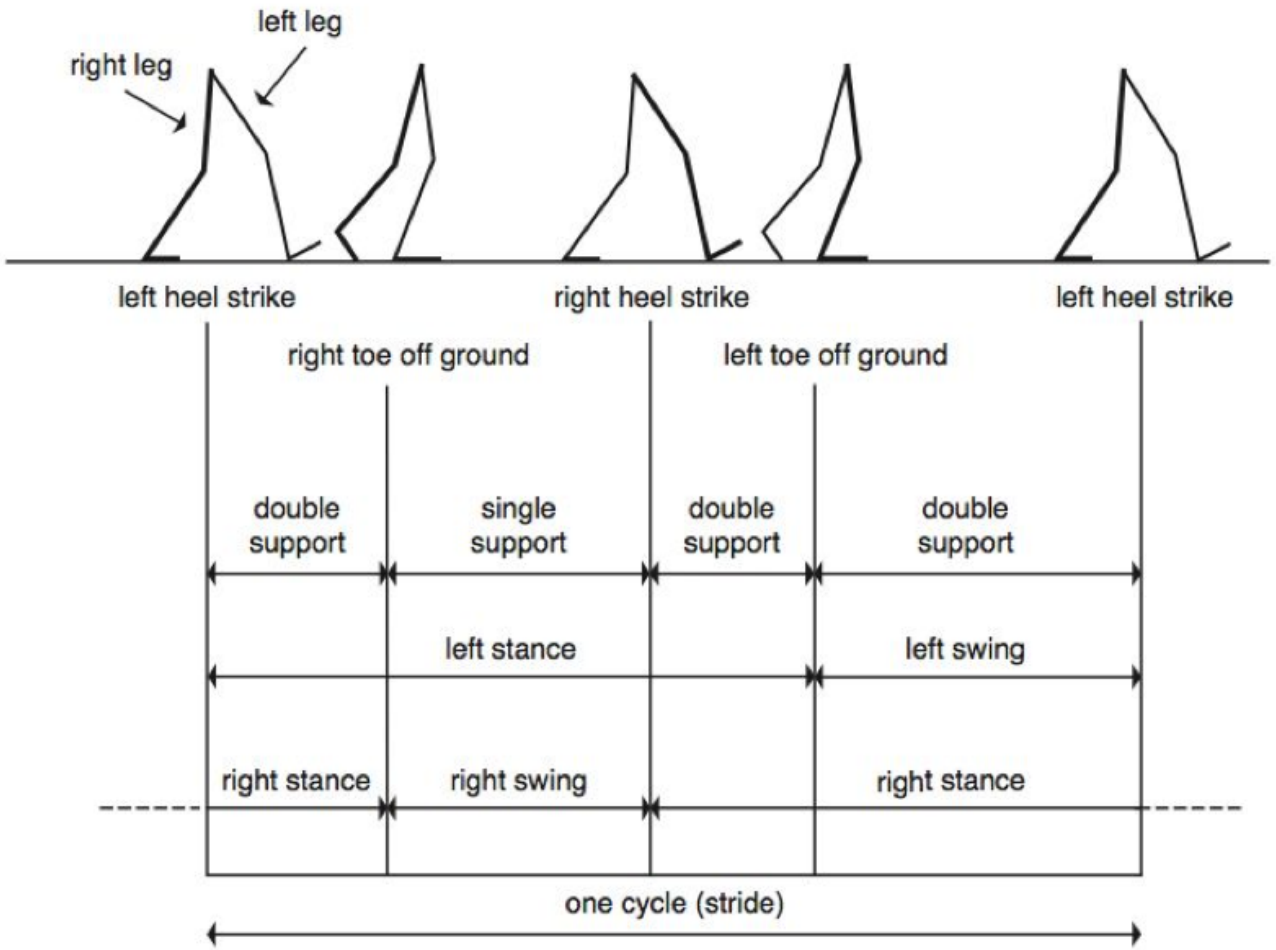
- Can use a gradient search
  - Local min
  - Genetic Algs
  - Too close!



