# Computer Animation and Games I

## CM50244

# Skeletal Motion Capture

Some slides from Prof. Christian Theobalt, MPII

# Overview

- **Recap pre-knowledge of skeletal motion capture**
  - Motion capture
  - Skeleton structure and motion
- Skeletal Motion Capture and Main Technologies
- Marker based Skeletal Motion Capture

# Recap: Motion Capture

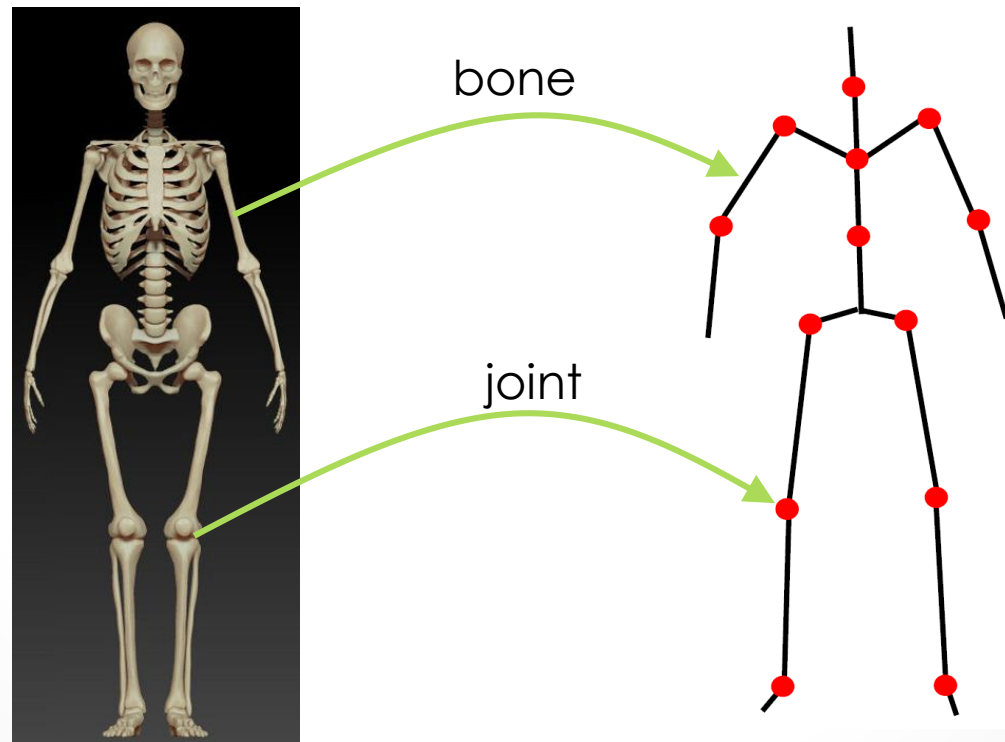- Record live action
- Transform to virtual character

# Motion Capture in Movies



[Avatar - Making of]

# Recap: Skeleton Structure

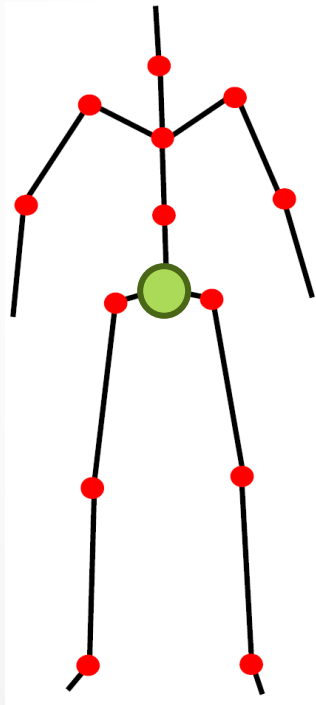- Animation/kinematic skeleton: inspired by anatomic skeleton



