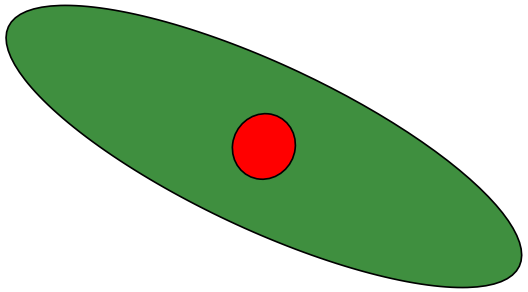
Motion Capture

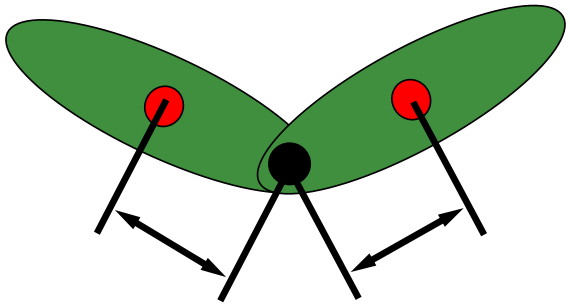
What do we need to know?

- x, y, z
- pitch, roll, yaw



Errors cause

- joints to come apart
- links to grow/shrink
- bad contact points



Sampling Rate and Accuracy

Motion Capture

Goals

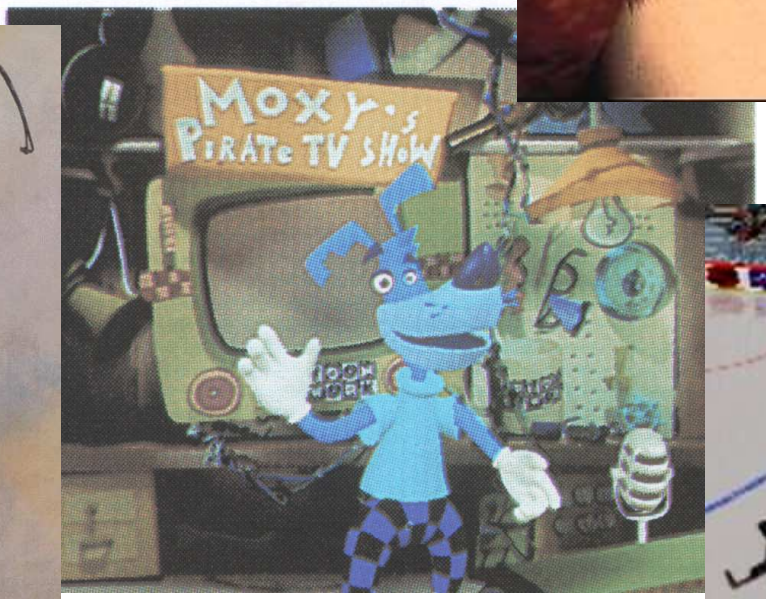
- realistic motion
- lots of different motions (300–1000)
- contact

Appropriate game genres

- sports
- fighting

Applications

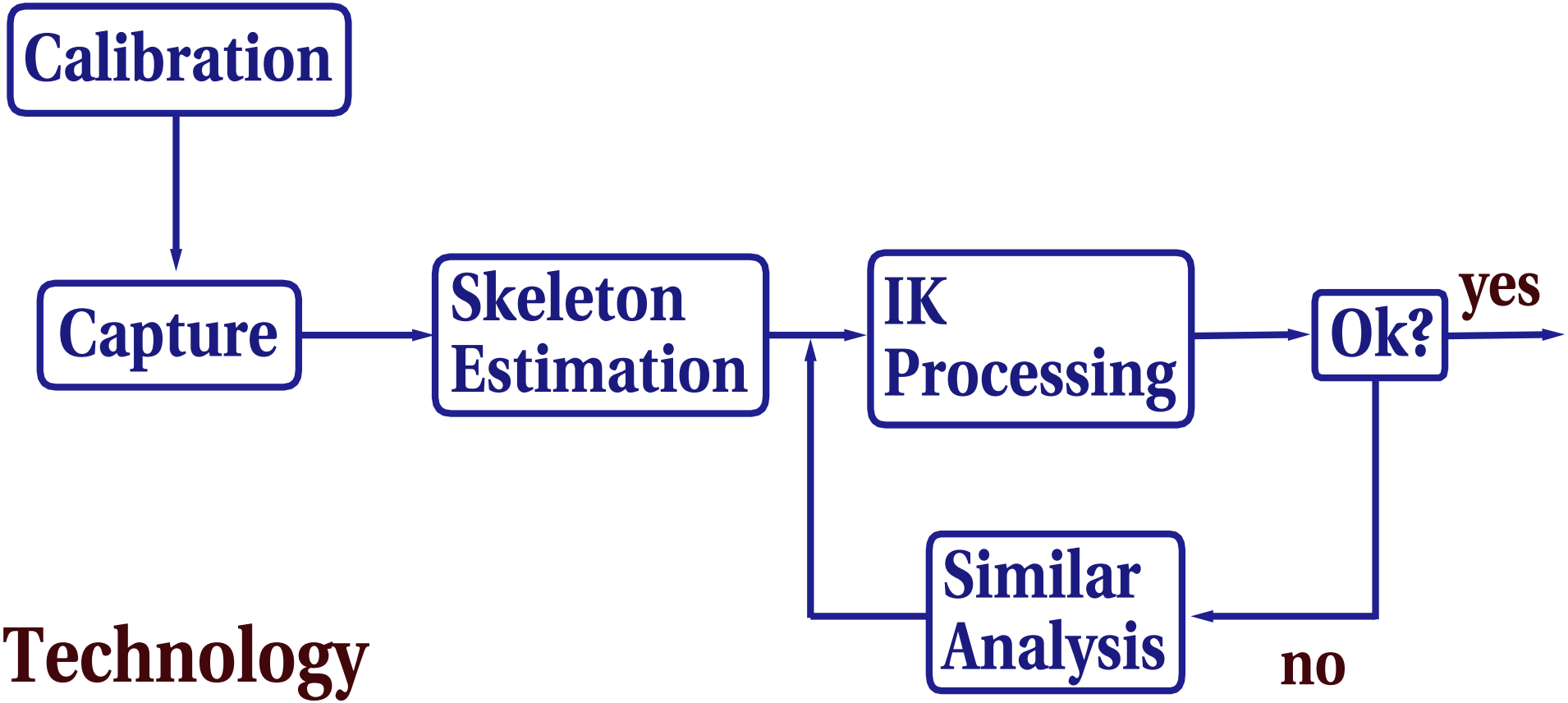
- movies
- tv shows
- video games
- performance animation



