Computational Photography and Capture:

Motion Capture

Gabriel Brostow & Tim Weyrich

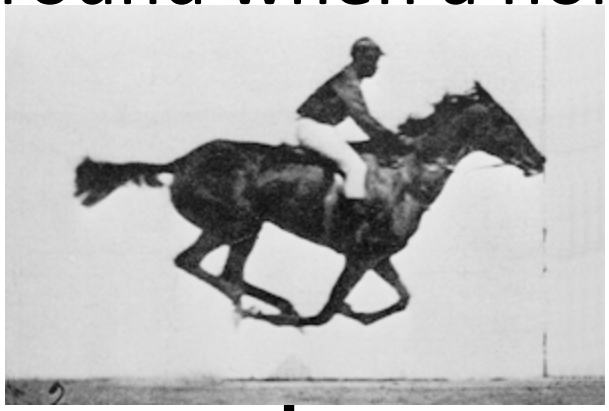
TA: Frederic Besse

Eadweard Muybridge

- Do all 4 legs come off the ground when a horse is in gallop?

Eadweard Muybridge

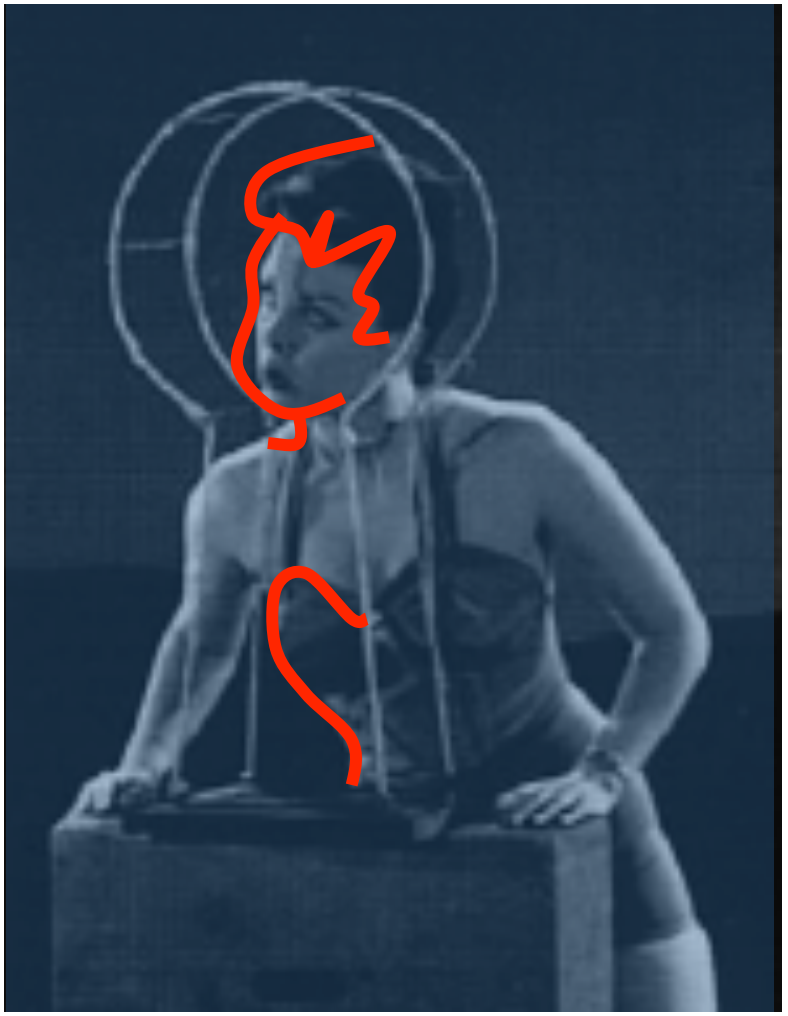
- Do all 4 legs come off the ground when a horse is in gallop?

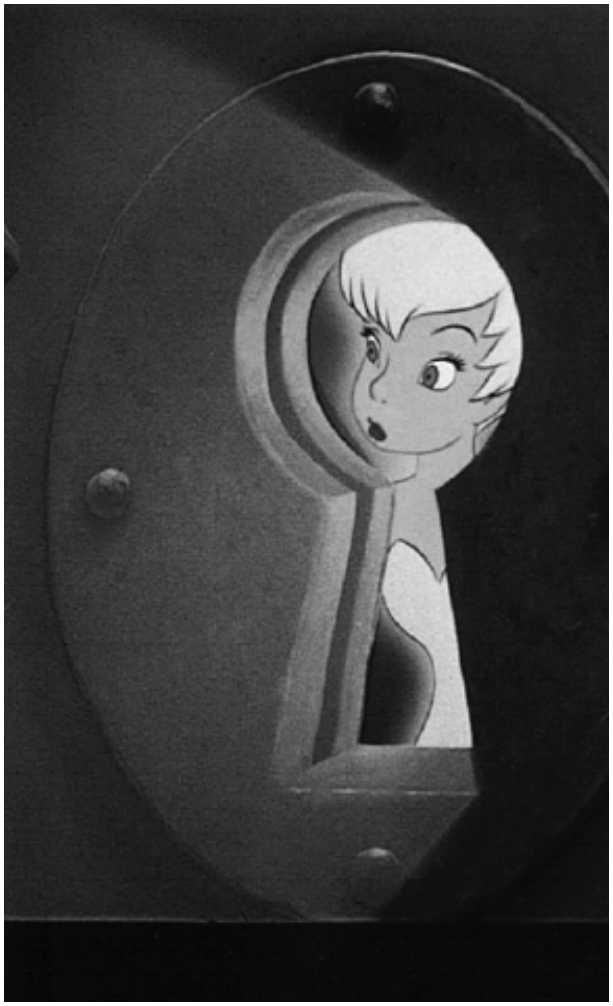


- Leland Stanford backed Muybridge's data collection: animals, men, women, children, etc.
- Chicago 1893: moving pictures viewed by paying public in first movie theater
- See also Étienne-Jules Marey

Rotoscoping

(Tinkerbell in Disney's "Peter Pan")

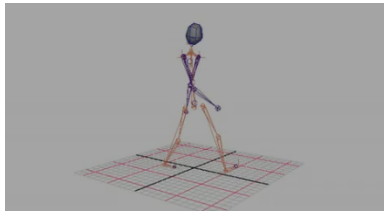




Margaret Kerry posed for 11 months as Tinkerbell, "The Illusion of Life", Thomas & Johnston

Pose Animation

- Keyframing



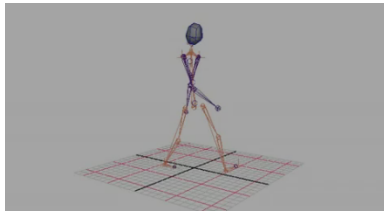
By sacul109498 link

Keyframing in Maya

Pixar productions

Pose Animation

- Keyframing

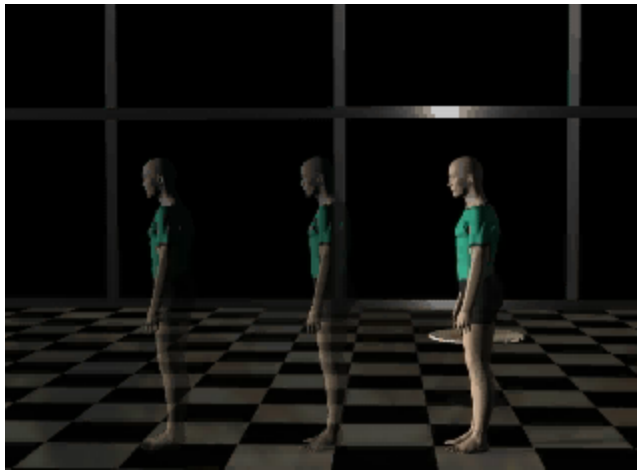


By sacul109498 link

Keyframing in Maya

Pixar productions

- Physical Controllers
  - Virtual
  - Real



Animating Human Athletics, Hodgins et al.

…→ Motion Capture!

