Computer Animation

Lesson 5 - Finite state machines

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Principle 5 - Anticipation

An action occurs in three parts: the preparation for the action, the action proper, and the termination of the action. *Anticipation* is the preparation for the action; the latter two are discussed in the next sections.

There are several facets to Anticipation. In one sense, it is the anatomical provision for an action. Since muscles in the body function through contraction, each must be first be extended before it can contract. A foot must be pulled back before it can be swung forward to kick a ball. [12] Without anticipation many actions are abrupt, stiff and unnatural.

Principle 5 - Anticipation example

2. Anticipation

Motivation: interactive animation in real-time games

- Games require real-time adaptation of animations to the story world
    - hand-crafted animations
    - performance-based animations (motion capture)
- Preserve personality and style of animation while interacting with a physically simulated world and taking orders from player and non player characters (AIs)
- Source: Animation with momentum, David Wu, GDC 2009

Pose control graphs

- A pose control graph is a state machine that has a particular pose associated with each state. The pose represents the desired internal configuration of the creature when the controller is in a particular state.

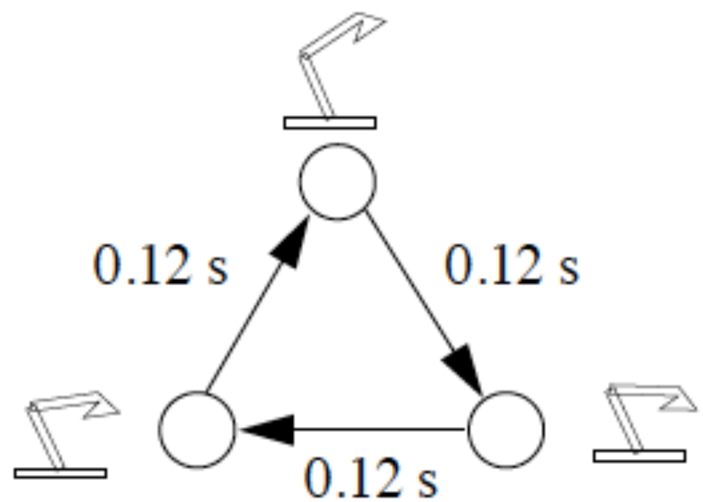


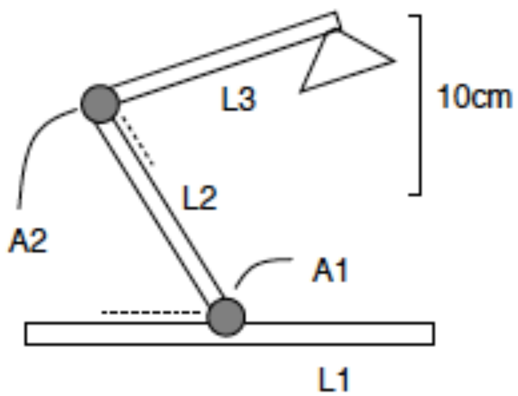
FIGURE 1. A pose control graph for Luxo, an articulated, hopping lamp. The pose for each state defines a desired internal configuration. Transitions between states happen after the time intervals indicated on the arcs.

- A pose creates torques to drive the shape of the creature toward the desired pose. Torques can be created simply using proportional derivative controllers at each joint, i.e. $\tau = k_s(\theta_d - \theta) - k_d\dot{\theta}$,

Source: Virtual windup toys for animation. Van de Panne, Kim and Fiume. GI, 1994.

Pose control graphs

mechanical configuration:



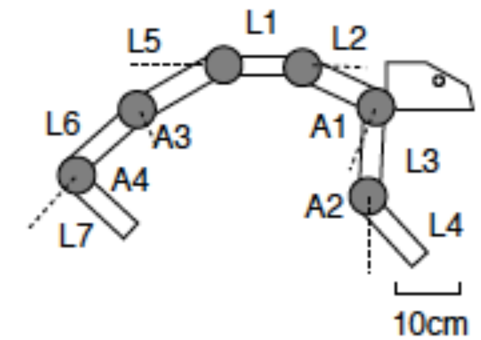
link	mass (kg)
L1	0.05
L2	0.10
L3	0.30

actuators:

act.	min	max	ks	kd
A1	−70	−50	0.05	0.001
A2	60	150	0.04	0.001

FIGURE 4. Luxo, the hopping lamp.