History

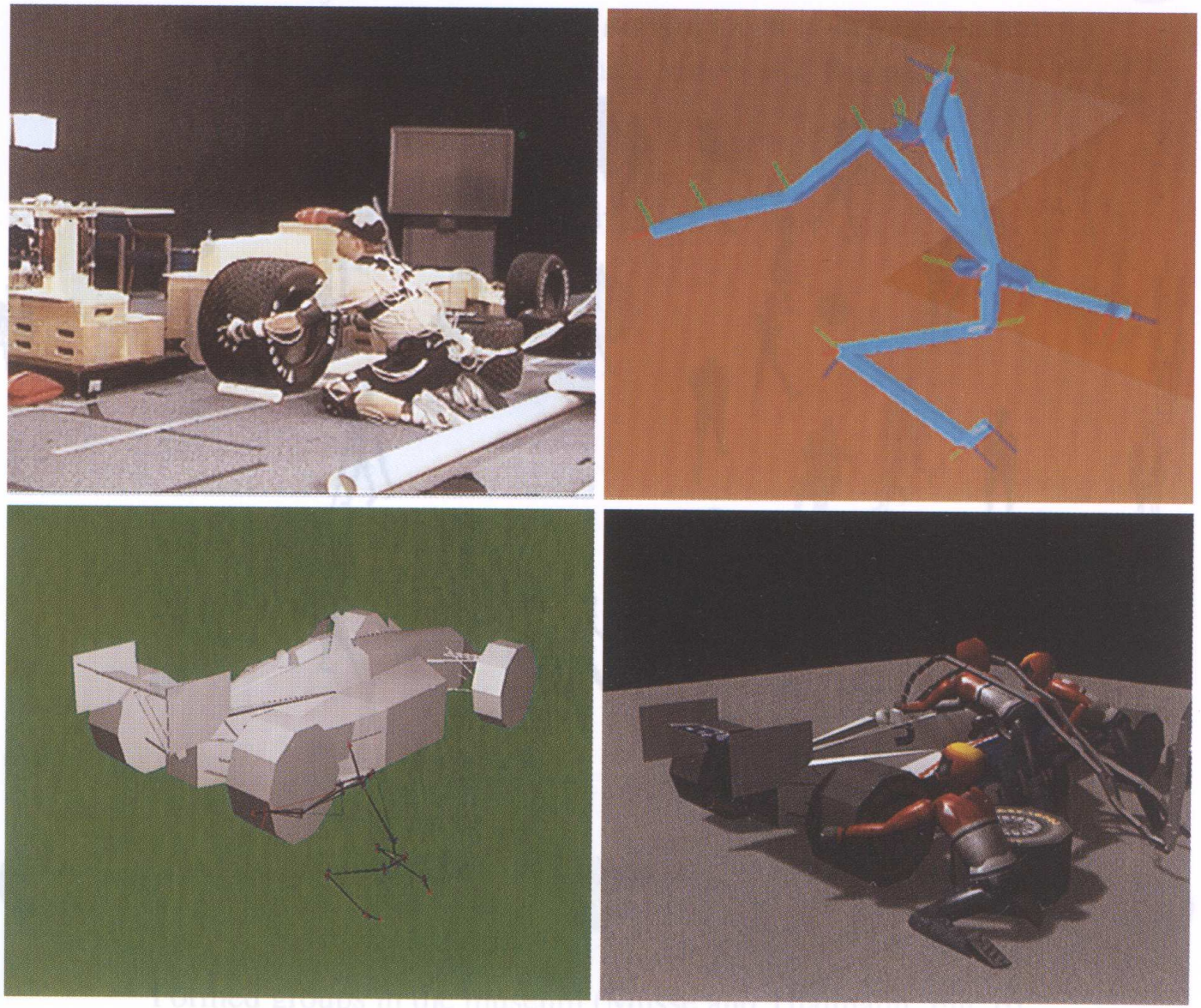
- recording motion for biomechanics
  - high accuracy
  - fewer recorded points
  - hand digitizing film
  - supplement with force plate, foot switches
- robot measurements
  - Selspot LED system
- computer animation
  - blue screen
- VR tracking technology
  - less accuracy
  - fewer sensors

Production Pipeline



Technology
Calibration
Skeleton Estimation
Remaining Issues: modifying and controlling

Production Pipeline



Various phases of the motion capture process (Bodenheimer et al., Fig. 11)

Plan out Shoots Carefully

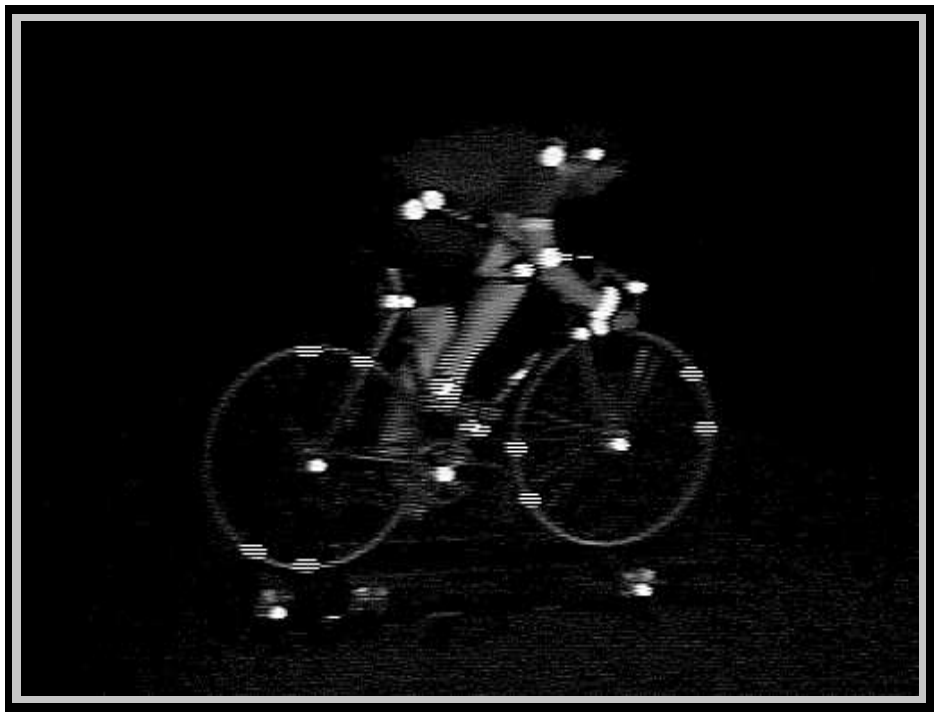
- know needed actions
  - bridges between actions
  - speed of actions
- hire the right actor
- marker/sensor placement
  - capture enough information
  - watch for marker movement
- check data part way through shoot
- videotape everything

Technology

passive reflection––Peak

hand or semi–automatically digitized
time consuming

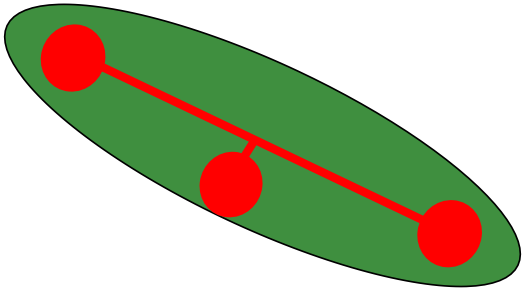
no glossy or reflective materials
tight clothing
occlusion of markers by props
higher frames/second