bone

joint

Anatomic skeleton

Kinematic skeleton

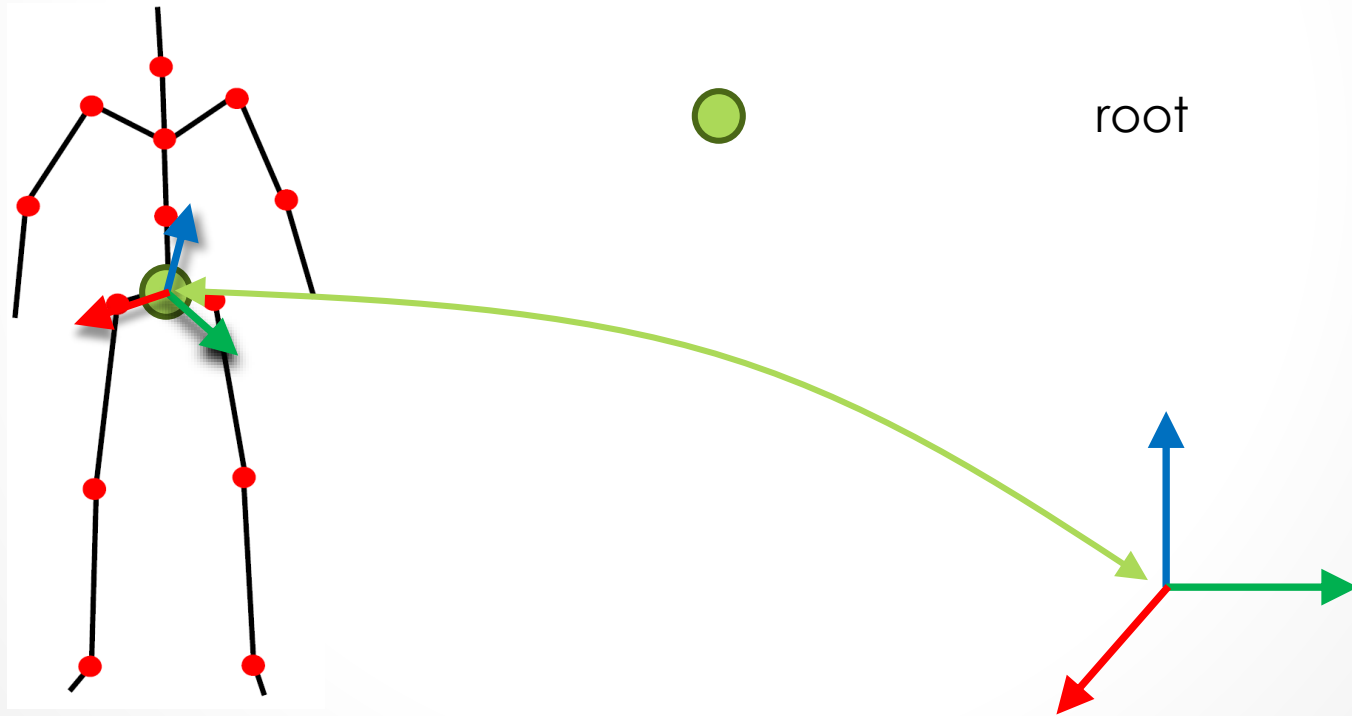# Recap: Skeleton Structure

- Skeleton = tree.



root

Kinematic skeleton

# Recap: Skeleton Motion

- Skeleton = tree.
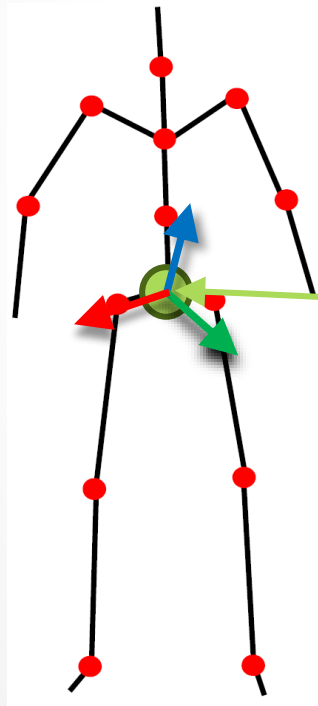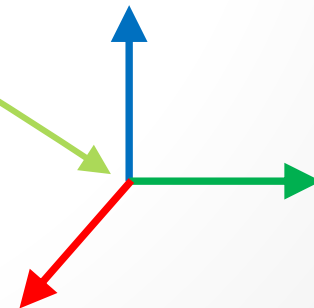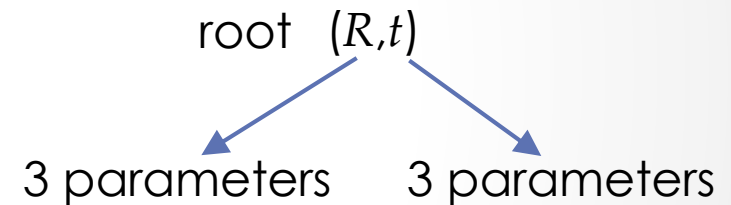- Joints = predefined transformations in an coord. frame

root

Kinematic skeleton

World coordinate frame

# Recap: Skeleton Motion

- Skeleton = tree.
- Joints = predefined transformations in an coord. frame



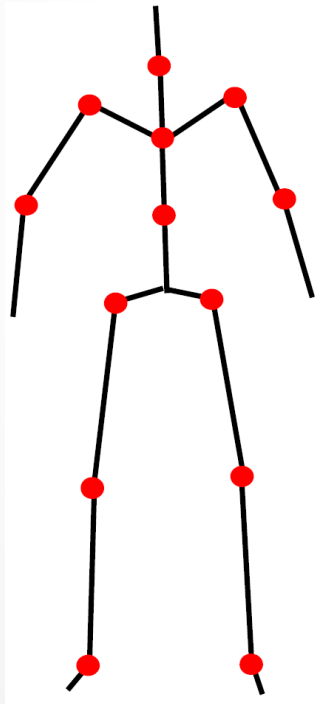root   $(R,t)$

3 parameters     3 parameters
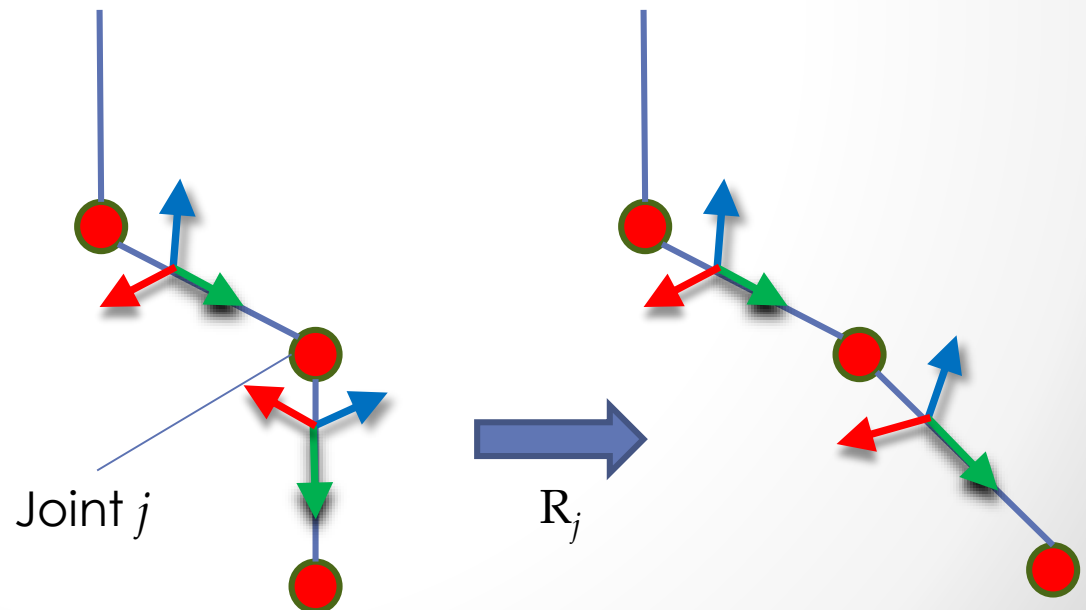
Kinematic skeleton