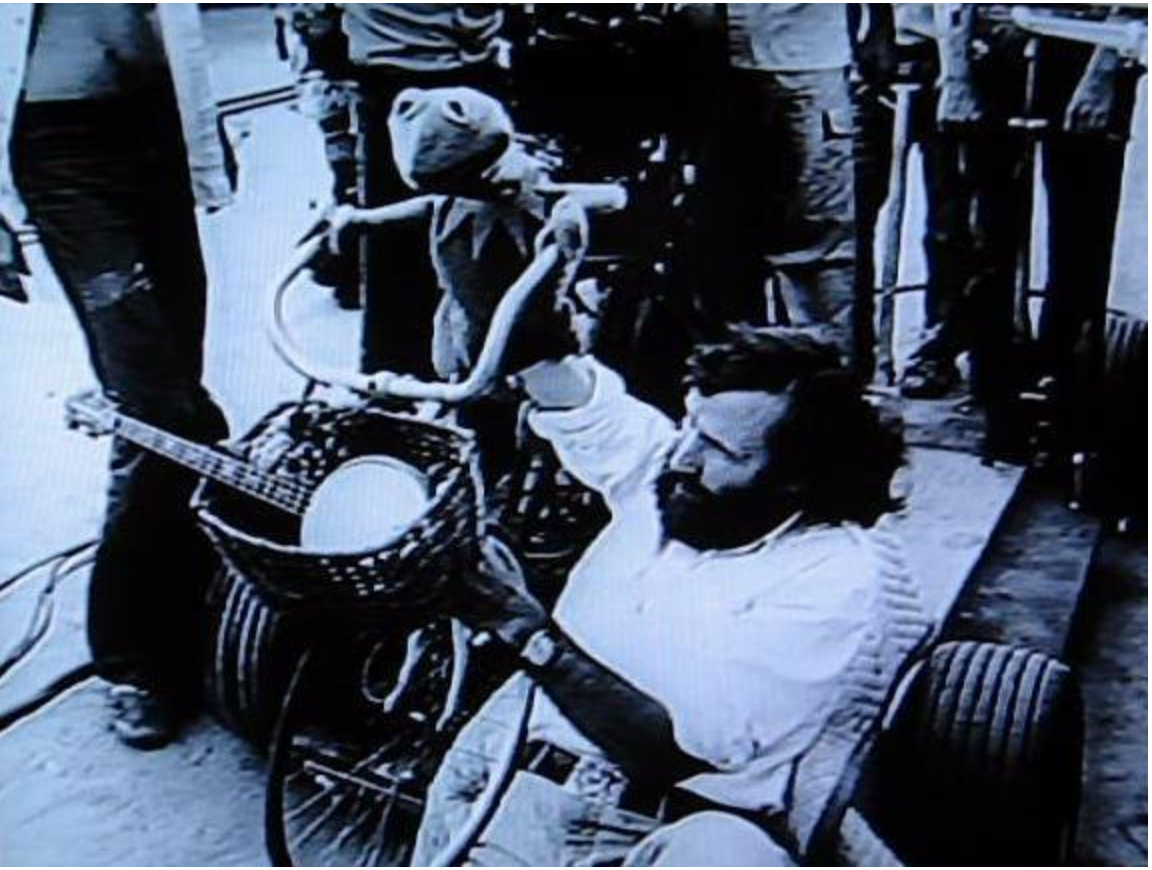
Puppeteering

Image: Jim Henson Productions

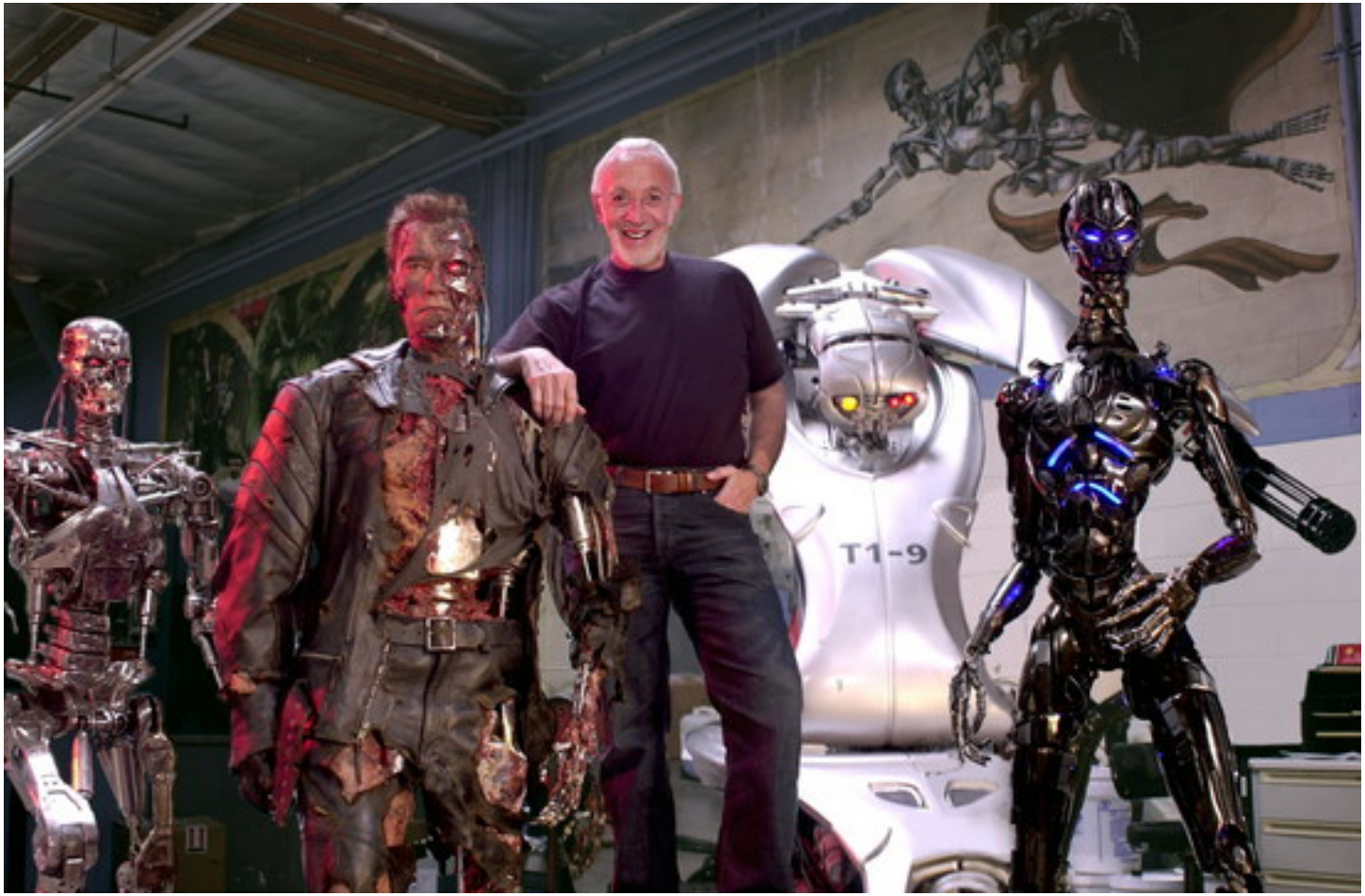
Monkey 2 by Inition

Image: Jim Henson Productions

http://muppet.wikia.com/wiki/Bicycles



Puppeteering



Stan Winston: 1946 - 2008

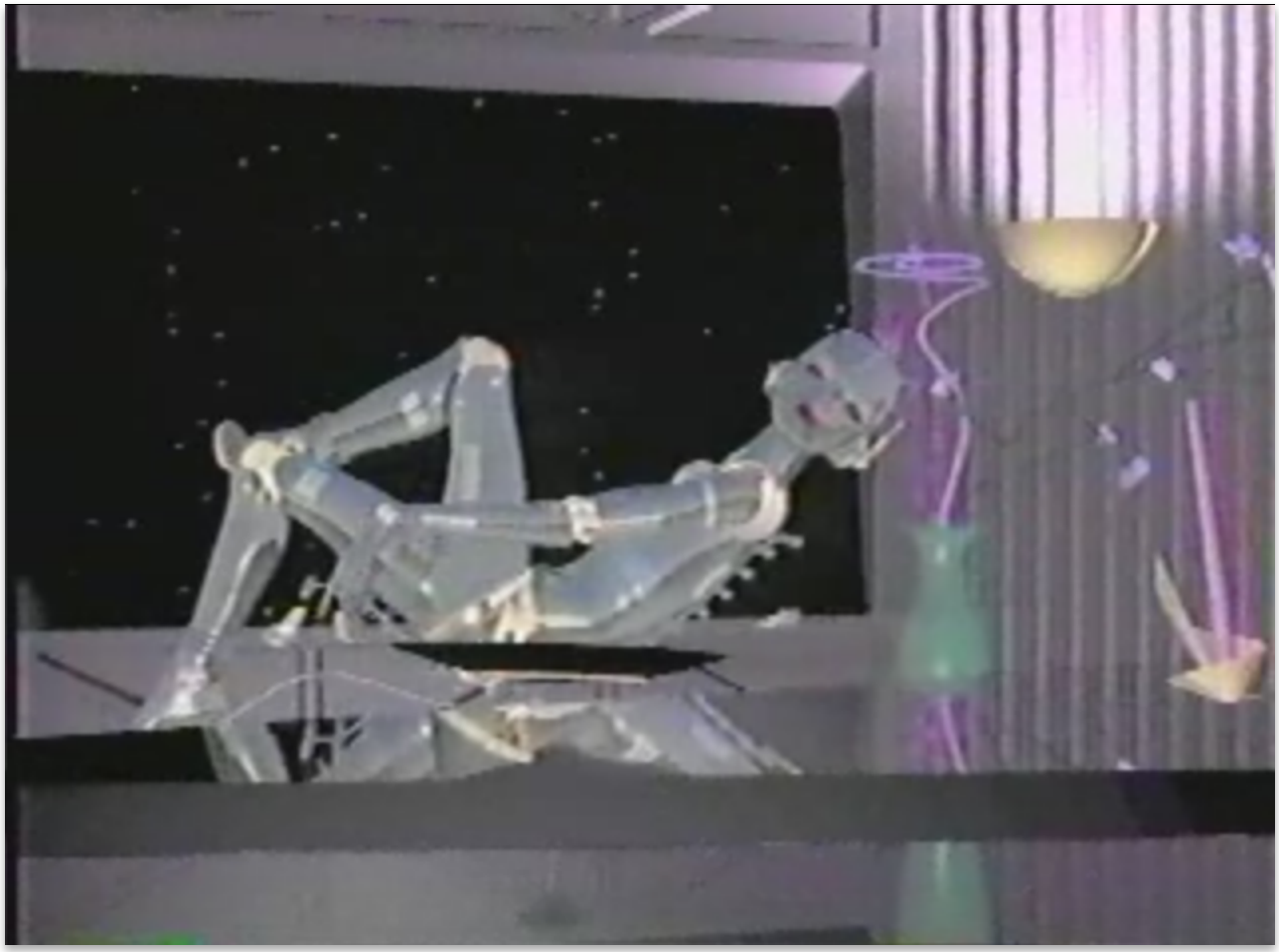
Puppeteering

Moving Light Displays

- Johansson (1973) experiments
- Video by Randolph Blake @ Vanderbilt

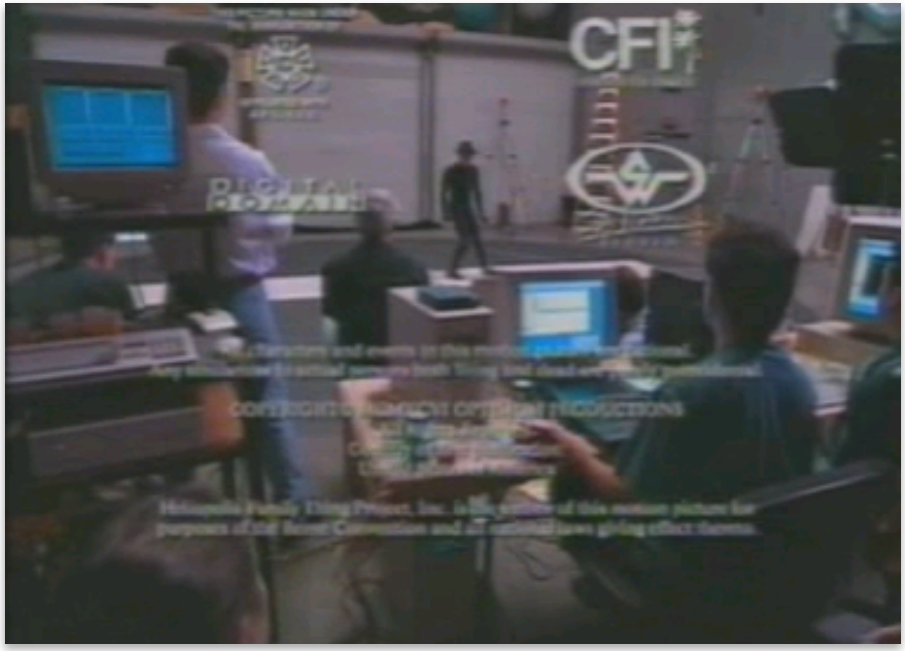
- Subsequent research showed similar phenomena
- Algorithmic versions:
  - For finding individuals in crowds: Brostow + Cipolla 2006
  - For recognizing objects in video: Brostow et al. 2008

First Motion Capture in Animation