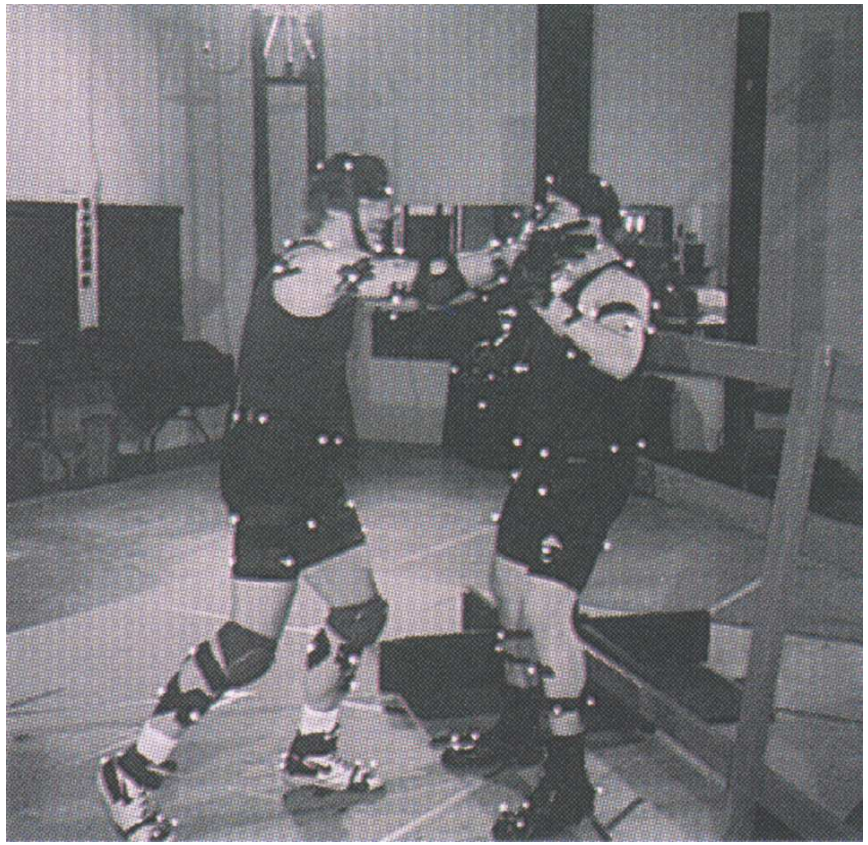


Technology

passive reflection––Acclaim, Motion Analysis,...

automatically digitized
240 Hz
not real–time
3+ markers/body part for 6 dof
2+ cameras for 3d position data

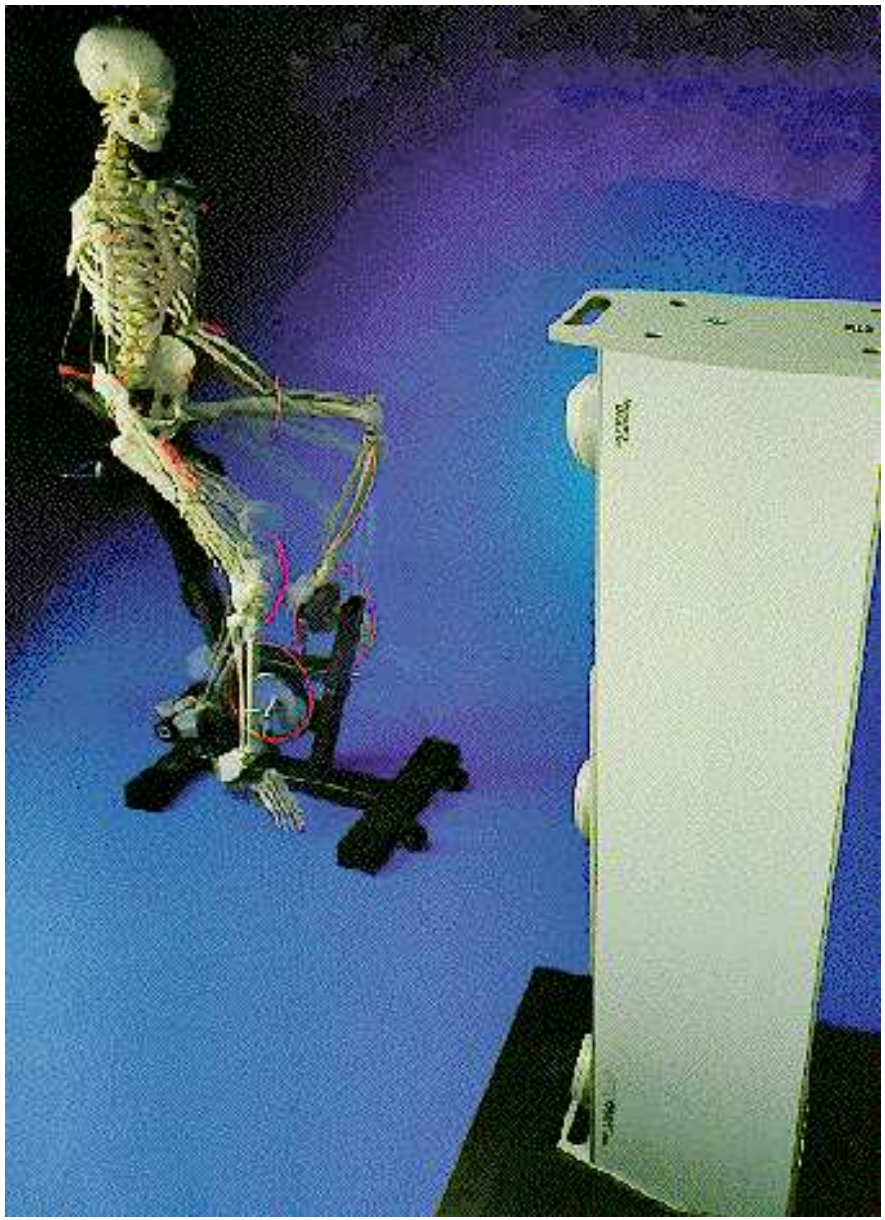




Technology

active light sources –– Optotrak

automatically digitized correspondence
256 markers
3,500 markers/second

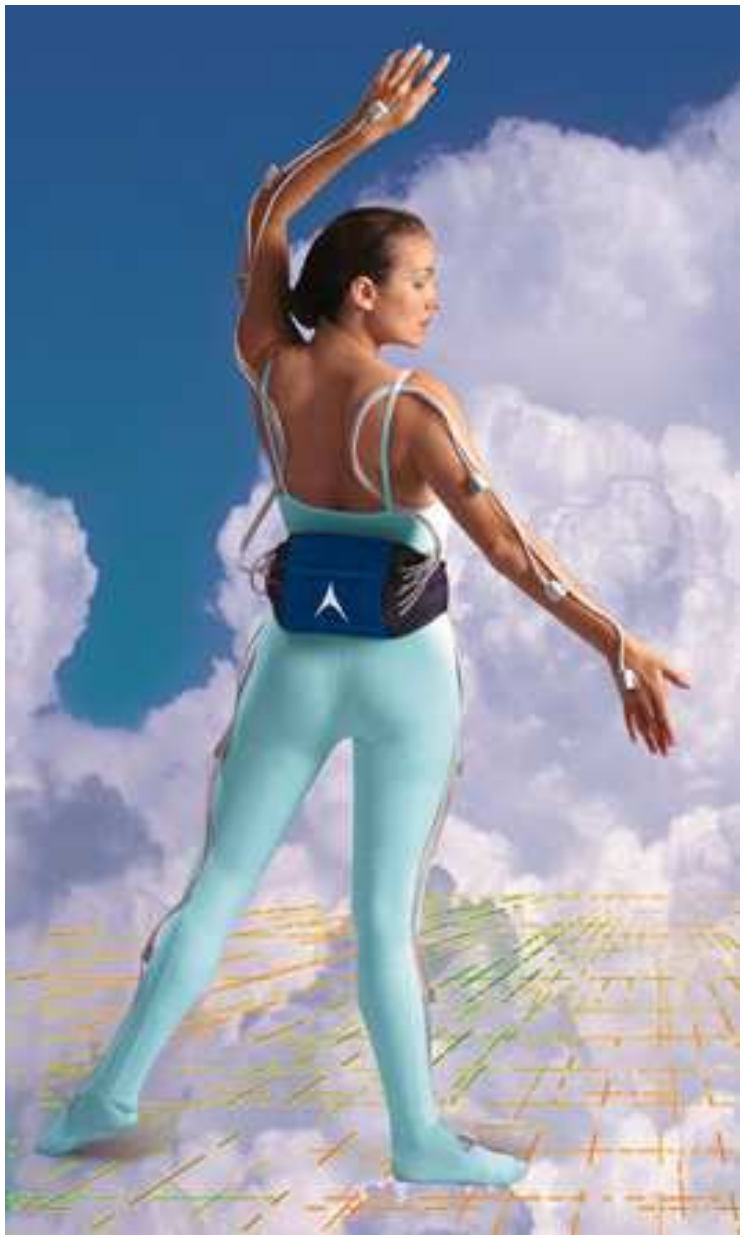


Technology

electromechanical transducers

- Accension flock of birds
- Polhemus Fastrak

limited range/resolution
pigtail (new wireless system)
metal in the environment
(treadmill, rebar!)
no identification problem
6 dof information
realtime
lower frequency: 30 to 144 Hz
few markers: ~13–18