mechanical configuration:



link	mass (kg)
L1	0.30
L2	0.35
L3	0.15
L4	0.10
L5	0.35
L6	0.15
L7	0.10

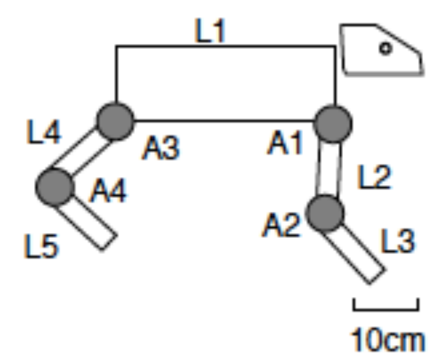
actuators:

act.	min	max	ks	kd
A1	−45	45	0.4	0.01
A2	−90	0	0.4	0.01
A3	40	70	0.4	0.01
A4	−120	−30	0.4	0.01

FIGURE 5. The cheetah creature. There are two joints in the back which have passive spring and dampers. Making the back flexible and allowing it to act as a spring capable of storing energy is important in obtaining natural running motions.

- Controlers and actuators specify internal motor forces acted by an articulated creature
- They are manually crafted as part of the state machine

mechanical configuration:



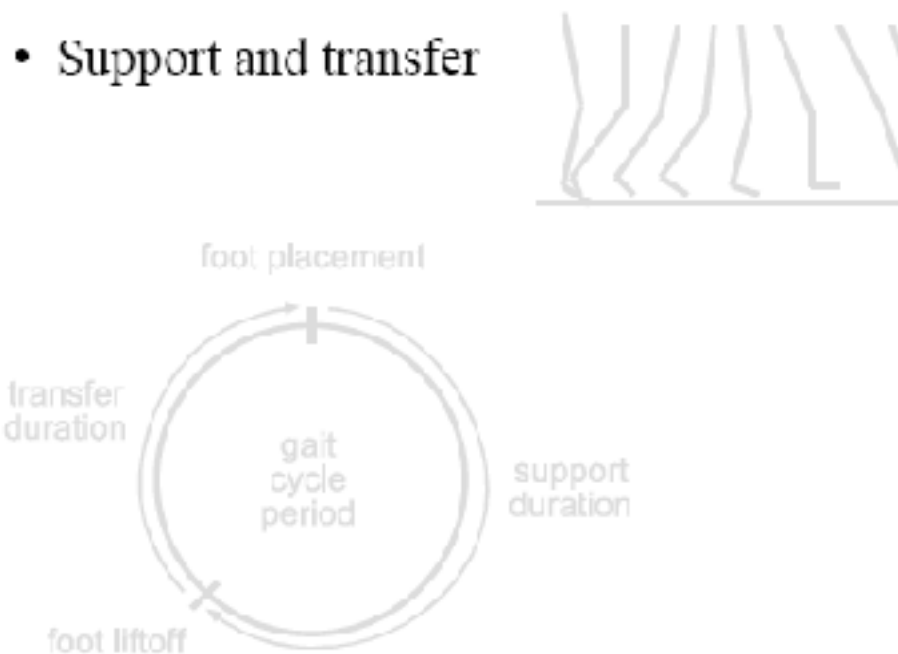
link	mass (kg)
L1	1.0
L2	0.15
L3	0.10
L4	0.15
L5	0.10