"Brilliance" by Abel and Associates, 1985

Motion Capture for F/X



Michael Jackson - Ghost

Motion Capture Technology

Magnetic

Active Markers

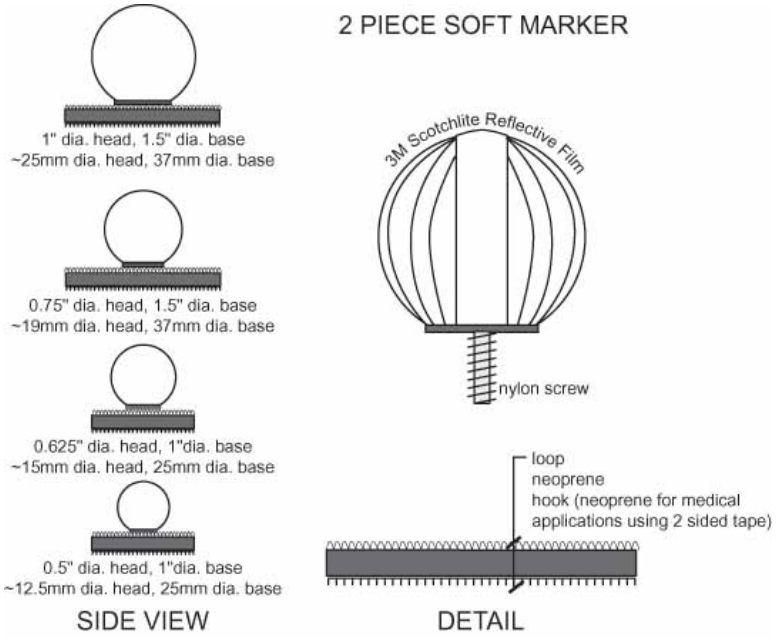
Mechanical

Optical

Passive Markers

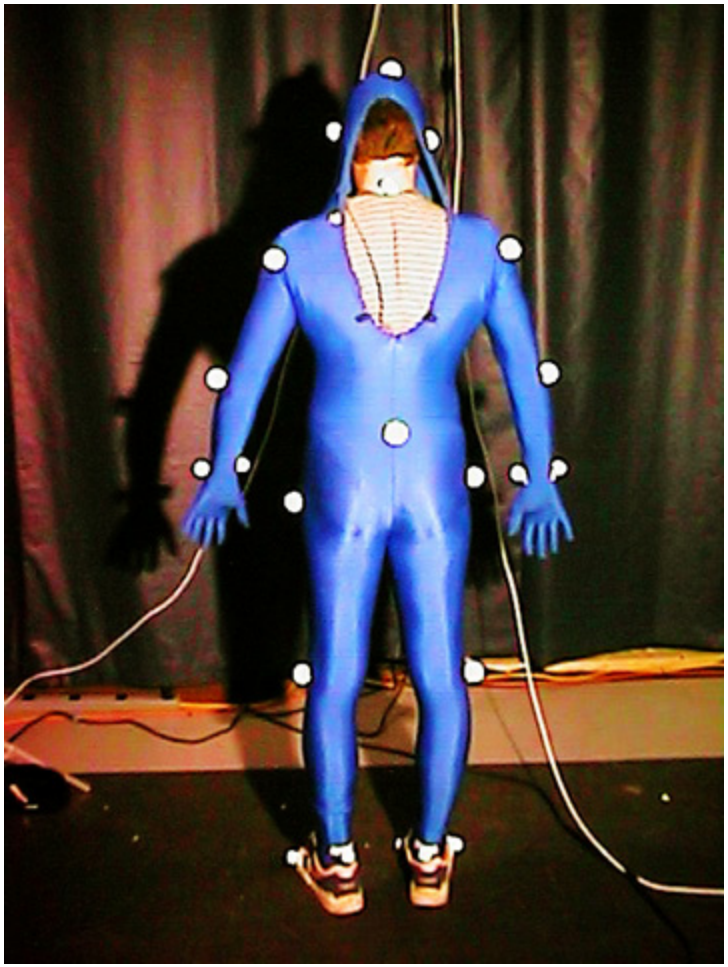
Active vs. Passive Markers

- Active Markers (broadcasting or sensing)
  - Need cable / transmitter for power + signal
  - Unique IDs
  - Magnetic systems report Rotation + Translation
- Passive Markers
  - Correspondence problem
  - Sizes vary(!)
  - Provide only Translation
  - Also avail. as bone-screws



From 3x3 Designs

Marker Configurations



Now usually agreed that better results achieved by offsetting markers and asymmetric placement.

