# Motion Capture

# Motion Capture in Movies



# Motion Capture in Games




## Magnetic Capture Systems

- Tethered
- Sensitive to metal
- Low frequency (60Hz)



## Mechanical Capture Systems

- Any environment
- Measures joint angles
- Restricts the motion



## Optical motion capture

- Place markers on the actor

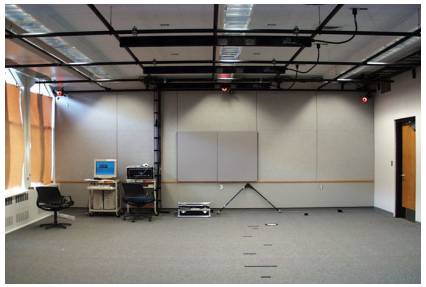
- Cameras can determine marker positions



## Optical Capture Systems

- 8 or more cameras
- Restricted volume
- High Frequency (240Hz)
- Occlusions

# How Does It Work?



8 cameras + 120 Hz + Special tape = Raw Point Data



# Optical motion capture process

1. Find the skeleton dimensions and exact marker positions on the body
2. Perform a motion trial
3. Compute marker positions from camera images
4. Identify and uniquely label markers
5. Calculate joint angles from maker paths

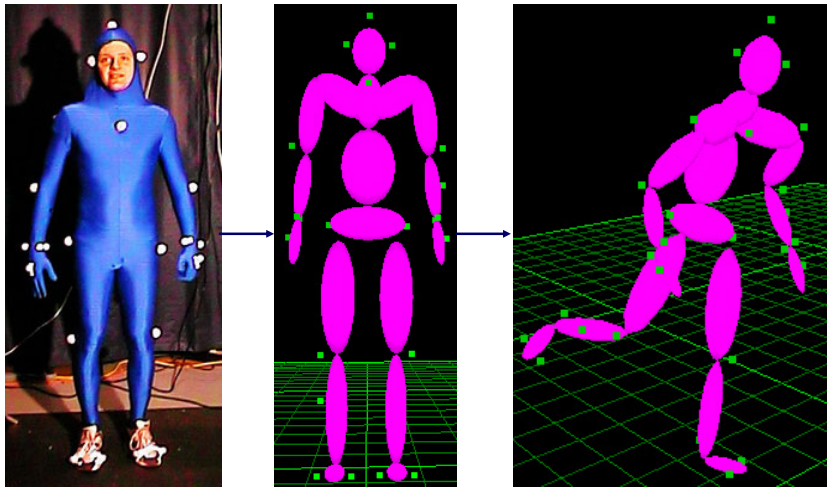


# Optical motion capture process

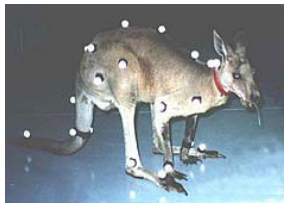
1. **Find the skeleton dimensions and exact marker positions on the body**
2. Perform a motion trial
3. Compute marker positions from camera images
4. Identify and uniquely label markers
5. Calculate joint angles from maker paths



# Problem Statement



# Automatic Calibration

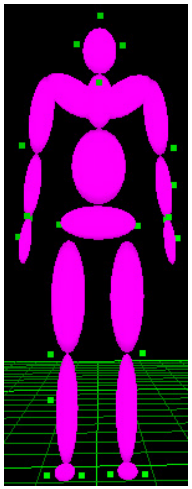


Design Goals:

- Fully automatic
- Any skeleton
- Accurate

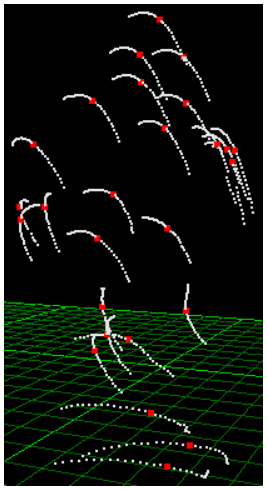


# Input



*Generic Skeleton*

Actor's kinematics structure, and rough handle positions

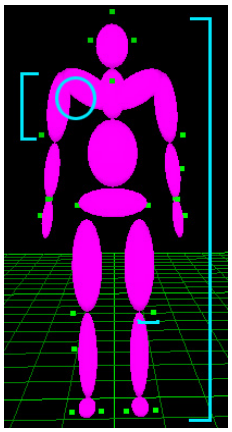


*Calibration Data*

Initial path data that exercises all of the subject's DOFs



# Independent Variables



DOFs

Bone lengths

Handle offsets

Global scale



# Optical motion capture process

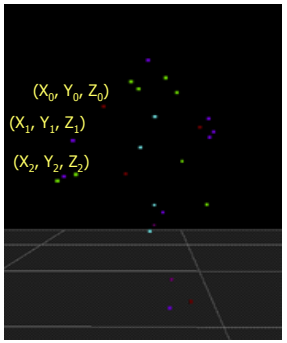
1. Find the skeleton dimensions and exact marker positions on the body
2. Perform a motion trial
3. Compute marker positions from camera images
4. **Identify and uniquely label markers**
5. Calculate joint angles from maker paths

# Optical motion capture process

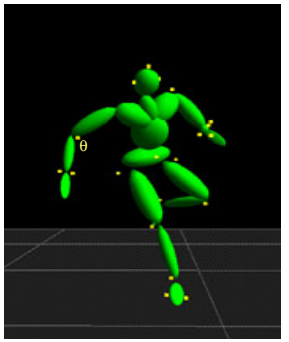
1. Find the skeleton dimensions and exact marker positions on the body
2. **Perform a motion trial**
3. **Compute marker paths from camera images**
4. Identify and uniquely label markers
5. Calculate joint angles from maker paths