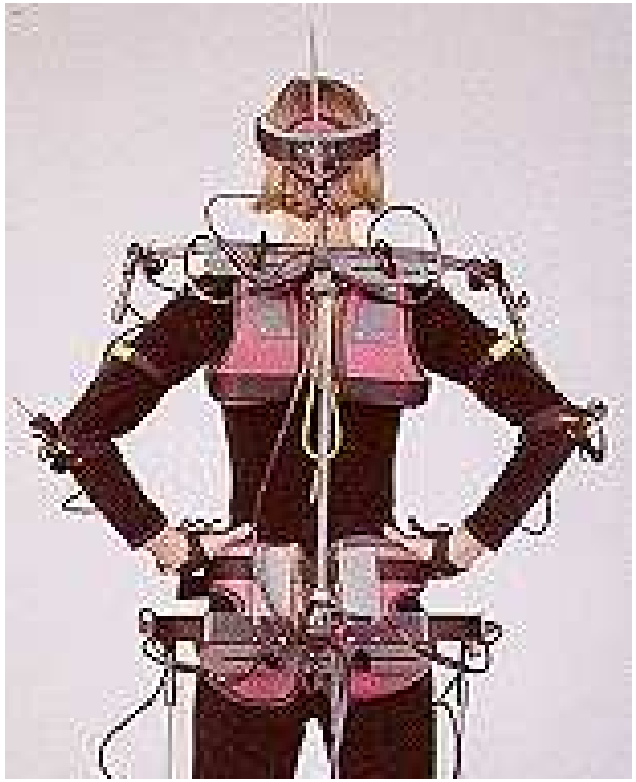


Technology

exoskeleton + angle sensors

Analogous

pigtail
no identification problem
realtime
high frequency: 500Hz
not range limited
fit
rigid body approximation



Technology

mechanical motion capture

dataglove

low accuracy
focused resolution

monkey

high accuracy
high data rate
not realistic motion
no paid actor

Technology Issues:

- resolution/range of motion
- calibration
- accuracy
- occlusion/correspondence

Animation Issues:

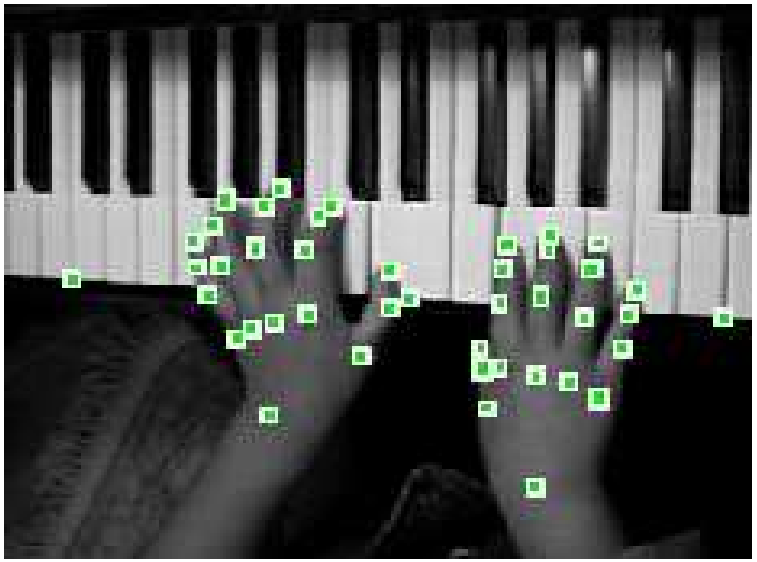
- style
- scaling
- generalization

Technology Issues:

- resolution/range of motion
- calibration
- accuracy
  - marker movement
  - sensor noise
  - skew in measurement time
  - restrictions on the environment
  - frame rate
- occlusion/correspondence