World coordinate frame

# Recap: Skeleton Motion

- Skeleton = tree.
- Joints = predefined transformations in an coord. frame
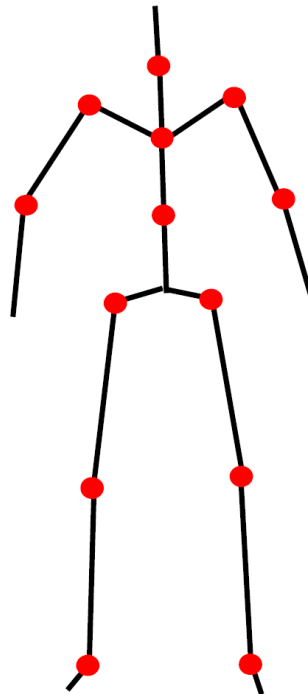- Hierarchy of transformations (usually rigid body)

Other joints – relative transformation, bone length fixed

Kinematic skeleton

Joint $j$

$R_j$

# Recap: Forward Kinematics

- Find joint parameters: $(R_{\mathrm{root}}, t_{\mathrm{root}})$, $(R_1, t_1)$, …, $(R_n, t_n)$.
- Around 40+ parameters (degrees of freedom).
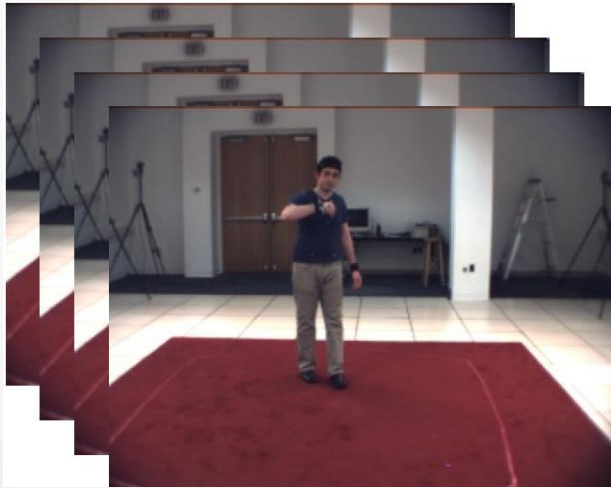- For every time step of a motion.
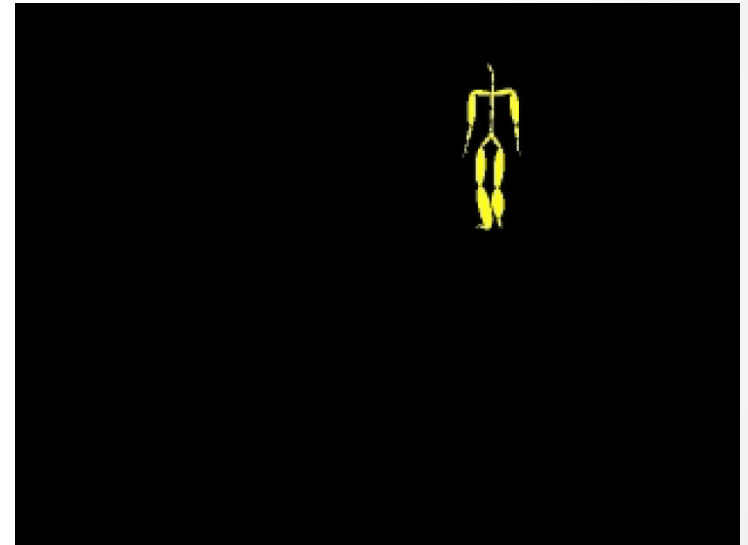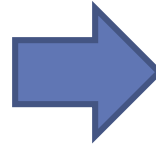
Kinematic skeleton

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- Marker based Skeletal Motion Capture

# Skeletal Motion Capture



Sensor data

Model: Kinematic skeleton

# Motion Capture Technology (1)

- Sensor (active sensing) based systems
  - accelerometer, gyroscope, etc.

[Metamotion]

[Xsens]