Prof. Zoran Popovic ("Clown for a day")

From production of
"Scott Pilgrim vs. the World"

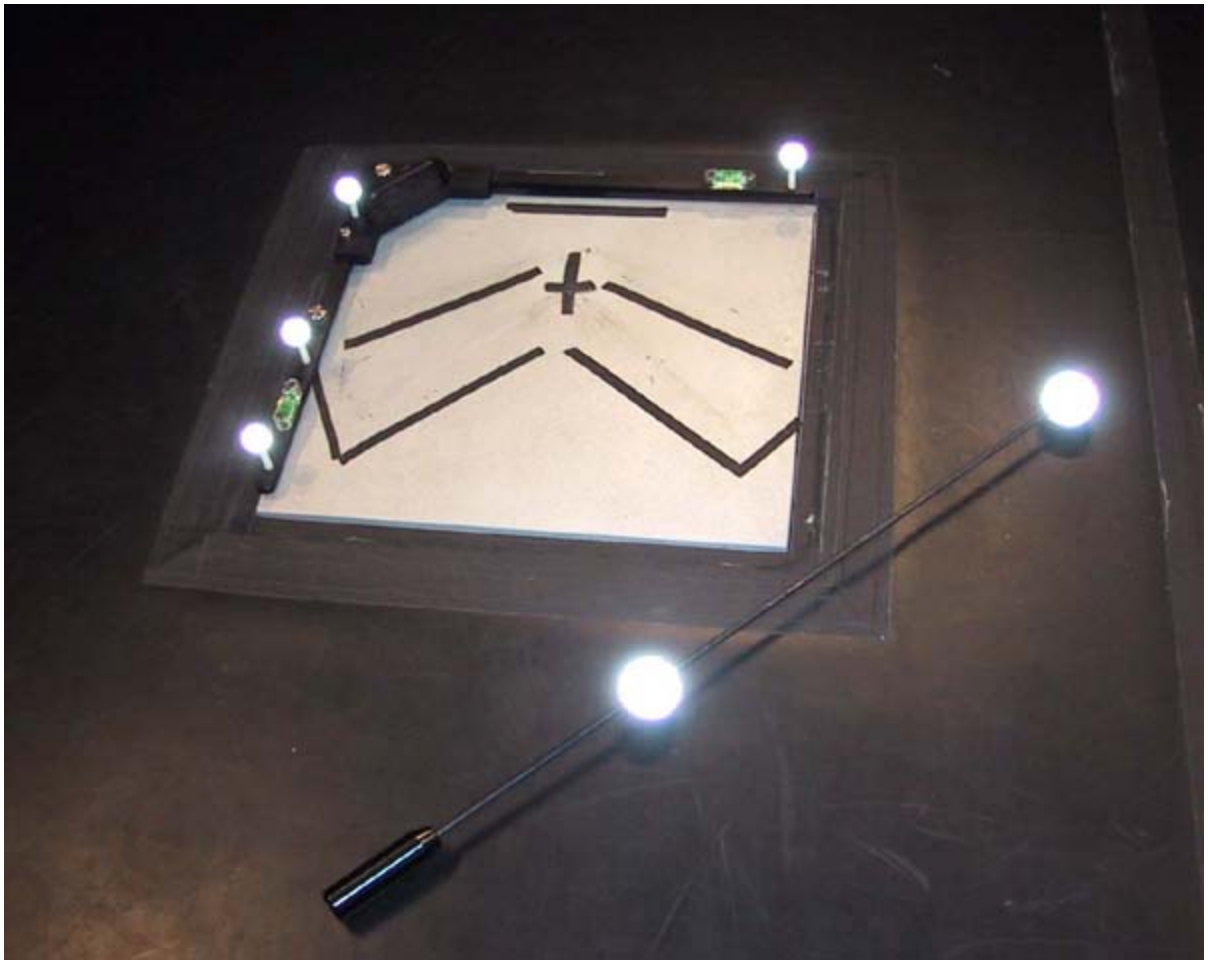
CMU mocap DB

Where to Place Cameras?

Tony Hawk's Project 8

Wide baseline for better triangulation
vs.
Narrow baseline for easier correspondences and predictable occlusions

Camera Calibration



Calibration frame (centered on force platform) and wand,
from LIU Instrumented Analysis of Human Movement

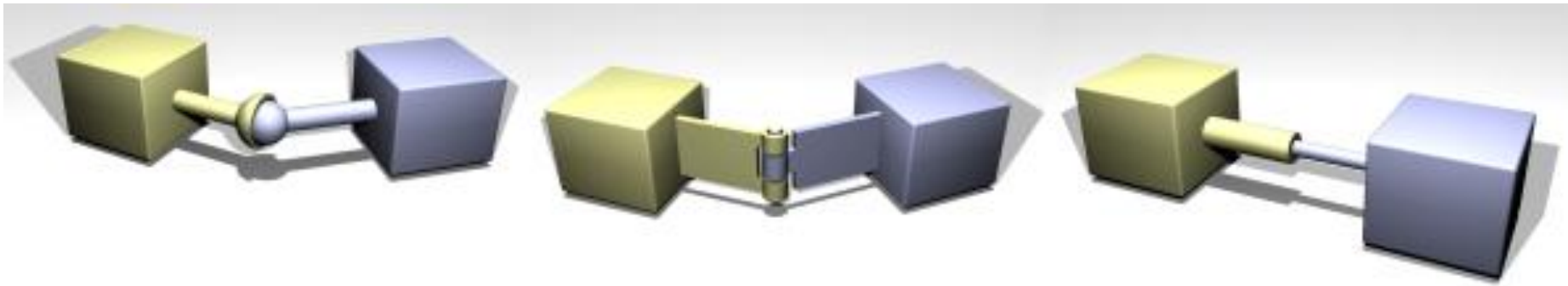
2D "centers"

↓

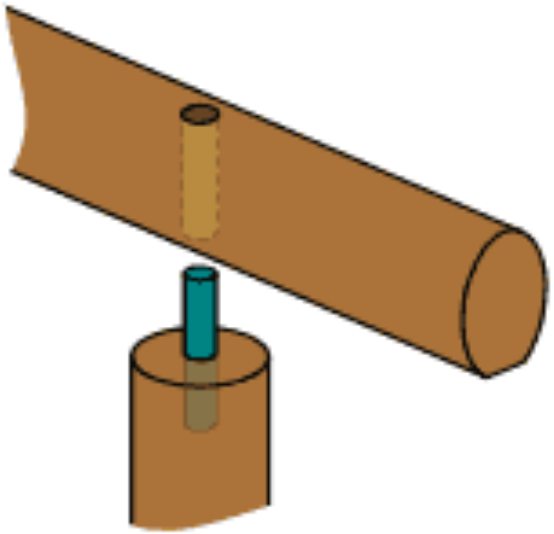
3D rays

↓

3D correspondence



Joints: Degrees of Freedom (DOFs)



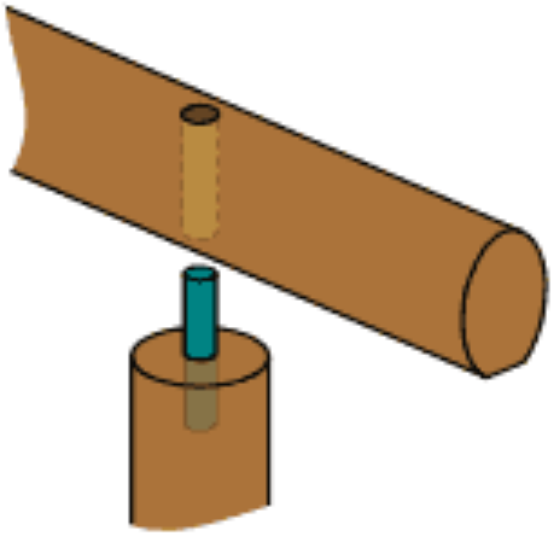
From Ydalir Vikings Tent poles

“hair line cracks on the cheap ball joint”
(see more at Eternal Rollerz C.C.)

___?___ ___?___

DOF’s?

Joints: Degrees of Freedom (DOFs)