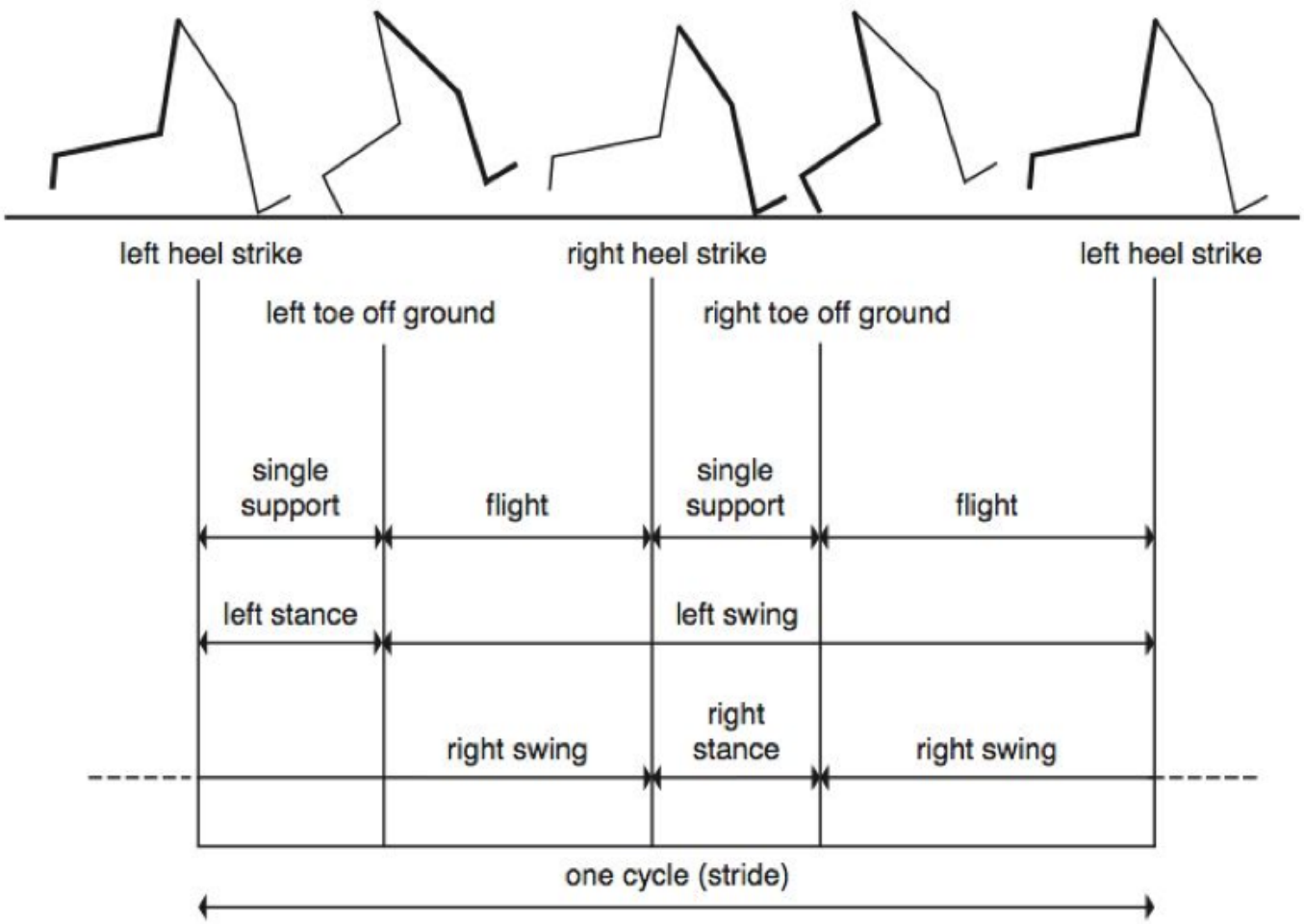
Walk Like an Egyptian

- Differs from reaching because it is cyclic
- Also, needs to carry us
  - Dynamics plays a bigger role
  - Needs to be more "organic"
- Walking is dynamically stable, but statically unstable
- Knowledge of walking motion is necessary
- What makes walking different from running?