# Motion Capture Technology (2)

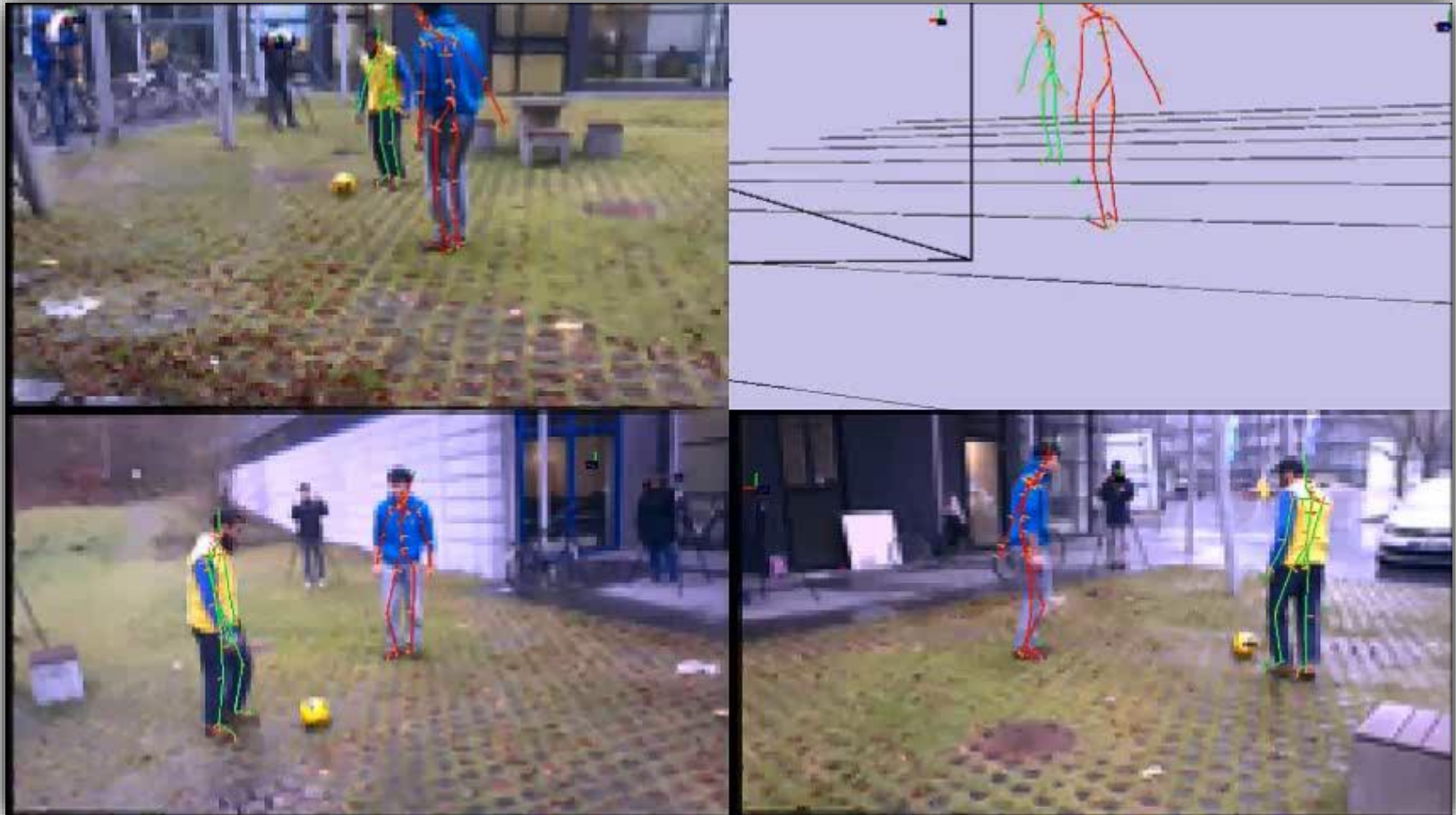- Marker-based optical systems



Passive retroreflective markers



Active markers

# Motion Capture Technology (3)
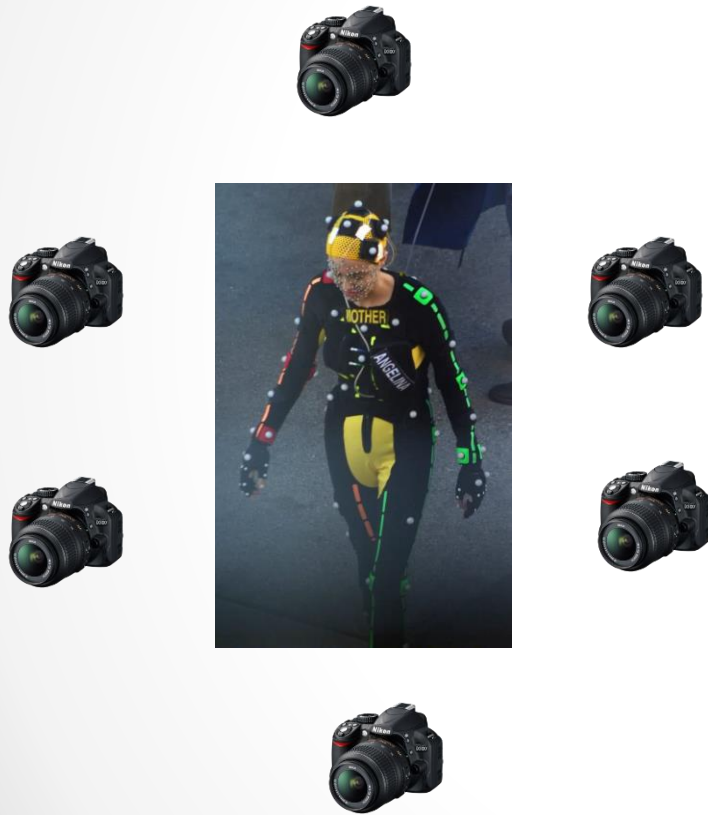
- Marker-less motion capture



[Elhayek et al., Outdoor human motion capture by simultaneous