From Ydalir Vikings Tent poles

“hair line cracks on the cheap ball joint”
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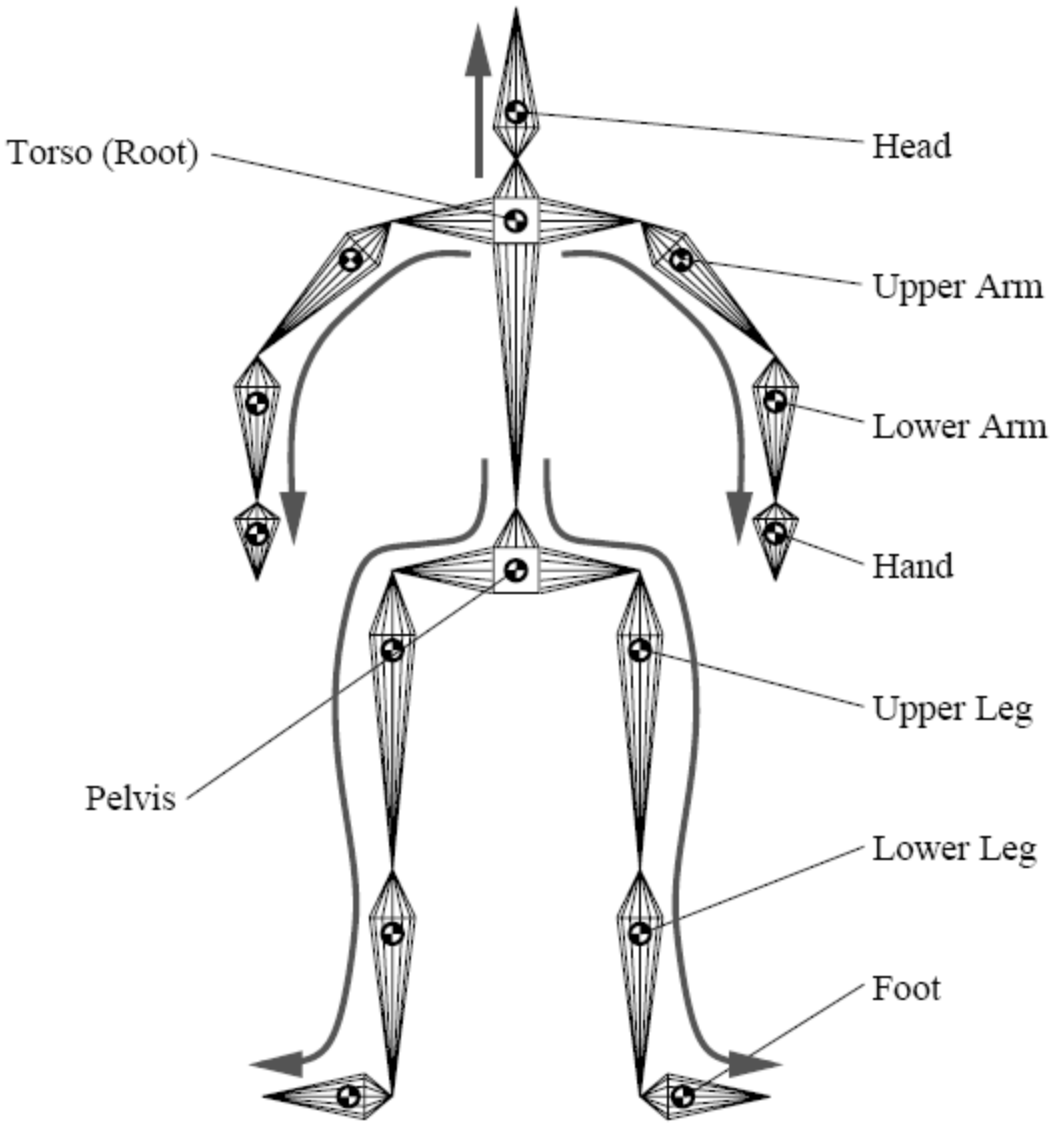
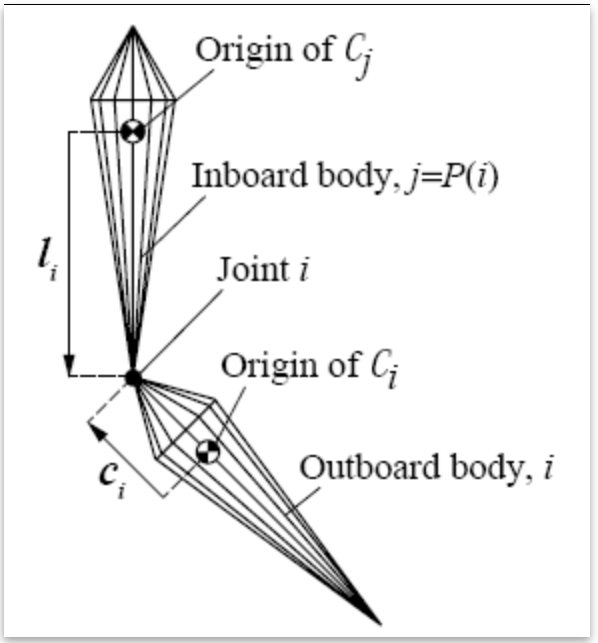
__1__ __3__

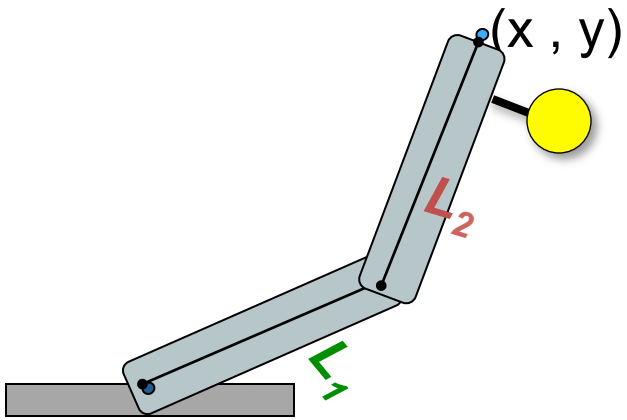
DOF’s?



- Most joints are approximated by ball joints, while Root has 3 translational degrees of freedom. Good enough?



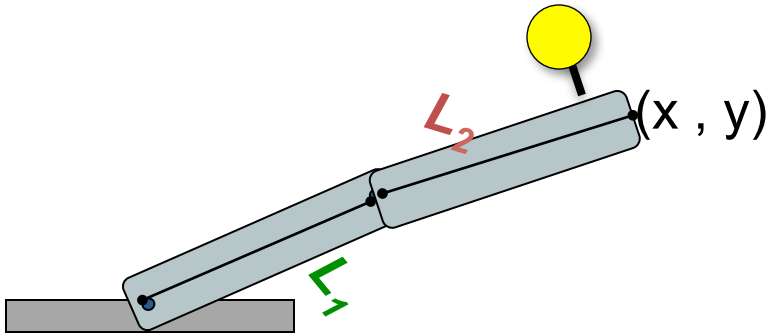
Joint Angle Estimation



3D: If L_1's pose is known, and L_2 is attached with a ball-joint, is the shown marker enough?

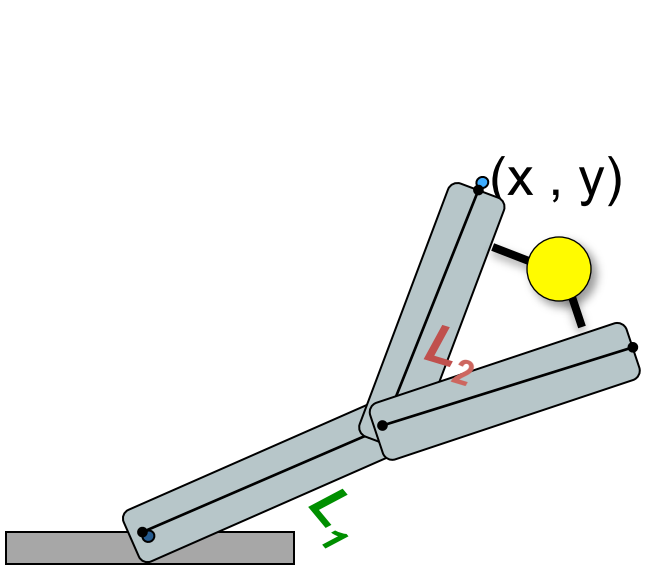
Based on diagram of Prof. Howie Choset, Introduction to Robotics