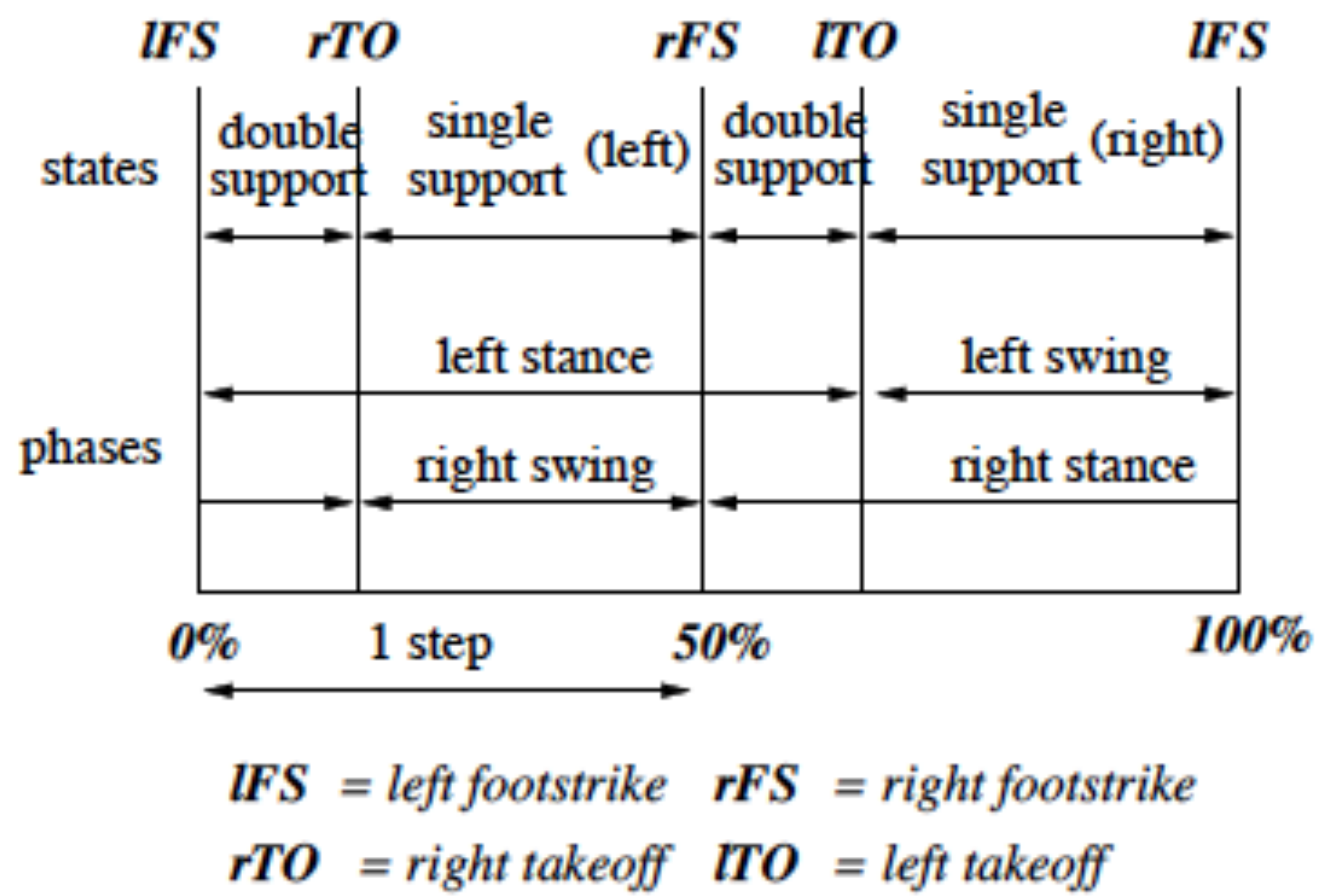
FIGURE 8. The bounder creature. The back is modelled as a single rigid link. The actuators have similar ranges and strengths to those specified for the cheetah.

Case study : animation of walking

- Alternance of support and swing phases
- The legs are coordinated
- The motion is near periodic
- The need for realism is high