# Marker Identification



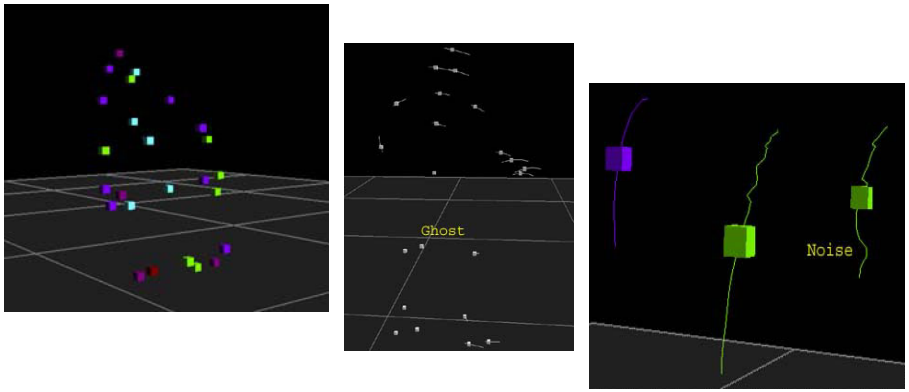

At each frame, motion capture gives us a set of points




We would like something more intuitive



# Marker Identification Problems



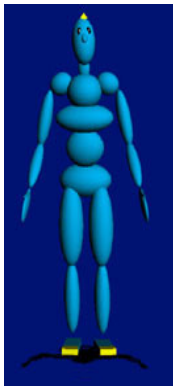

Making sense of raw data…



# Optical motion capture process

1. Find the skeleton dimensions and exact marker positions on the body
2. Perform a motion trial
3. Compute marker positions from camera images
4. Identify and uniquely label markers
5. **Calculate joint angles from maker paths**

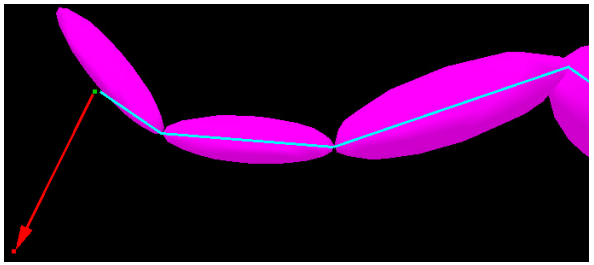
# IK Problem Definition



1. Create a handle on body
   - position or orientation
2. Pull on the handle
3. IK figures out how joint angles should change



# Inverse Kinematics

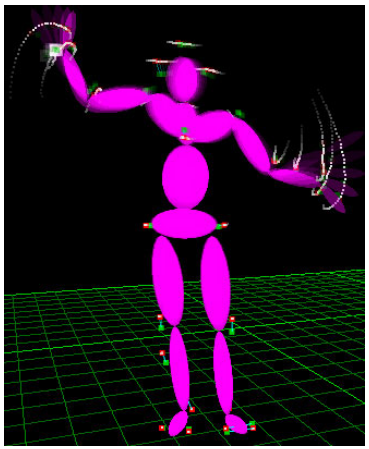


*Inputs:*
An articulated skeleton with handles. Desired positions for handles.

*Outputs:*
Joint angles that move handles to desired positions.



# Inverse Kinematics (con't)



We are solving IK on a complex model (~50 DOFs and 30 handles).

Motion capture data often contains missing markers.

Many different formulations for IK problem, would like to use one that is best for motion capture data.



# More Formally

**Let:**

**q** **actor *state vector* (joint bundle)**

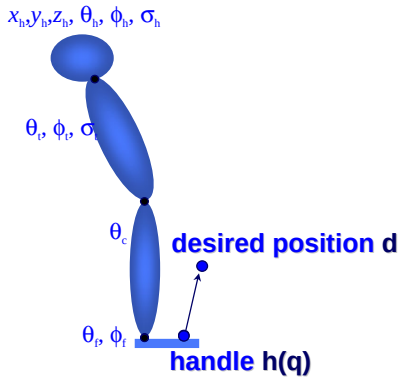
**C(q)** **constraint functions that pull handles**

**Then:**

**solve for q such that C(q) = 0**

# What's a Constraint?

$q=[\ x_h, y_h, z_h, \theta_h, \phi_h, \sigma_h, \theta_t, \phi_t, \sigma_t, \theta_c, \theta_f, \phi_f\ ]$

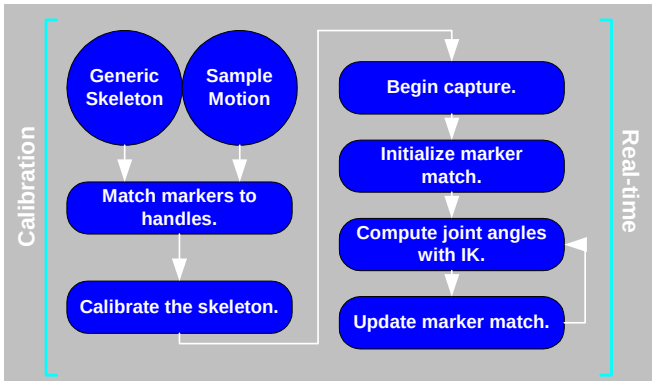



- Can be rich, complicated
- But most common is very simple:
- Position constraint just sets difference of two vectors to zero:

$$C(q) = h(q) - d = 0$$



# Real-time Motion Capture






# Motion capture as UI

- Map a "whiteboard space" anywhere
- Use acting for animation interface



# Motion Transformation

- Start with a mocap sequence
- Edit it to fit the needs of the animation
- Try to be as close to the original motion as possible