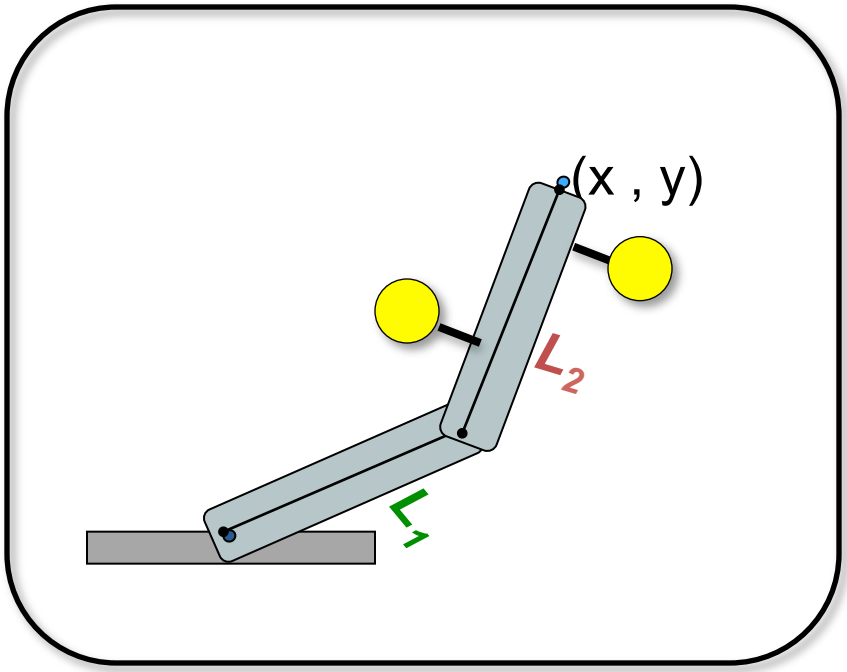
Joint Angle Estimation



3D: one marker leaves L_2 underconstrained

Joint Angle Estimation



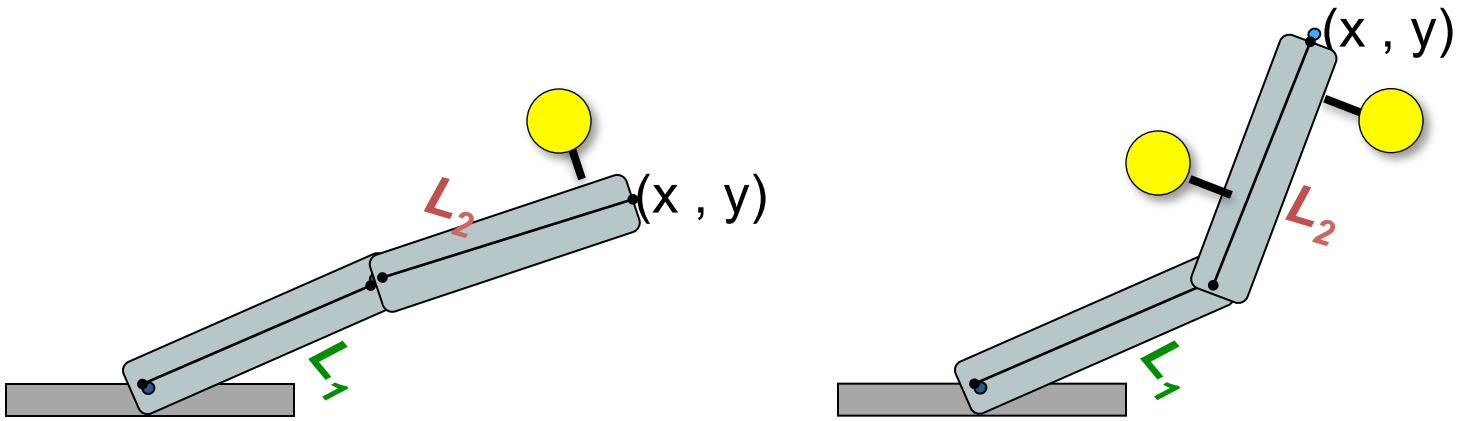


Now L_2's pose is constrained

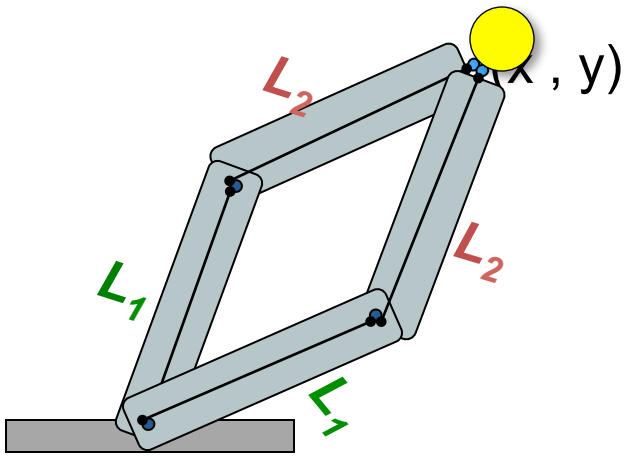
(assuming known L_1 and marker placement)

New question: if all joints on the right are pin-joints, do we need any markers on L_1?

Joint Angle Estimation



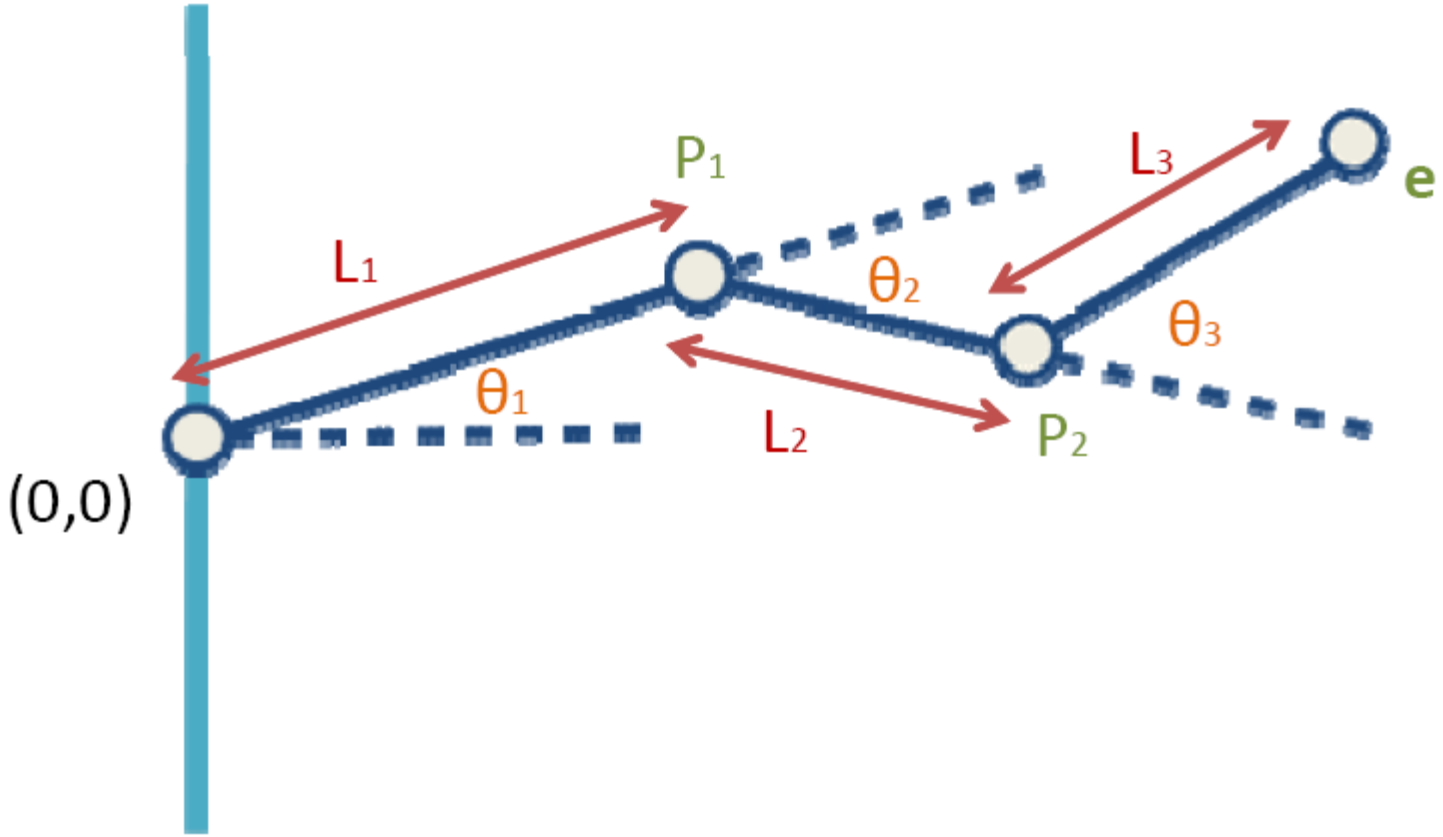
New Challenges Emerge



1. Inverse kinematics
2. Practical calibration of marker locations (and limb hierarchy)
3. Data cleaning…

From slides of Prof. Howie Choset, Introduction to Robotics

Forward Kinematics



Slide from Nancy Pollard's Technical Animation Class

Kinematics & End Effectors

Forward Kinematics

$$\boldsymbol{\theta} = [\theta_1, \theta_2, \ldots, \theta_M]$$

All degrees of freedom in 1 vector

We want to find the end effector position in 3D:

$$\mathbf{e} = [e_1, e_2, e_3]$$

FK has form: $\mathbf{e} = f(\boldsymbol{\theta})$

Inverse Kinematics

We have end effector(s):