Resolution

positioning of camera

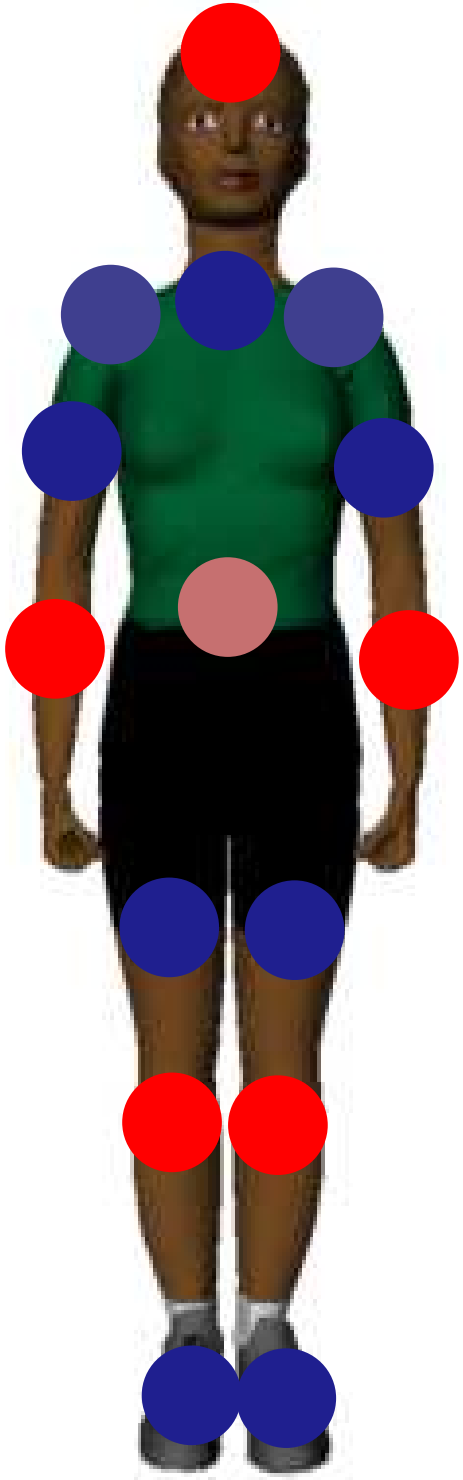


Marker Placement

location should move rigidly with joint

stay away from bulging muscles

shoulders: skeletal motion not closely tied to motion on skin



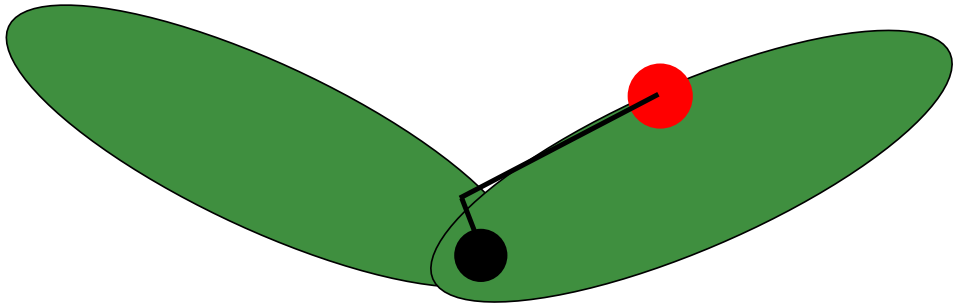
Calibration

zero position
fine calibration by hand

Finding Joint Locations

move markers to joint centers

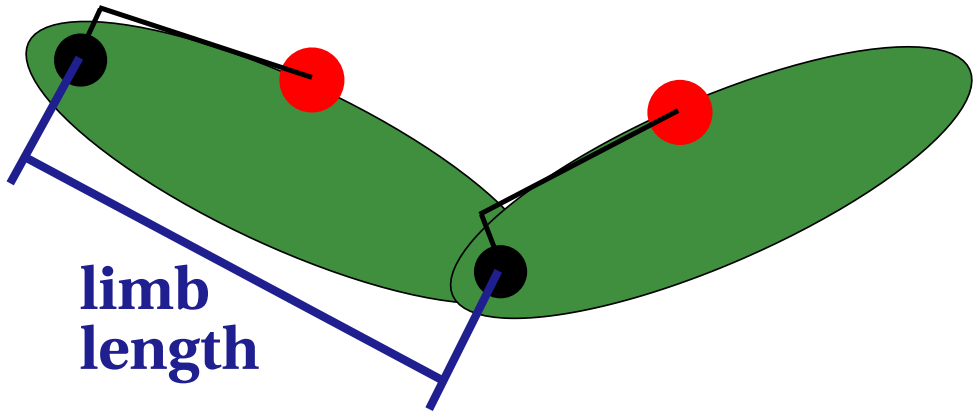
assume rigid links, rotary joints



shoulder?

Extract Best Limb Lengths

use estimator to compute limb length



minimize or reject outliers

508 frames of walking
6 bad frames
hand editing: 13.3cm collar bone–>shoulder
estimator: 13.2cm
arithmetic mean: 14.1cm

IK for Joint Angles

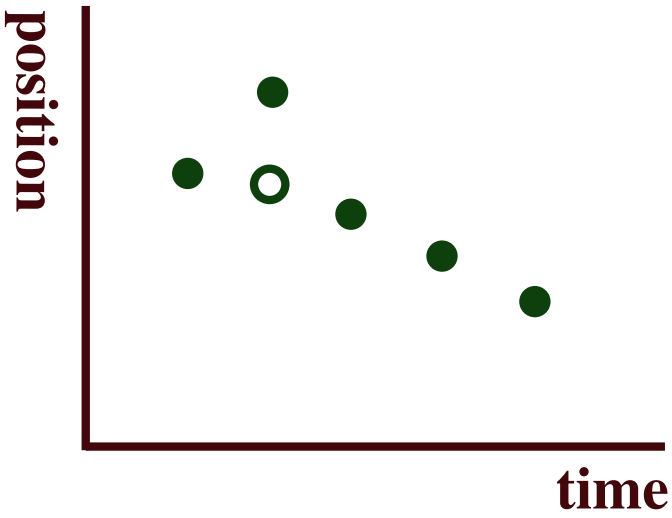
non–linear optimization
joint angles should be smooth
to allow resampling
minimize deviation between
recorded data and model

$$F(\theta) = \text{sum}\ (w_p(P-P')^2 + w_o(O-O')^2 + w_c c^2)$$

Accuracy

- marker movement
- sensor noise
- skew in measurement time

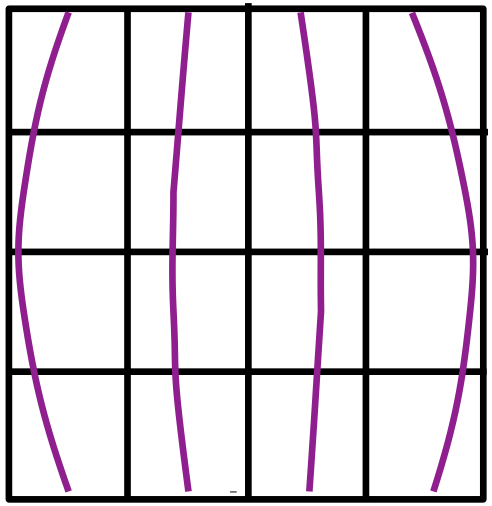
- filtering (requires high data rate)