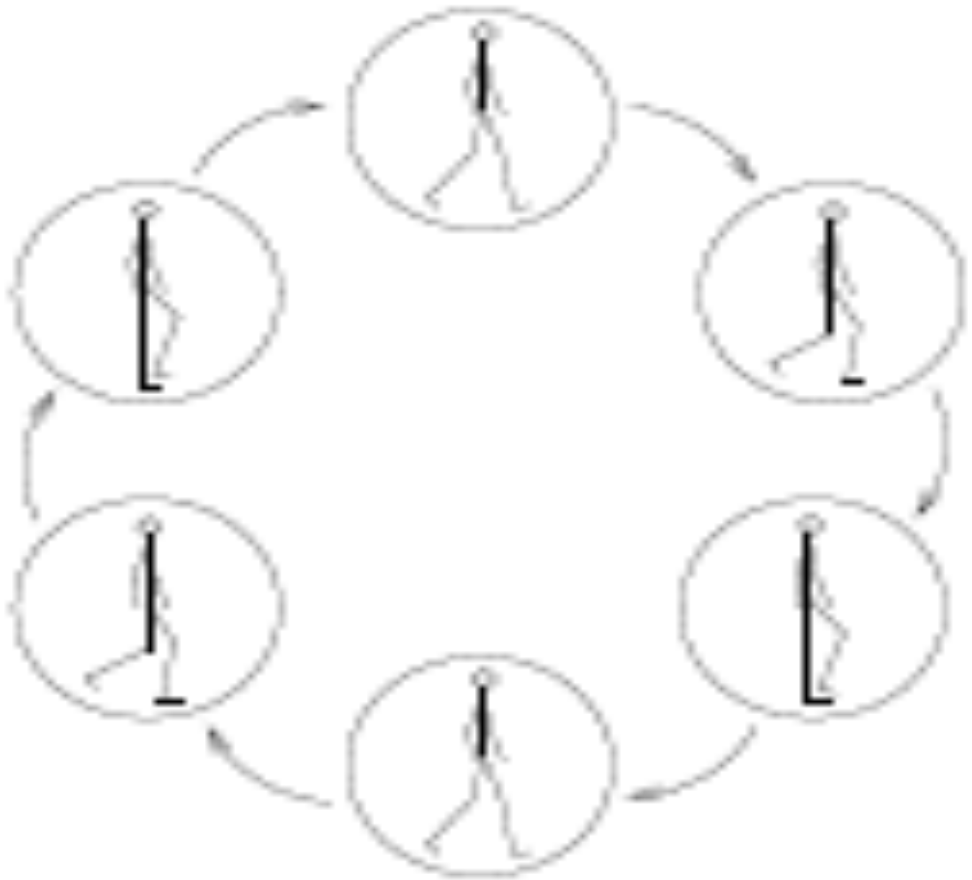
Walking cycle





Source: Computer animation of human walking: a survey, Multon et
1999.

Finite State Machine



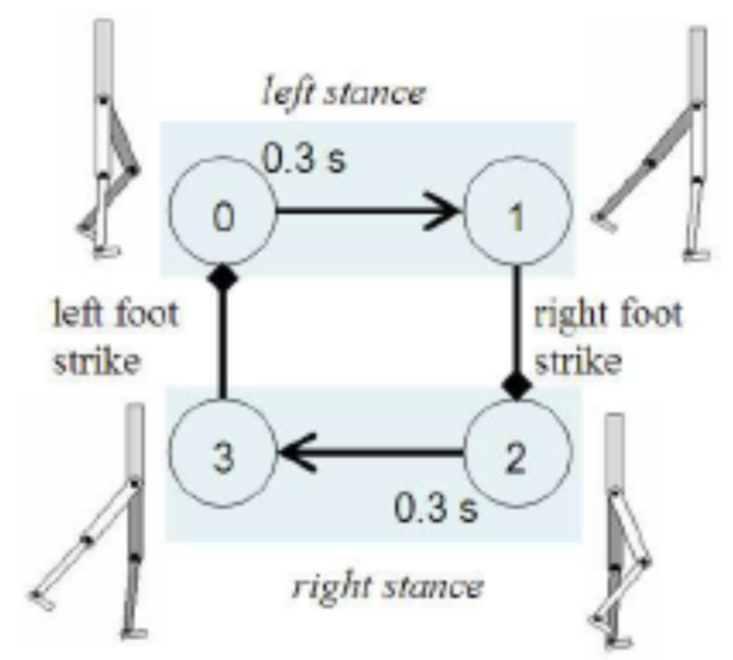


Figure 2: *Finite state machine for walking*

Left: Computer animation of human walking: a survey, Multon et al., 1999. Right: Simbicon, Van de Panne et al,

Contact

- The walk usually starts with the feet at the extended position – where the feet are furthest apart. This is the point where the character's weight shifts to the forward foot.

Recoil

- As the weight of the body is transferred to the forward foot, the knee bends to absorb the shock. This is called the recoil position, and is the lowest point in the walk.

Passing

- This is halfway through the first step. As the character moves forward, the knee straightens out and lifts the body to its highest point. This is called the passing position because this is where the free foot passes the supporting leg.