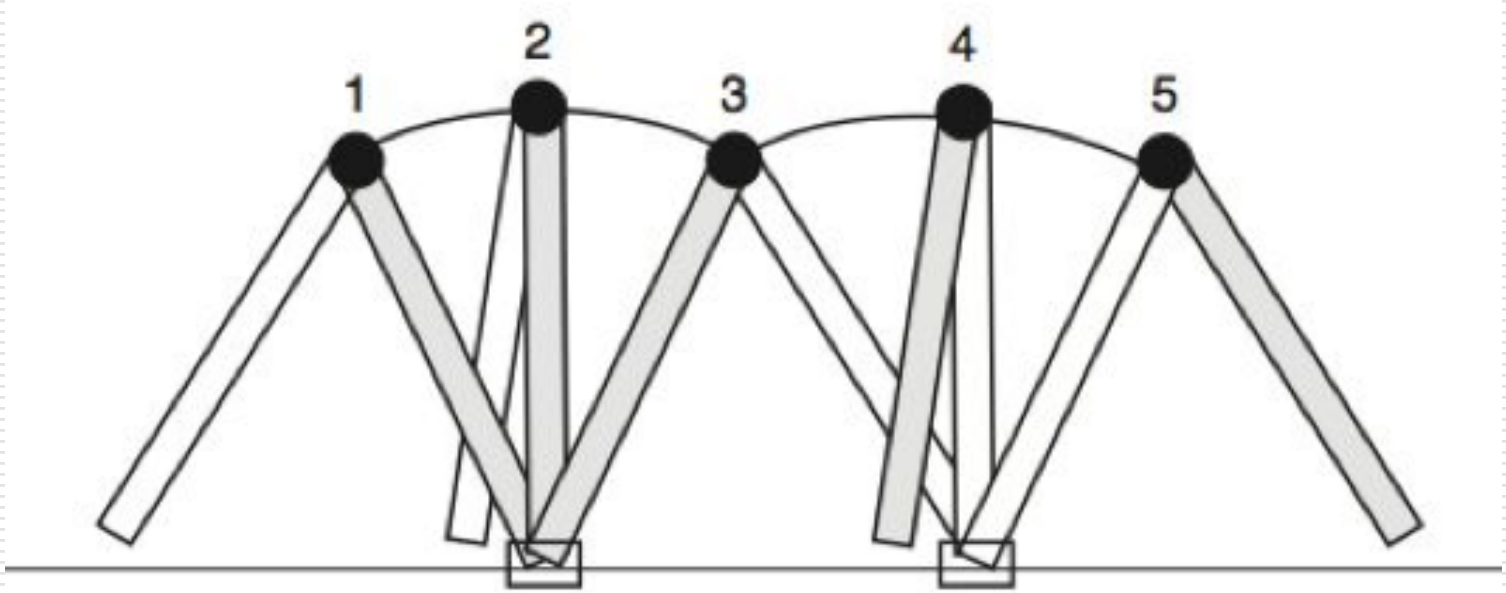
Mechanics of Locomotion: Walk Cycle



Mechanics of Locomotion: Run Cycle