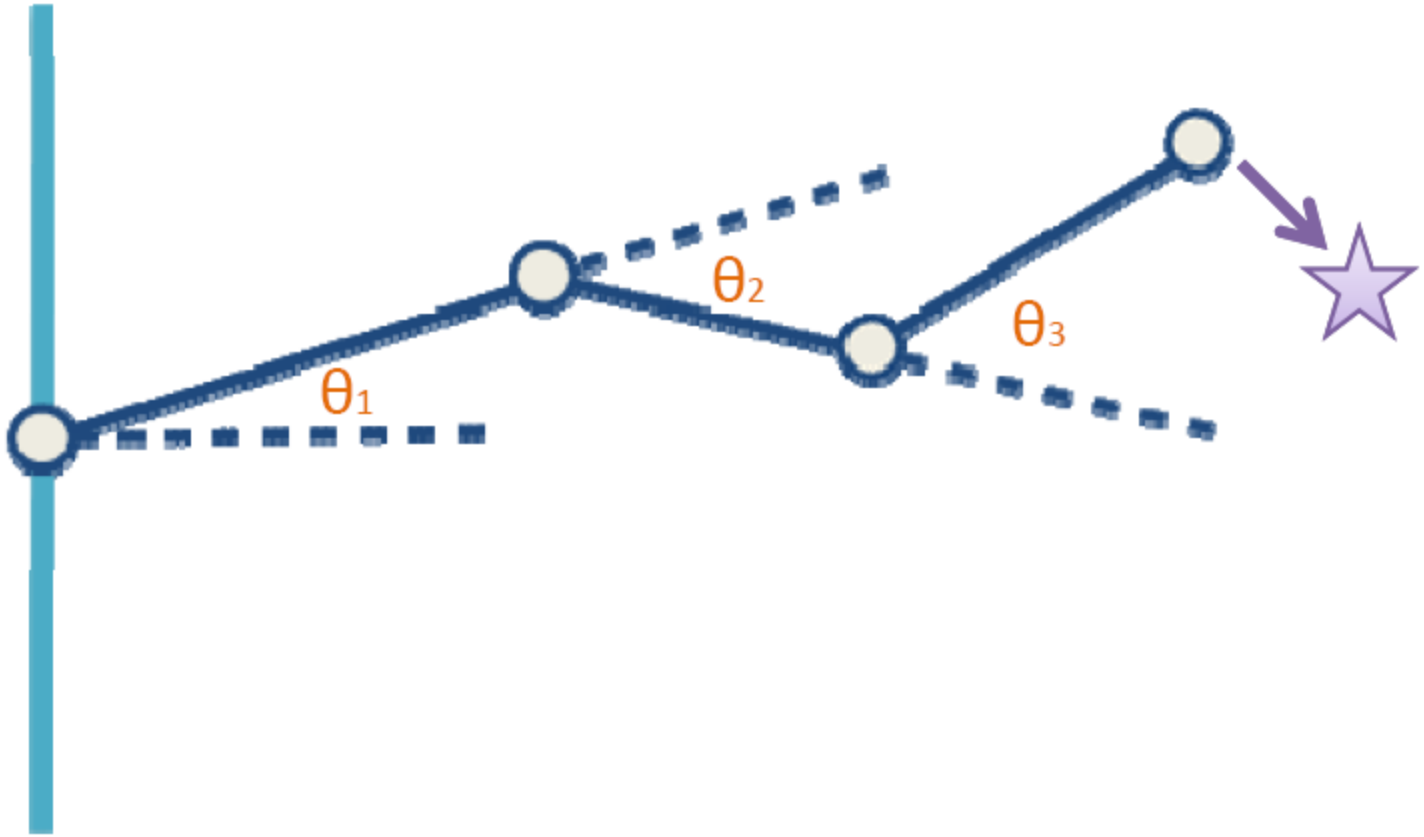
$$\mathbf{e} = [e_1, e_2, \ldots, e_N]$$

We want joint angles:

$$\boldsymbol{\theta} = [\theta_1, \theta_2, \ldots, \theta_M]$$

So we need: $\boldsymbol{\theta} = f^{-1}(\mathbf{e})$

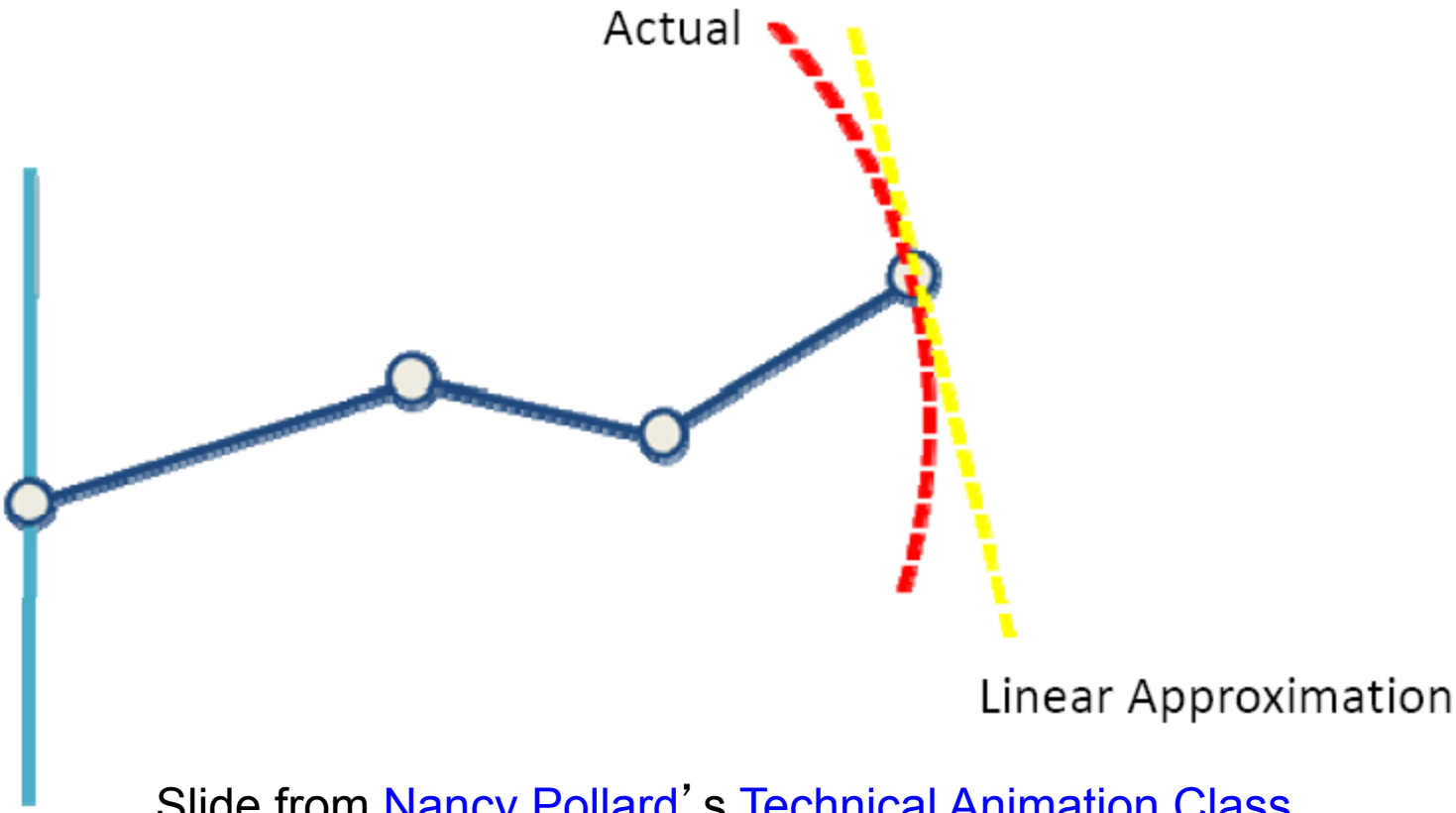
Inverse Kinematics



Slide from Nancy Pollard's Technical Animation Class

IK is Usually an Optimization of the Jacobian

- Jacobian: linear approximation of f(): $J = \frac{d\mathbf{e}}{d\boldsymbol{\theta}}$



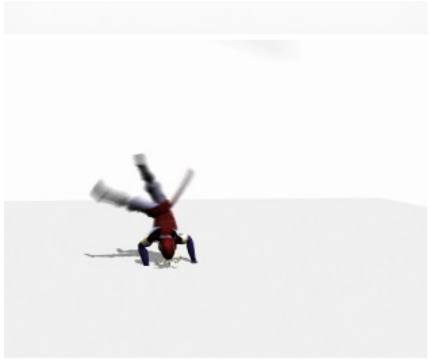
Slide from Nancy Pollard's Technical Animation Class

Skeleton + Marker Location Estimation

CMU Graphics Lab Mocap Database

- http://mocap.cs.cmu.edu

Subject #43 (swing on playground equipment) file index		- - asf					framerate
Trial #	Motion Description						
1	walk	tvd	c3d	amc		Animated	120
2	playground - grip bar, swing body	tvd	c3d	amc	mpg	Animated	120
3	playground - grip bar, swing body	tvd	c3d	amc	mpg	Animated	120



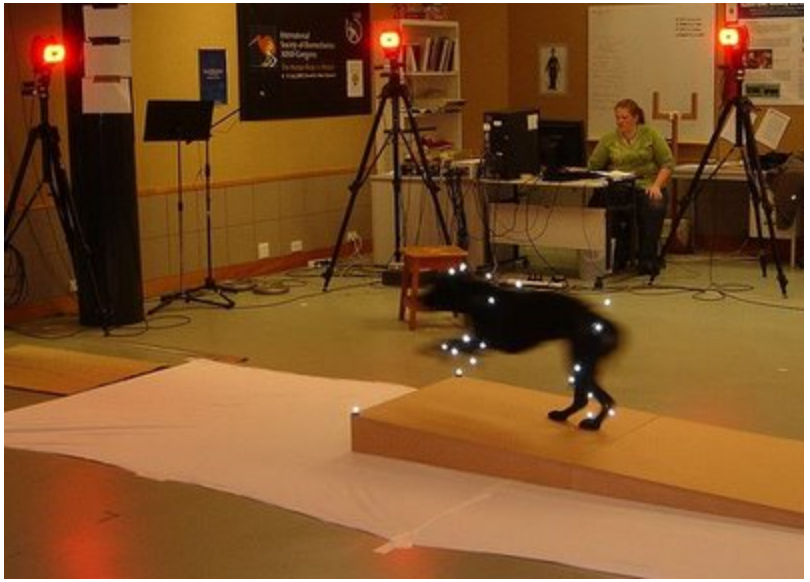
Samurai doing a cartwheel entrance to a forward somersault.