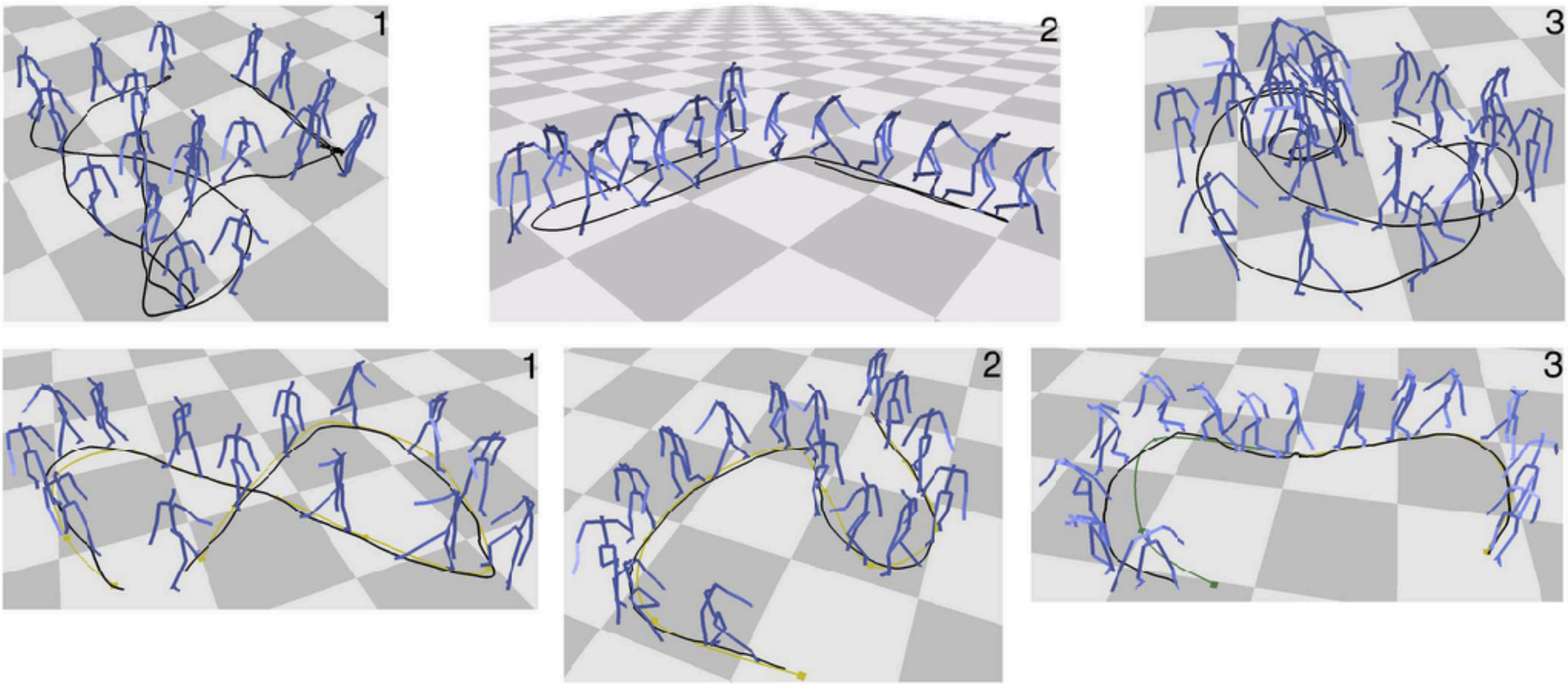
High point

- As the character moves forward, the weight-bearing foot lifts off the ground at the heel, transmitting the force at the ball of the foot. This is where the body starts to fall forward. The free foot swings forward like a pendulum to catch the ground.

Contact

- The free leg makes contact. This is exactly half the cycle. The second half is an exact mirror of the first. If it differs, the character may appear to limp.