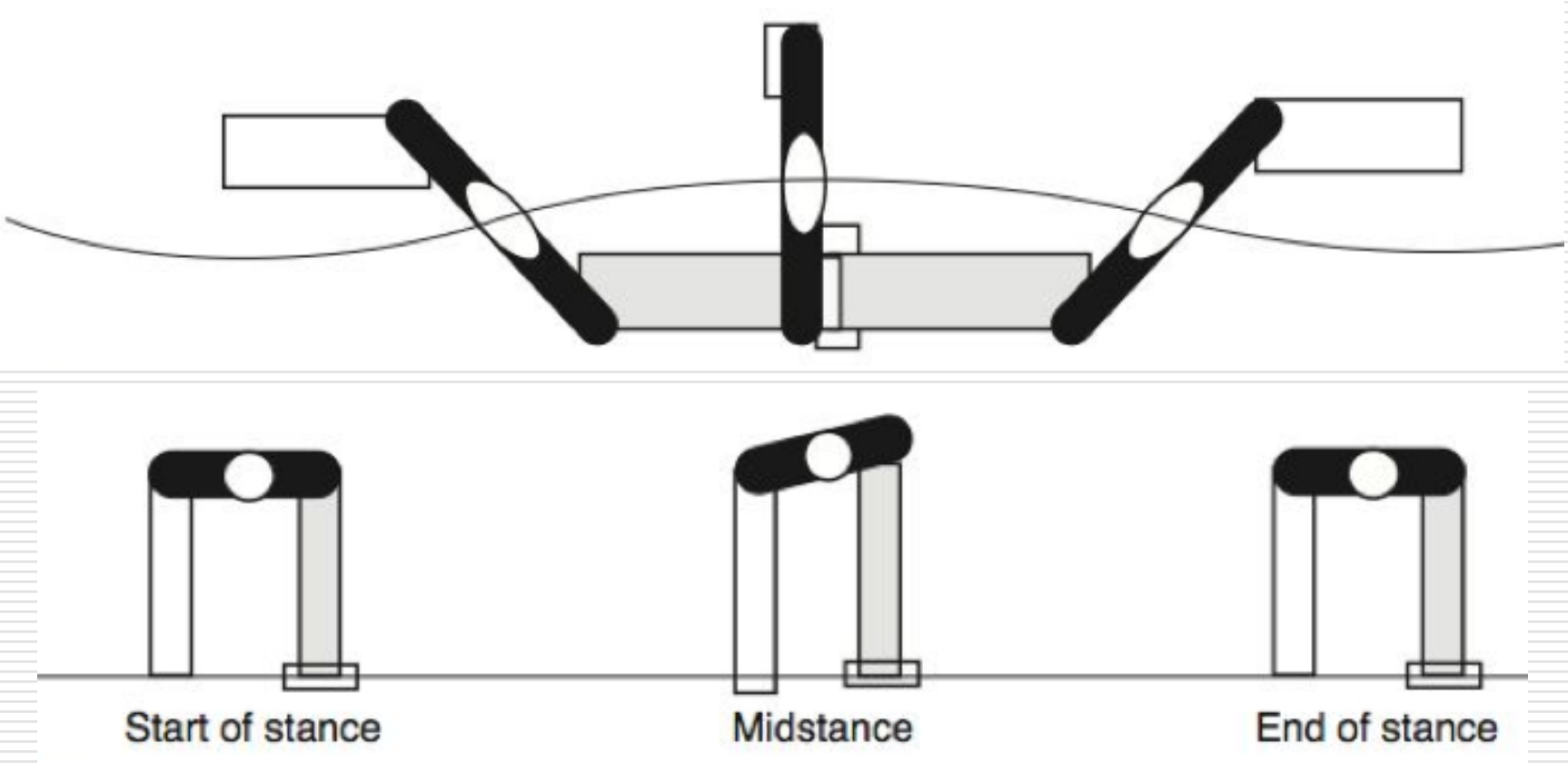


Pelvic Movement



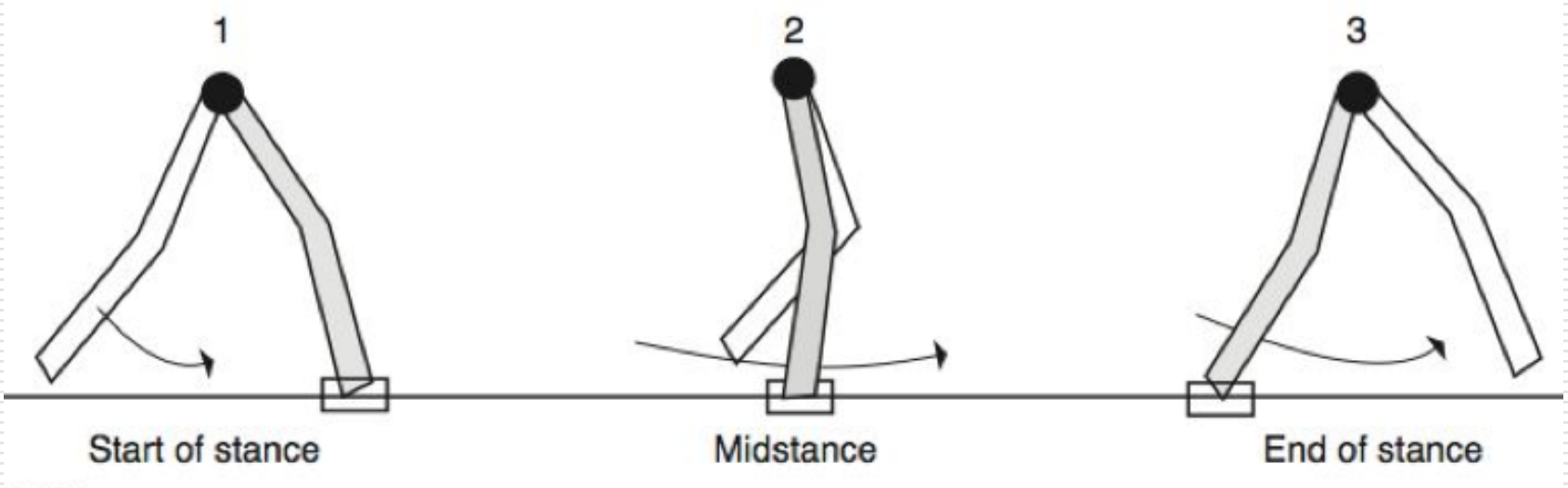
Pelvic Movement (cont.)