Camera Calibration

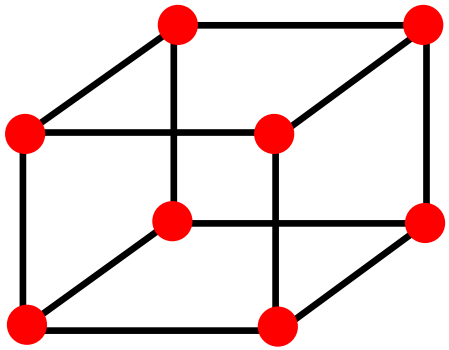
internal camera parameters

optical distortion of lens



external parameters

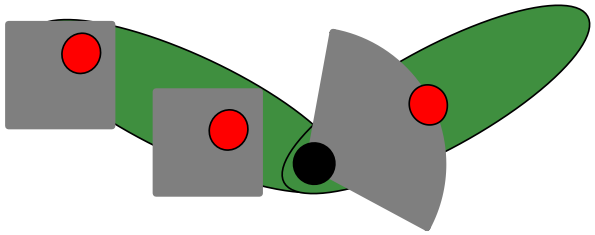
position and orientation



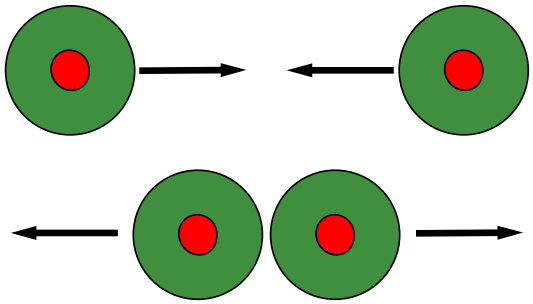
correlation between multiple cameras

Model–based Techniques

restricted search space for markers



objects don't pass through each other



no infinite accelerations

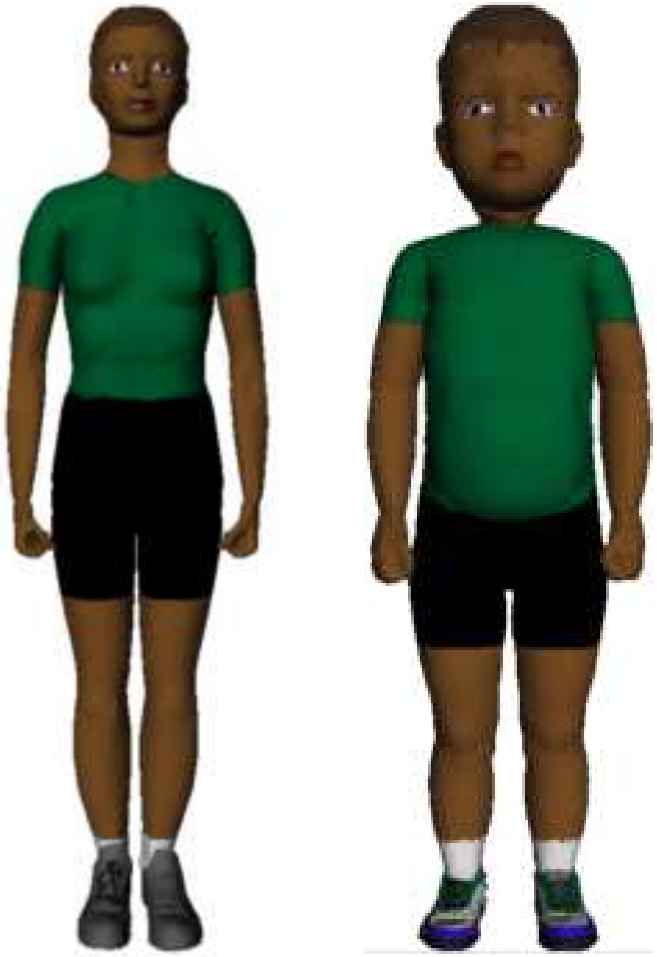
model of bodies for occlusion

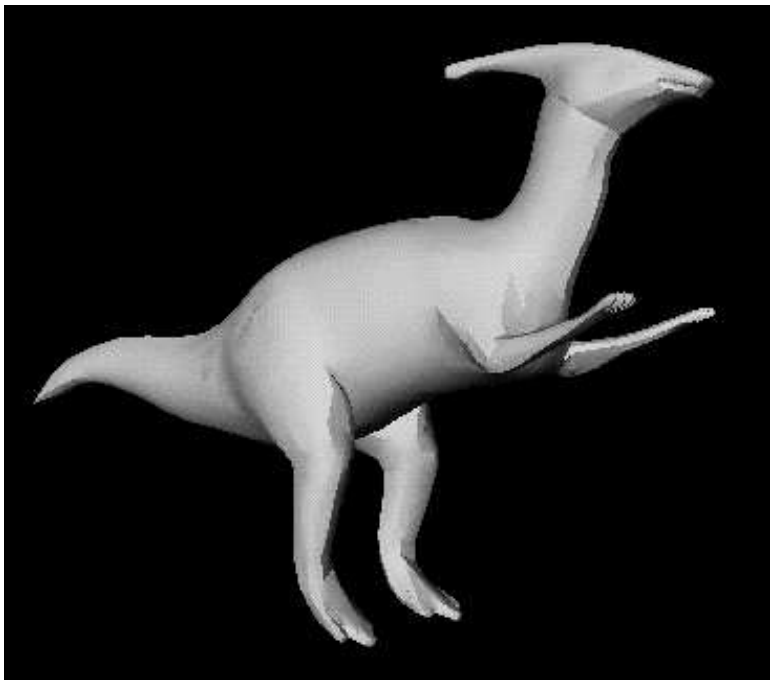
Animation Issues: scaling

contact

movement style

inverse kinematics?