From motion capture data to finite state machines



Kovar, Gleicher, Pighin. Motion graphs, Siggraph , 2002

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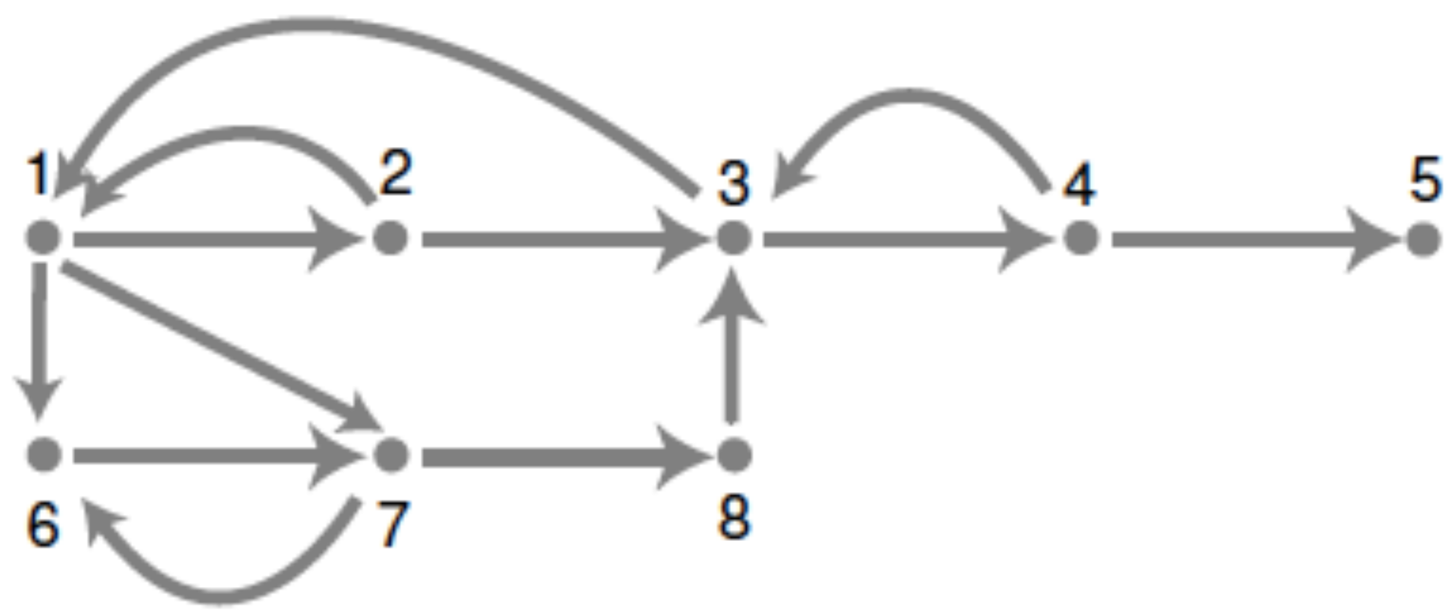

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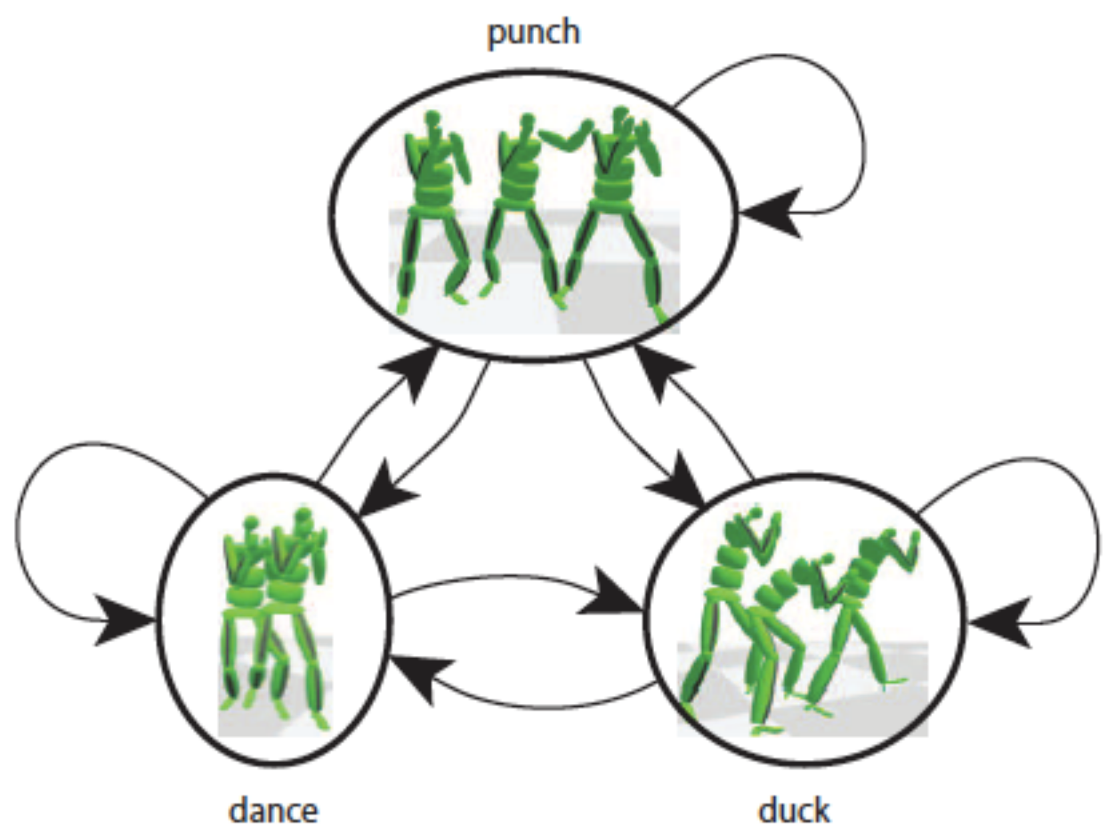