- List



Knee Flexion

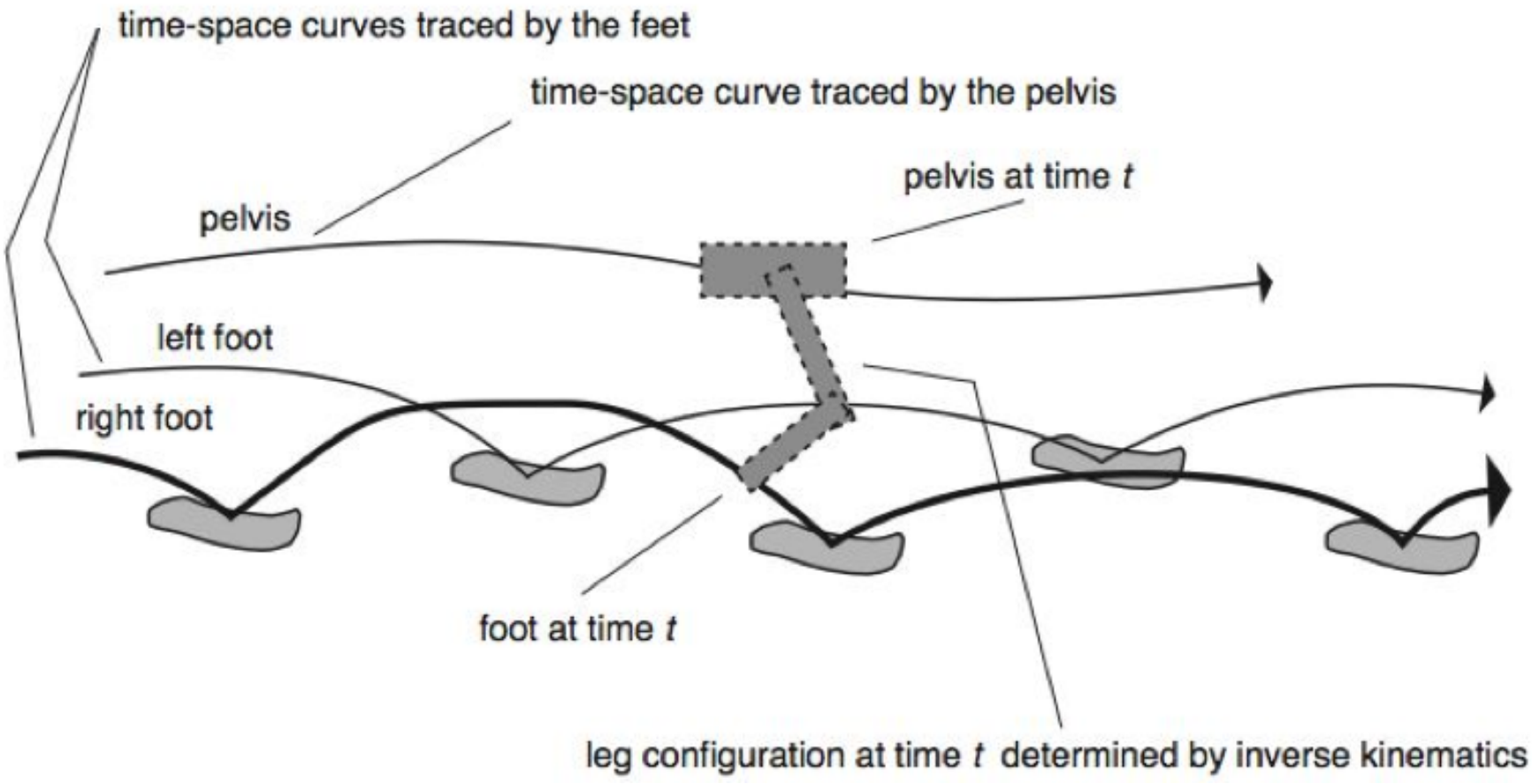
- Can make the swing foot avoid contact



Kinematic Walking

- Walking has
  - Stance phase: From heal strike to toe lift off
  - Swing phase: From toe lift off to heal strike
- One approach:
  - Position pelvis (e.g., using spline)
  - Position feet (e.g., using spline)
  - Orient pelvis according to gate phase
  - Use IK to compute leg joints for foot location
- Animator can get info from many sources
  - Show book

Kinematic Walking (cont.)



Dynamic Walking

- Can add more realism by incorporating dynamics
  - Can cost a lot
- Take some short cuts
  - Simplify the dynamics (e.g., ignore swing leg on balance)
  - Consider forces to be constant over some interval
  - Replace high DOF leg with simple one (e.g., a telescoping leg)
  - Compute horizontal and lateral dynamics separately, then combine

Dynamic Walking (cont.)

- Stance leg provides upper force to the mass of the pelvis
  - Used to control torso dynamics
- Upward force of support leg must cancel downward acceleration of gravity
- To simplify, horizontal motion of the pelvis can be computed separately
  - Consider it to be constant over stance phase

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Hair

- Very complex to model/render
- About 100,000 strands of hair
- Like flexible cylinders
- MANY forces
  - Collisions
  - Stiffness
  - Cohesion

Hair (cont.)

- Other characteristics
  - Wetness
  - Oiliness
  - Cleanliness
  - Split ends

- Three main strand types
  - Asian (mostly straight and stiff)
  - African (mostly curly)
  - Caucasians (somewhere in between)

Modeling & Rendering Hair

- Simple approach
  - Rigid geometry shaped/scaled like hair
  - Add texture/alpha maps to cheaply increase realism
  - Pony-tail style can be added to increase movement cues
- Can also model individually
  - Geometric tubes or particle trails

Modeling & Rendering Hair (cont.)

- Can model as hair mesh

Modeling & Rendering Hair (cont.)

- Or as individual strands

Some Examples

- Bingo:
  - http://www.youtube.com/watch?v=4h-O1R7iXqk
- Activision Movie
- Lots more!