optimization of pose and camera parameters, Computer Graphics Forum, 2014]
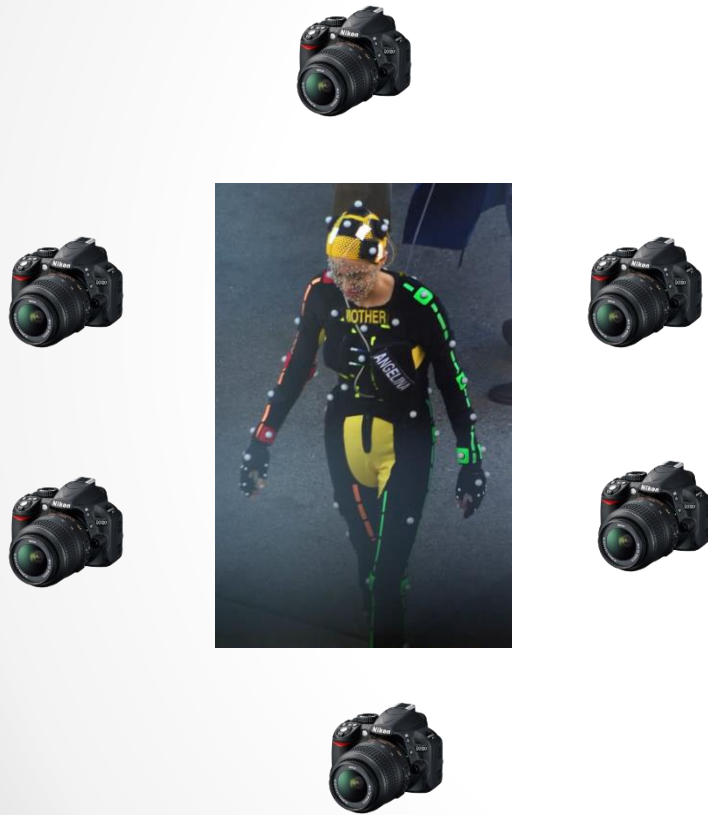
# Overview

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- **Marker based Skeletal Motion Capture**
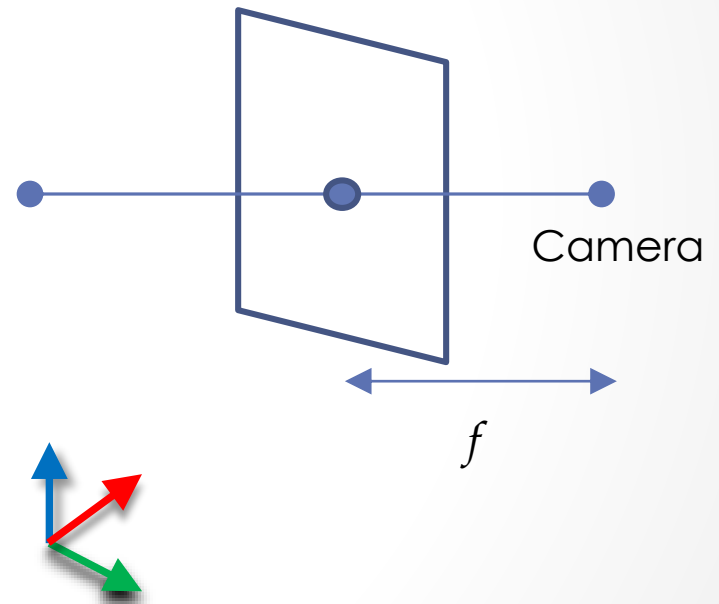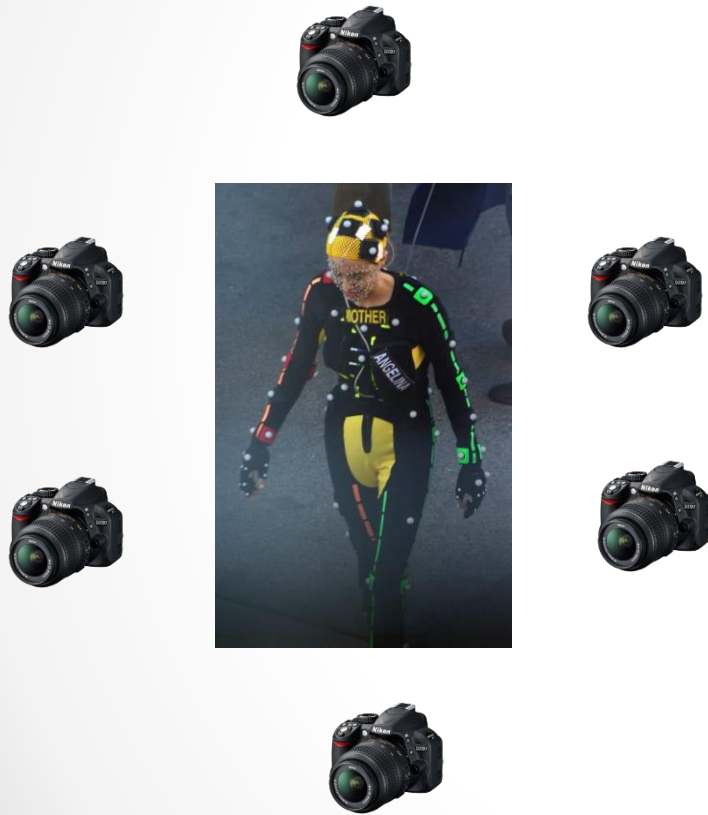
# Marker-based Motion Capture