Figure 6: A boxing graph.

Heck and Gleicher. Parametric motion graphs, I3D , 2007

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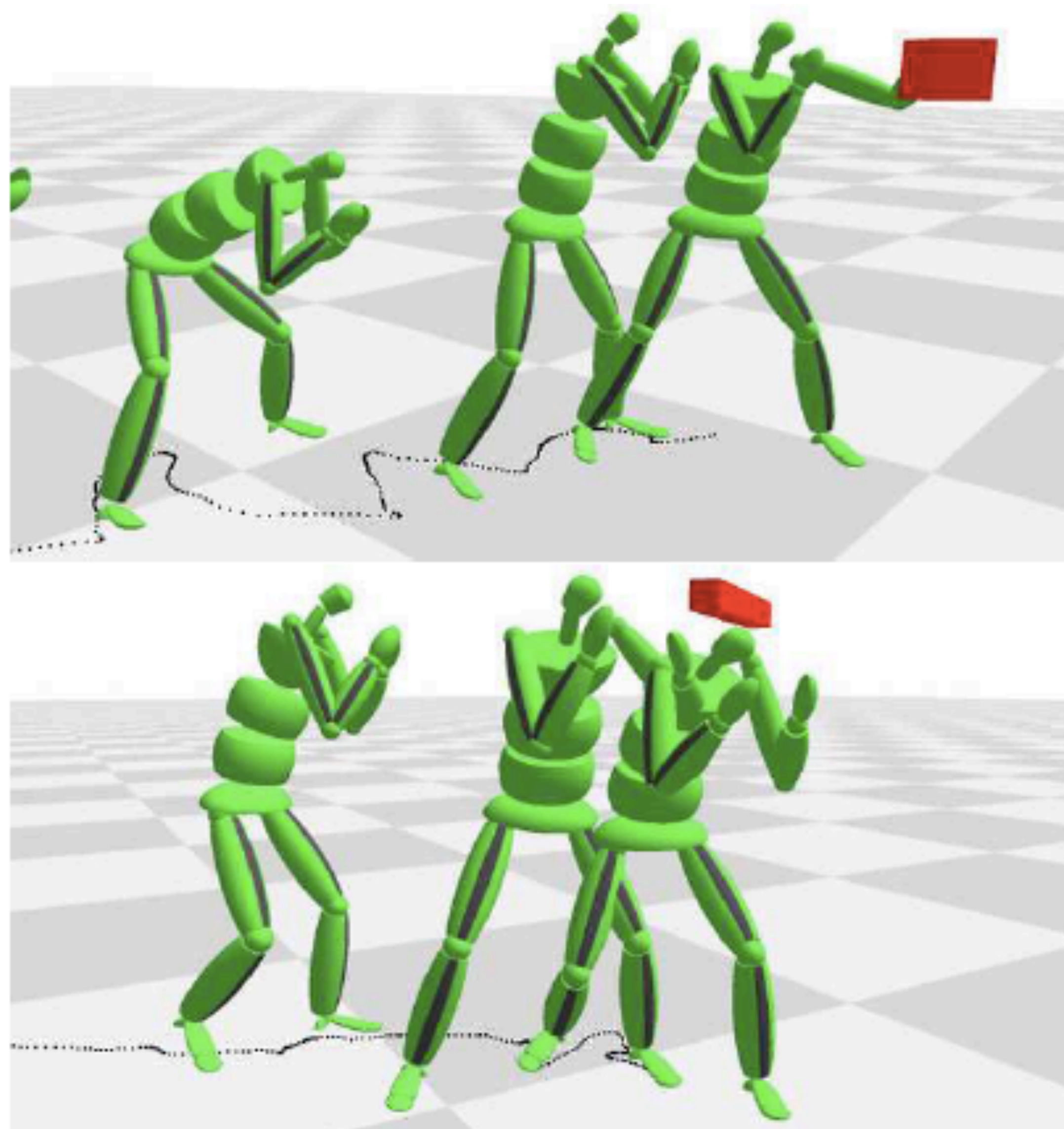