Samurai doing a reverse somersault.

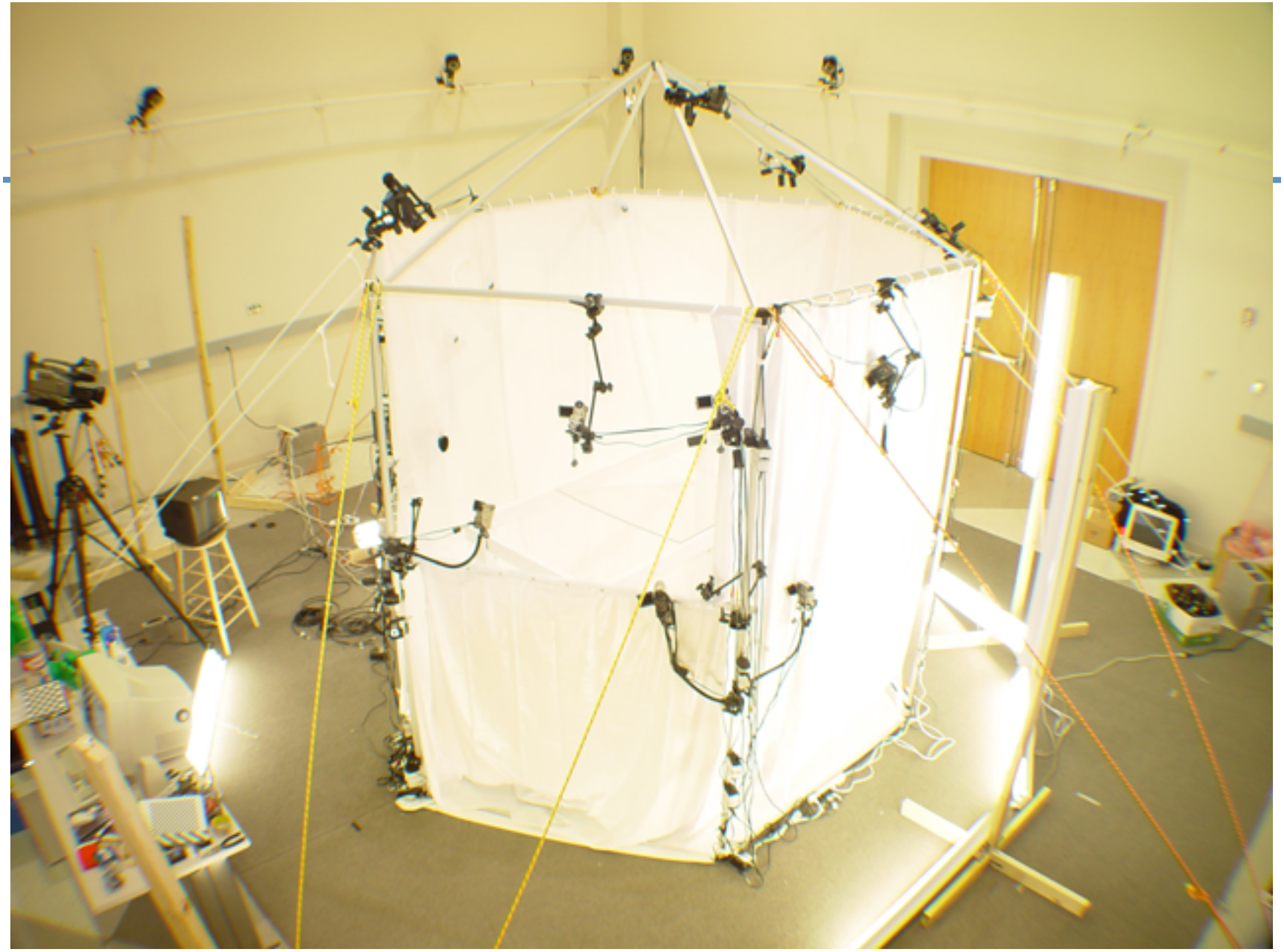
Mocap Beyond Human Limbs?

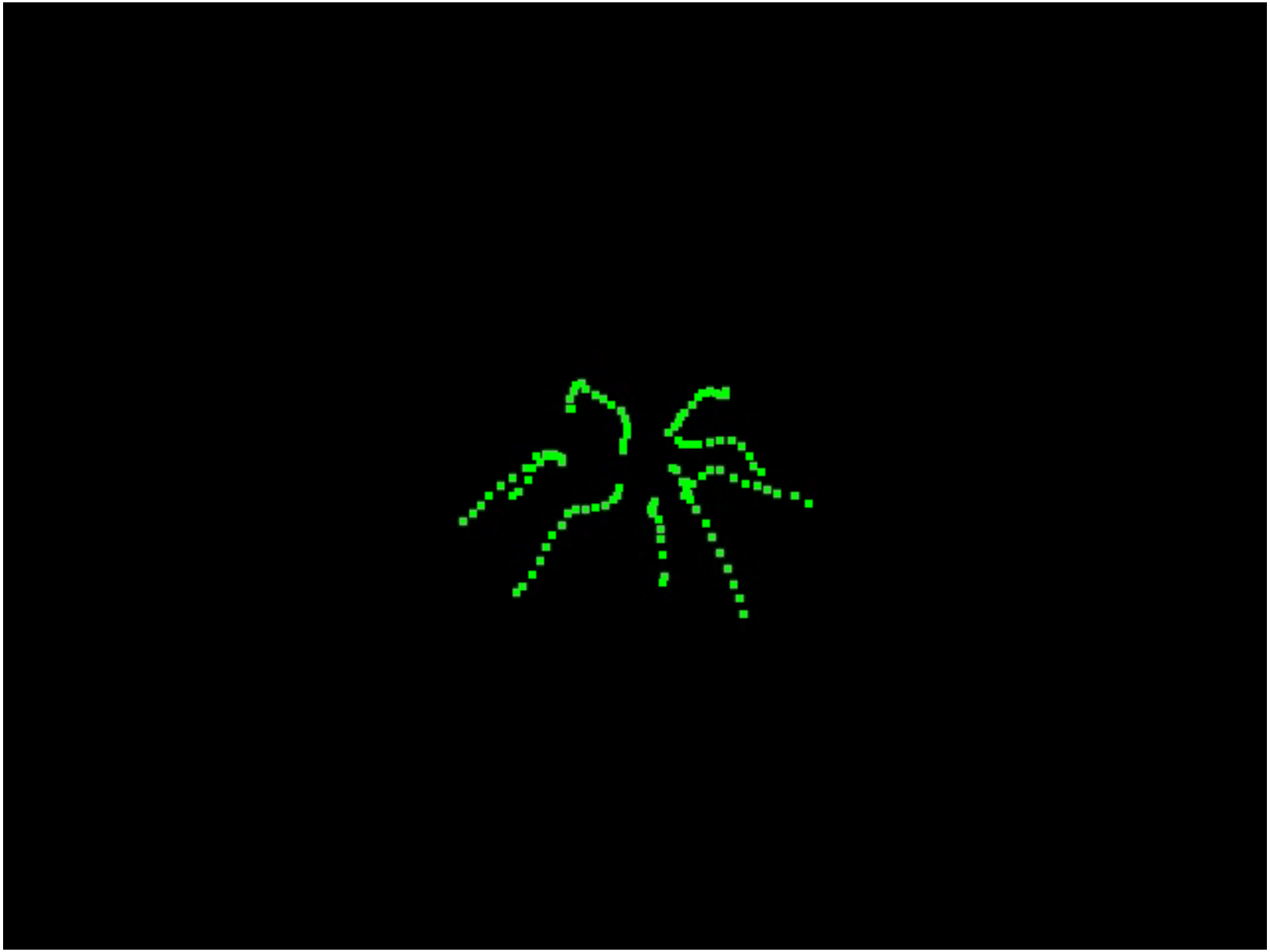
Faces, Animals, Cameras, Props…

See serkis.com and here



Free motion capture data here





Do's & Don't's of Mocapping Talent

- Adult actors are patient – but on a clock
  - Need ONE director
- Children have parents
- Monkeys eat markers
- Dogs are fast