Calibration

# Marker-based Motion Capture

Calibration

Camera

$f$

# Marker-based Motion Capture
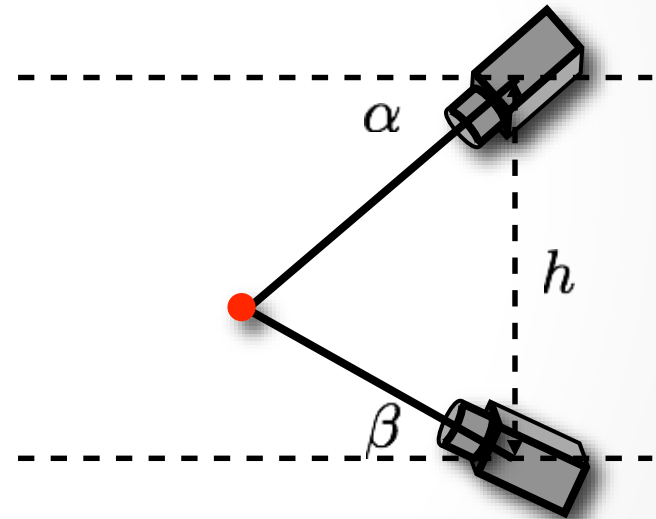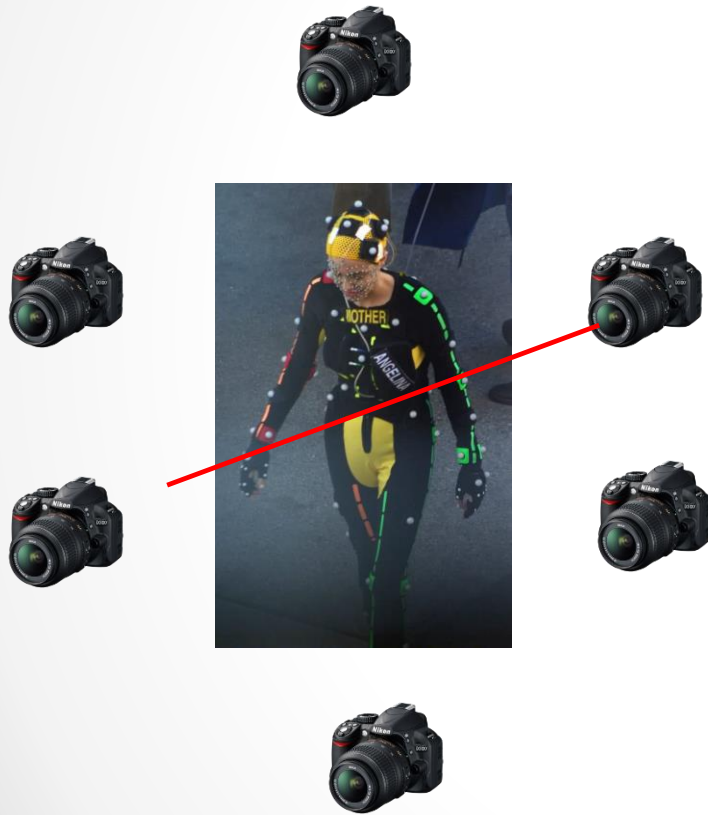


Calibration

Passive markers:
IR filters + IR light on camera

# Marker-based Motion Capture

- Triangulation and tracking.



Triangulation → 3D position

# Marker-based Motion Capture
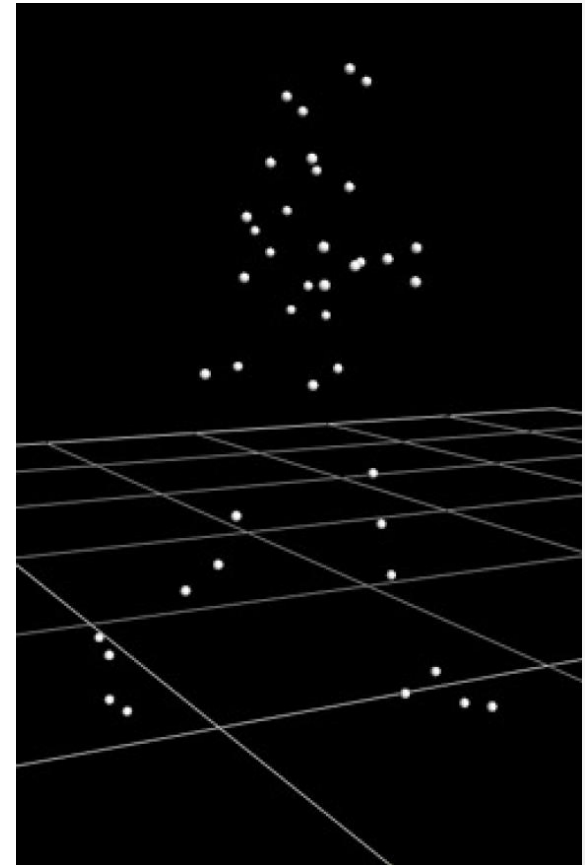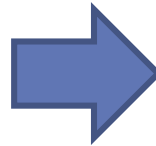
- Triangulation and tracking.