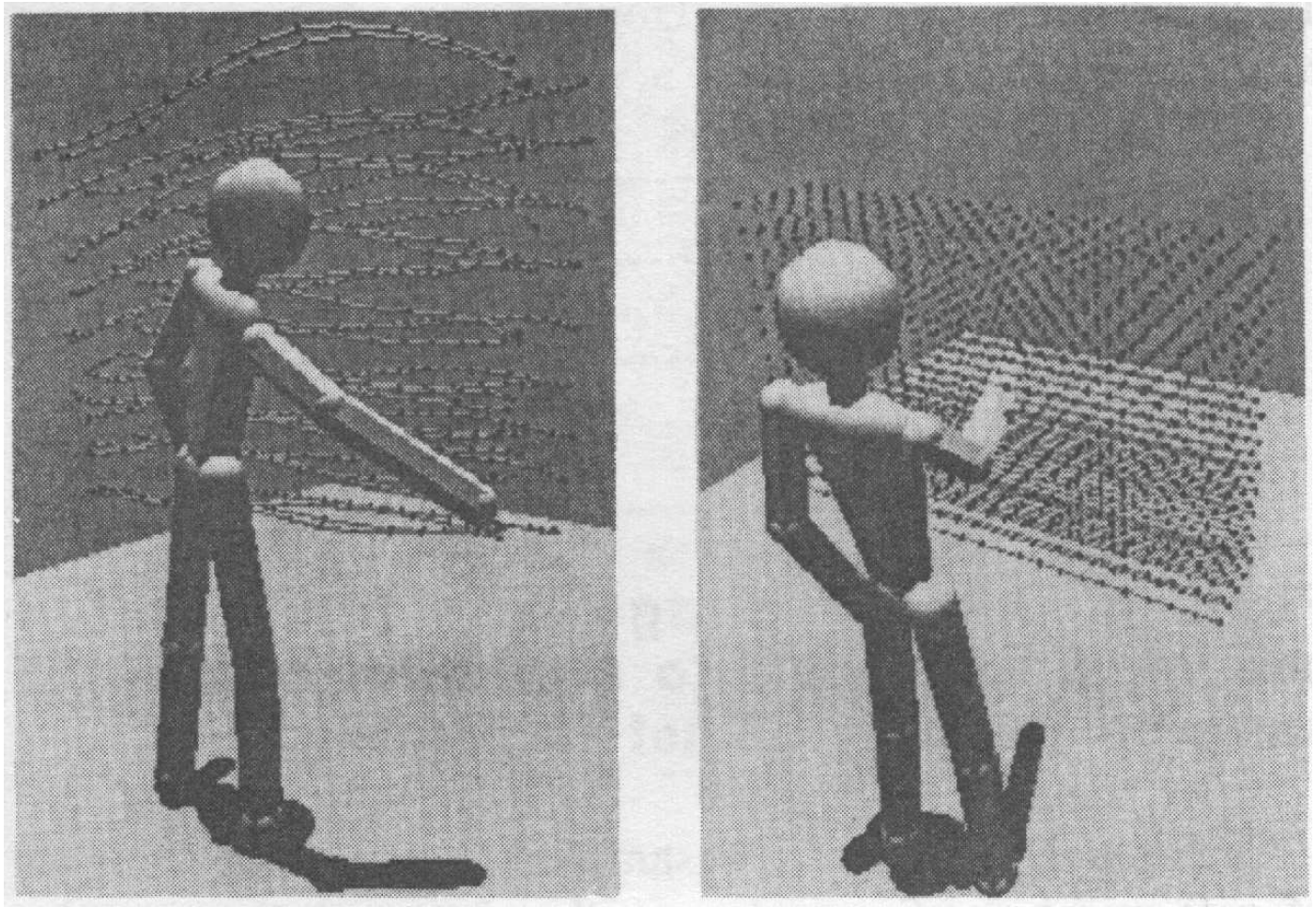




Animation Issues: generalization

Interpolation Synthesis for Articulated Figure Motion

Wiley and Hahn
Vrais '96



Initial Data

Resampled Data

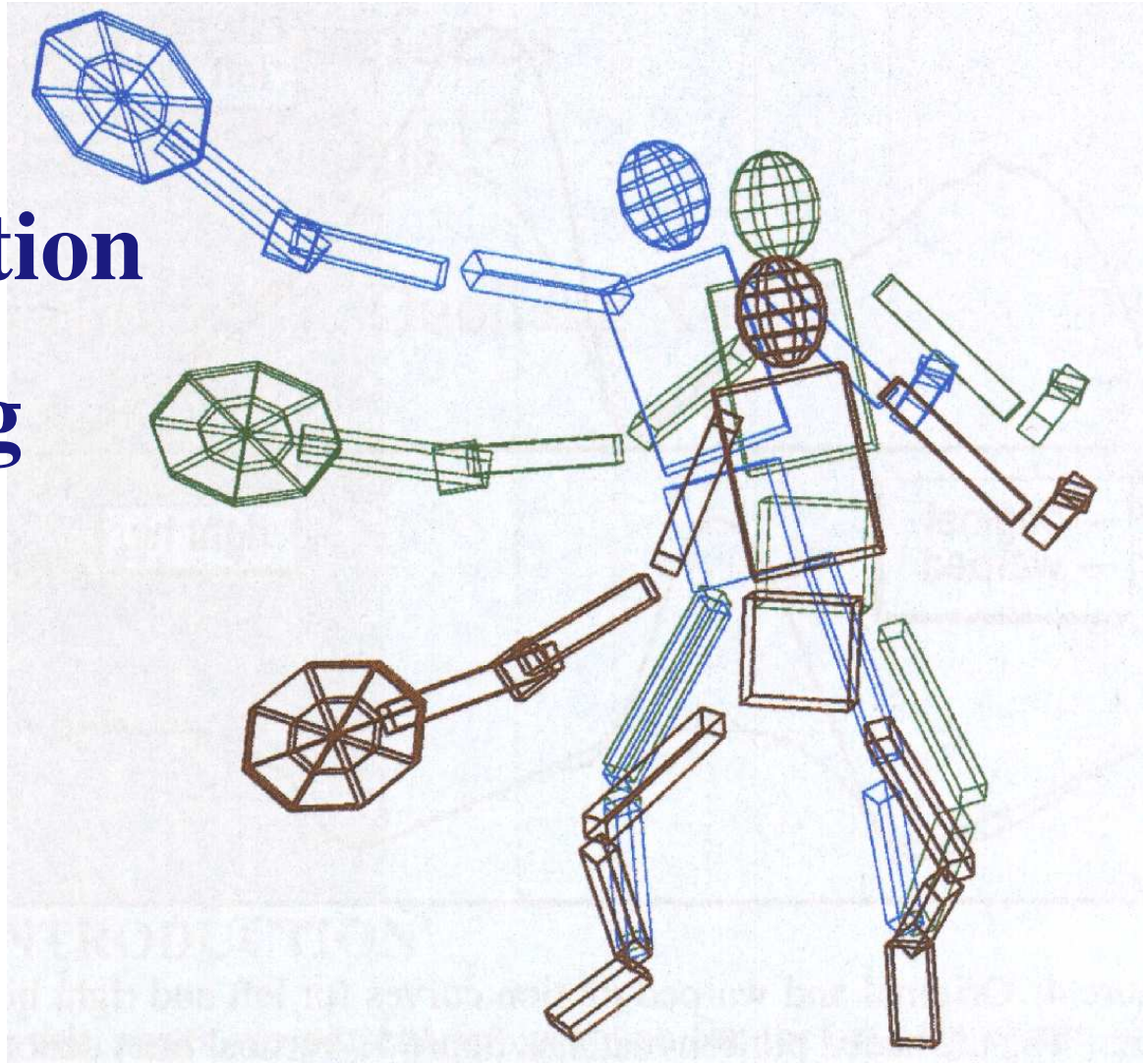
Animation Issues: generalization

Motion Warping
Witkin and Popovic, Siggraph '95

keyframes as constraints in a smooth deformation

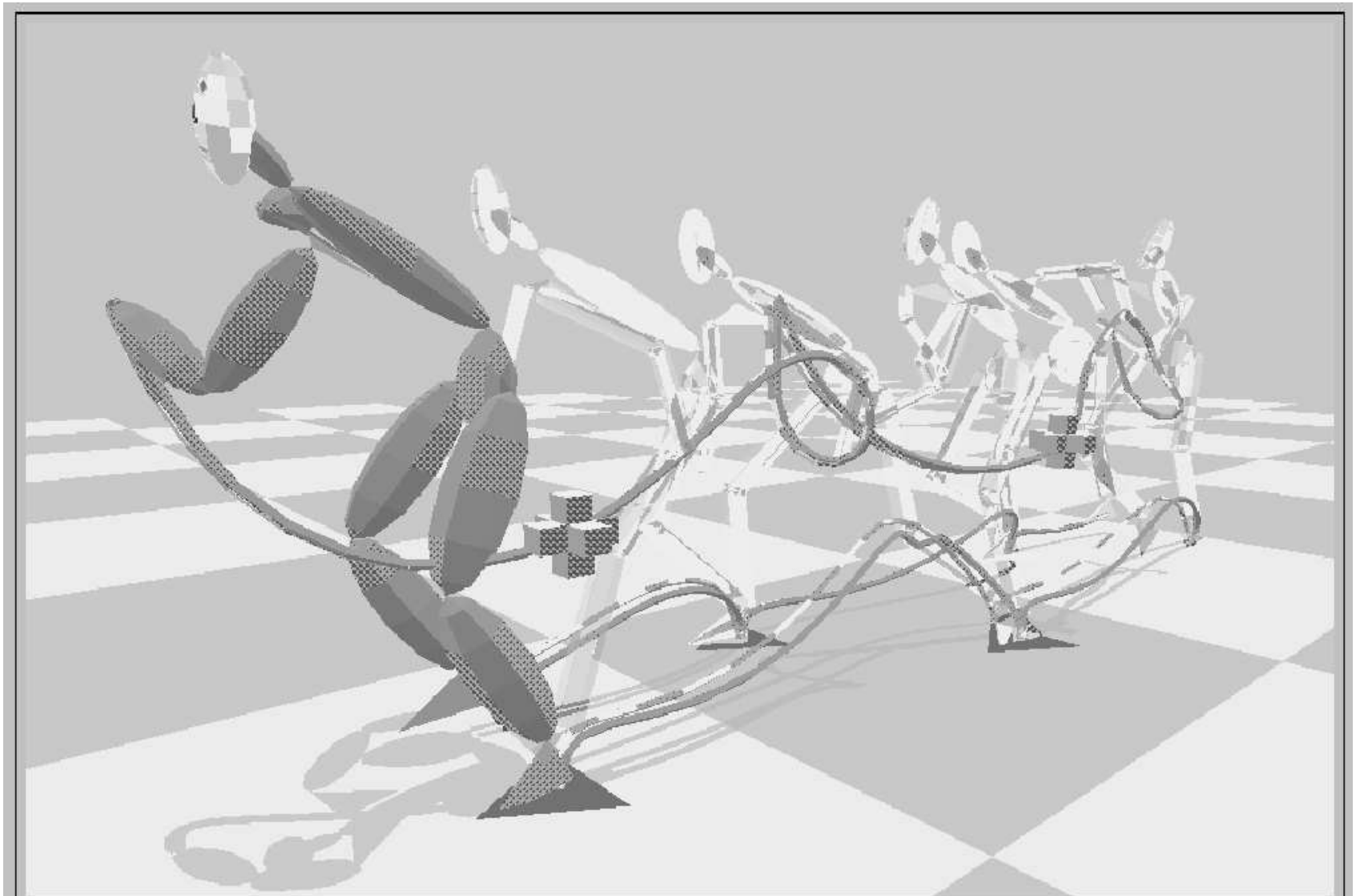
keyframe placing the ball on the racket at impact