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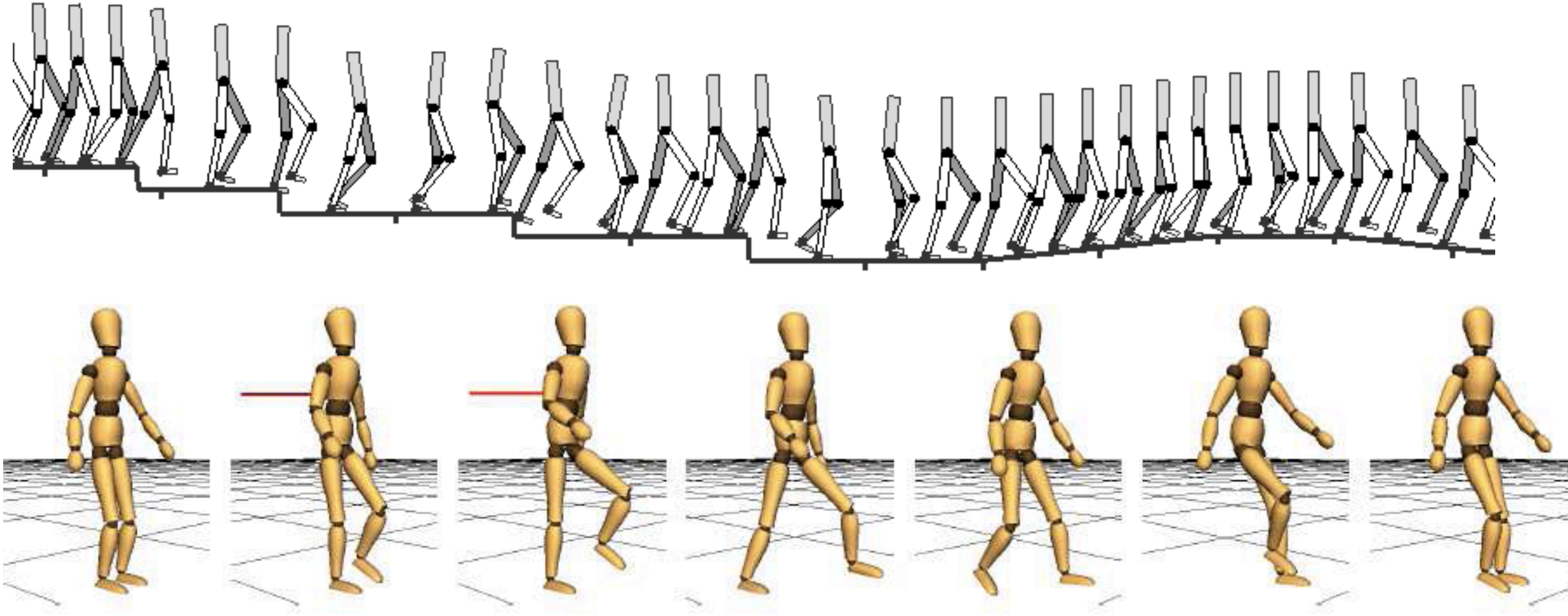
Paper 5 - SIMBICON: Simple Biped Locomotion Control (2007)



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