Triangulation → 3D position

# Marker-based Motion Capture
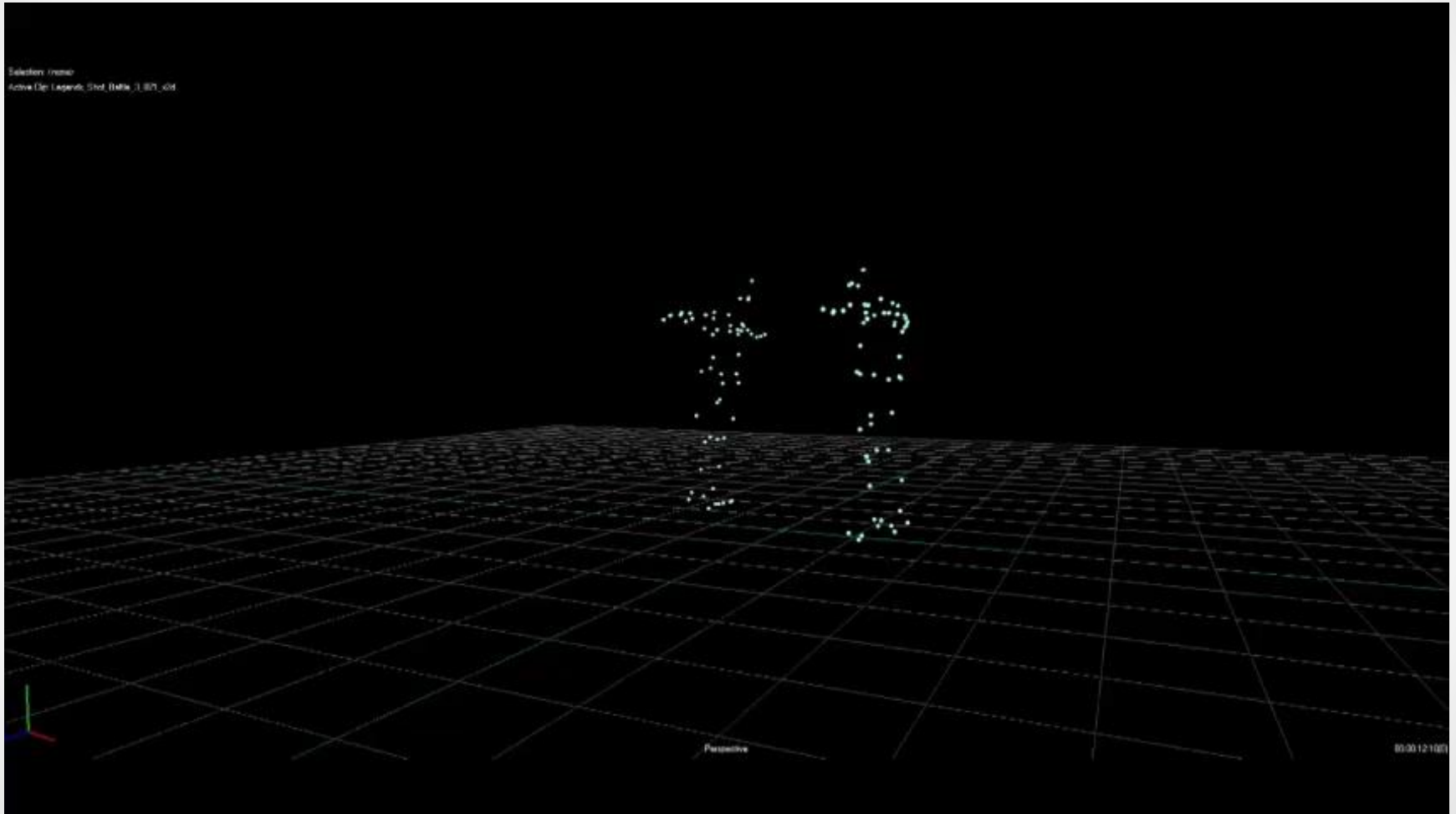
- Triangulation and tracking.



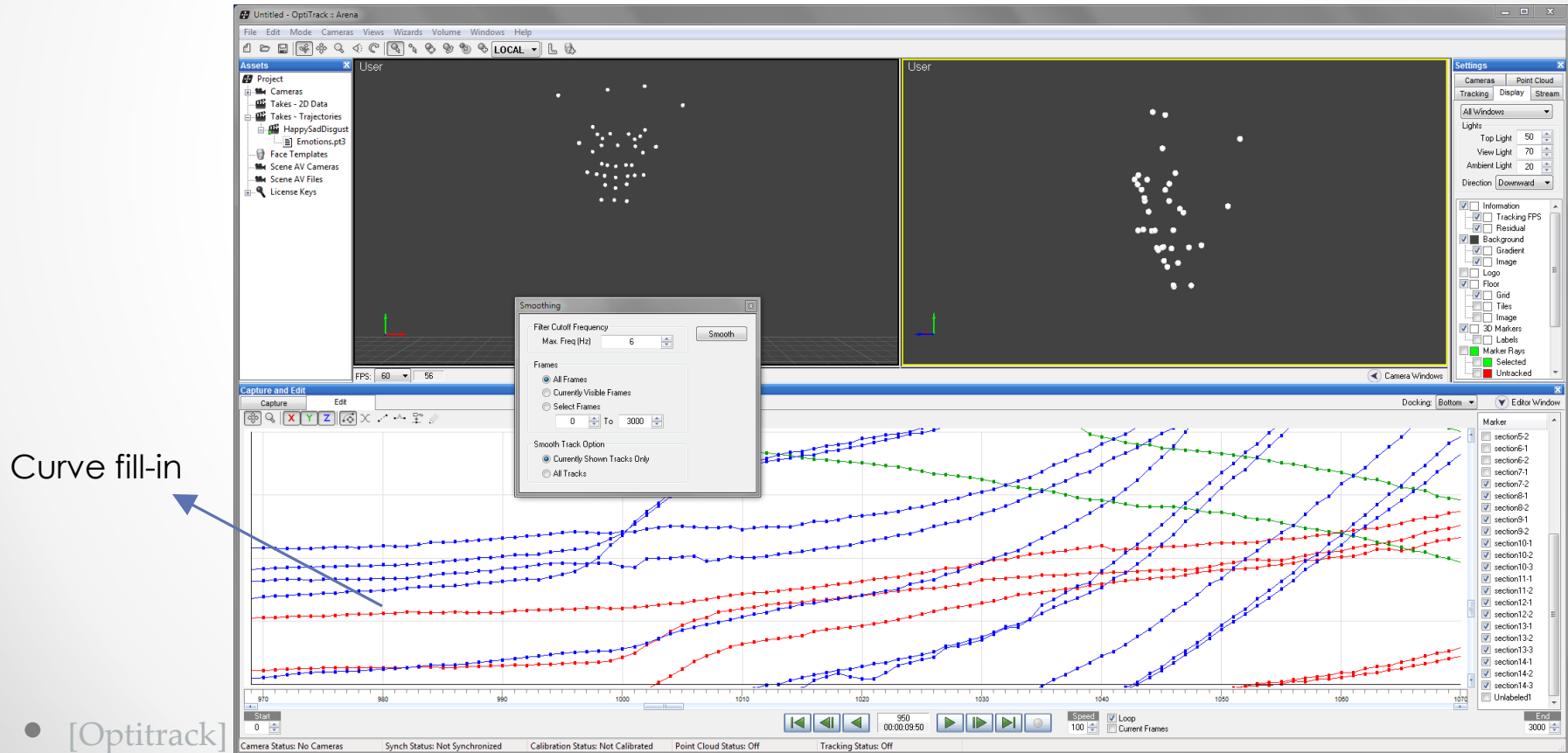Triangulation → 3D position



[Carleton University]