,



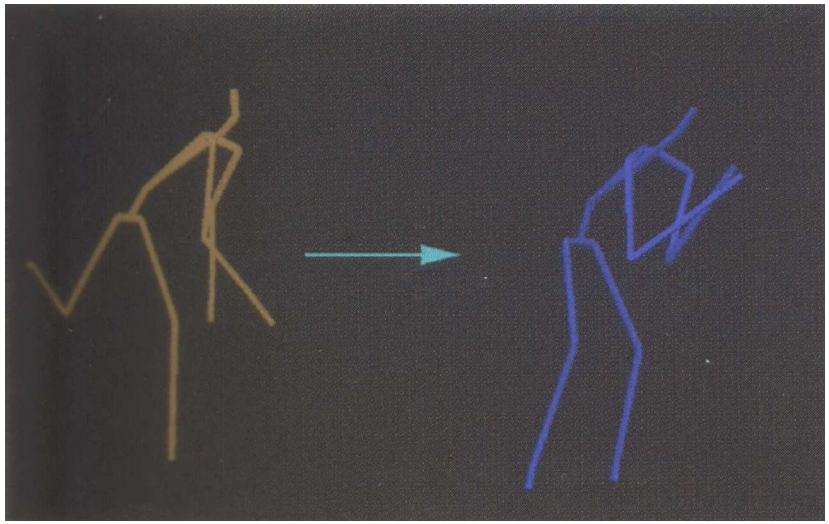
Animation Issues: generalization

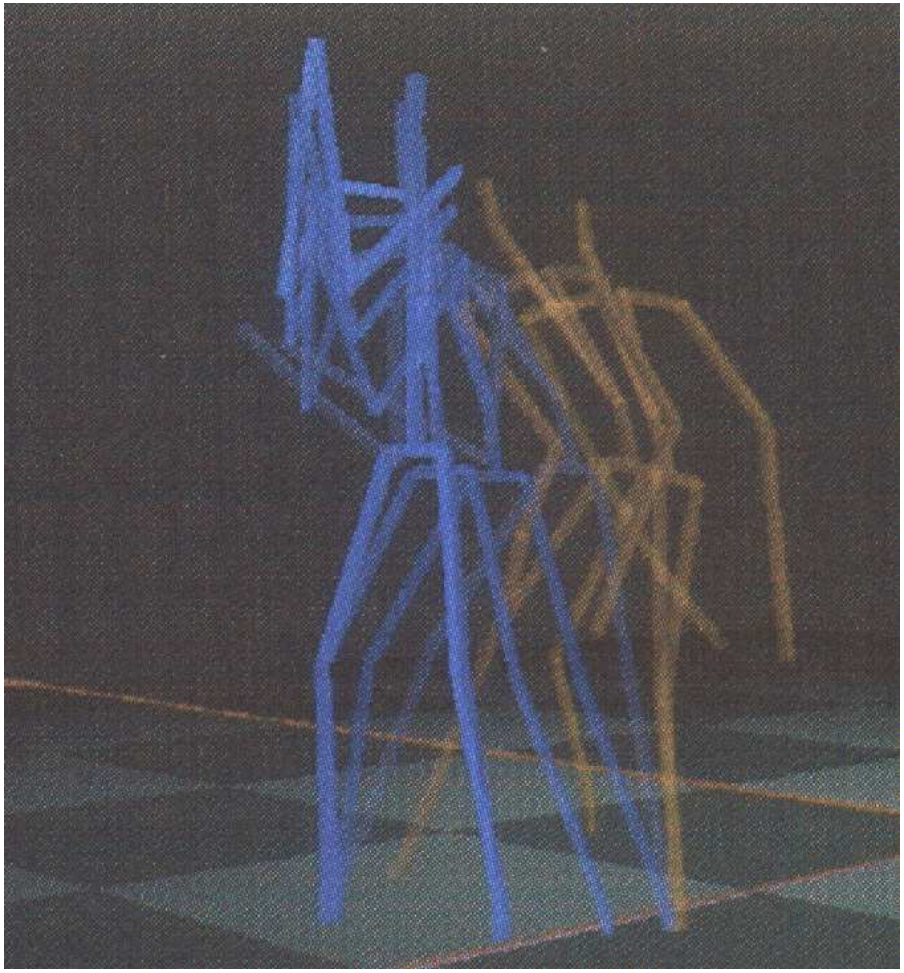
Motion Editing with Spacetime Constraints
Gleicher
1997 Symposium on Interactive 3D Graphics



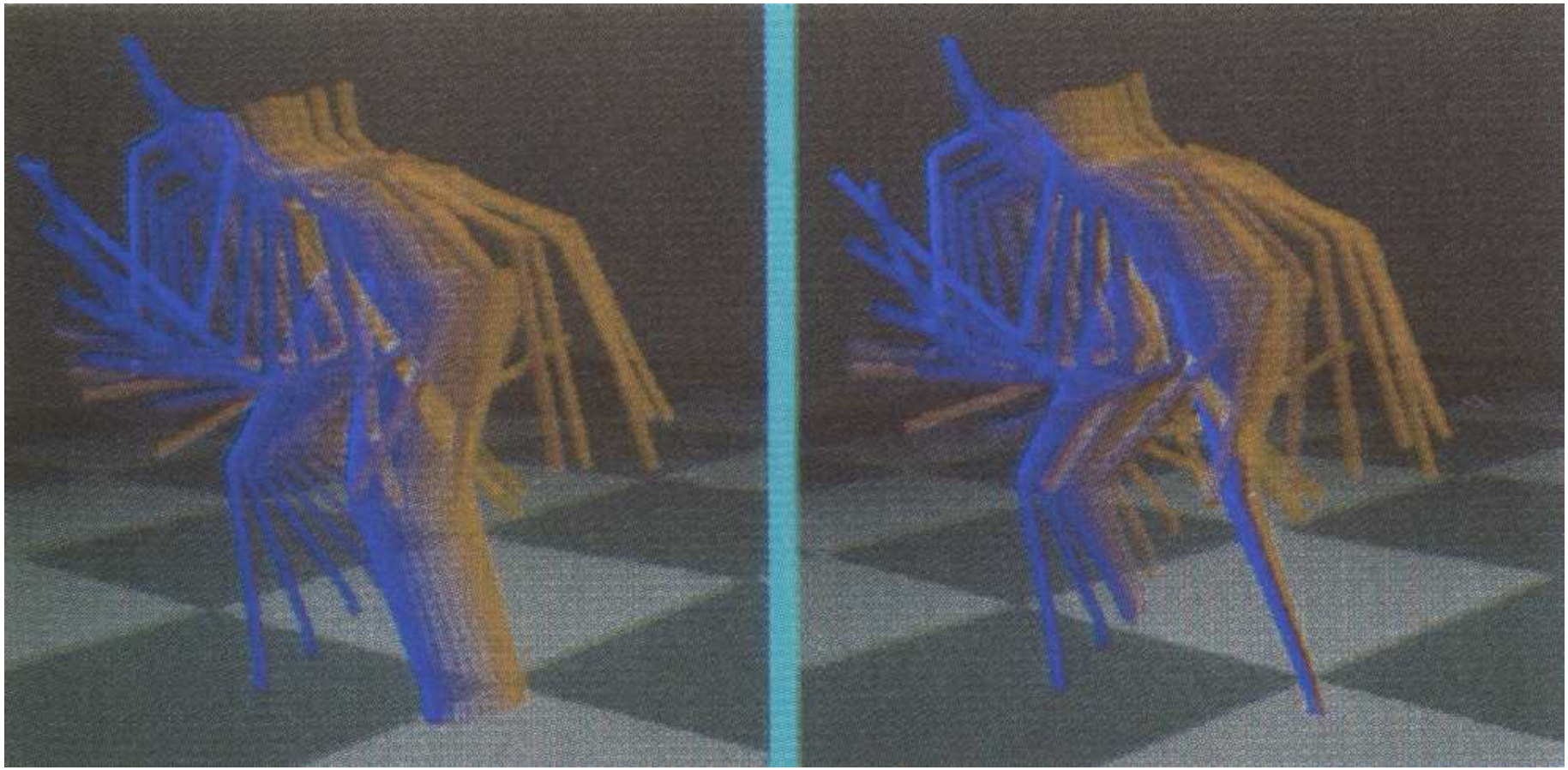
Animation Issues: blending

Efficient Generation of Motion Transitions using Spacetime Constraints
Rose, Guenter, Bodenheimer, Cohen
Siggraph ’96





Inverse Kinematics for the feet



Type of Modification:

- style of motion
- cyclification
- constraints on the motion
- transitions between motions

Evaluation Criteria:

- how many motions?
- how good is the motion?
  - kinematic/dynamic/natural
- how automatic is the process?