# Marker-based Motion Capture: Step 1



[Motion Capture Processing 102 - Youtube]

# Marker-based Motion Capture: Step 2

- Marker cleanup
  - Repair broken trajectories.
  - Semi-automatic – vendor specific tools.
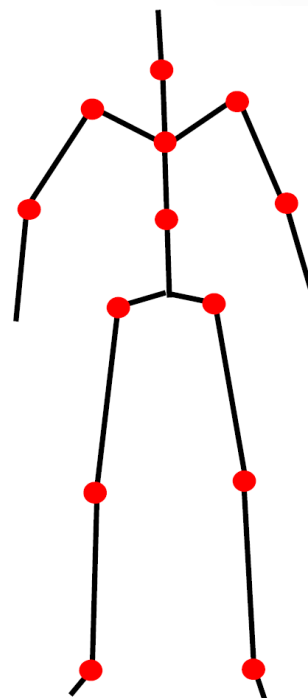


Curve fill-in

[Optitrack]

# Marker-based Motion Capture: Step 3



[O'brien,
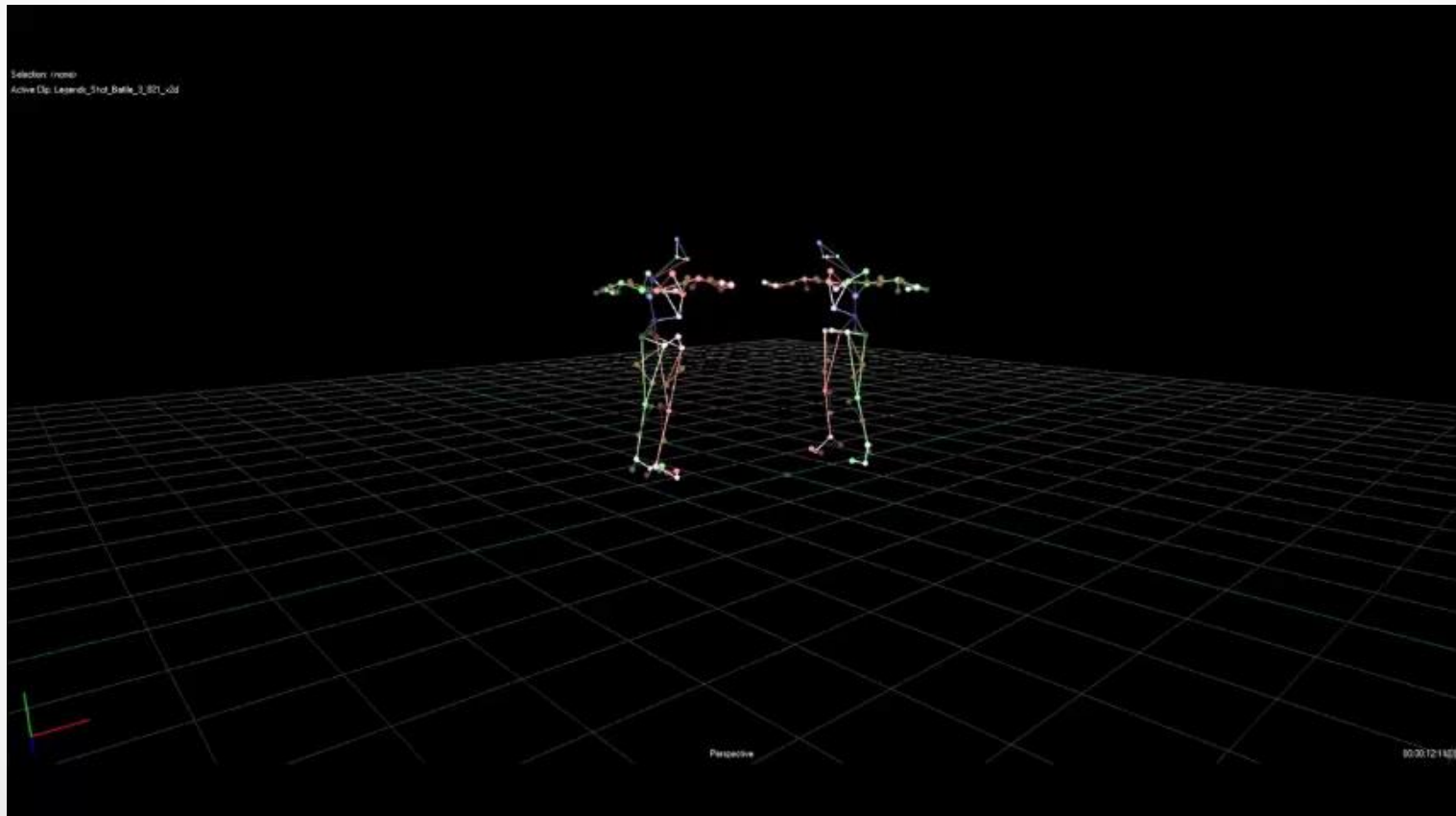UC Berkeley]

Initialization motion

- Rigid segments with IDs of attached markers.
- Bone lengths.
- Joint locations

Adam G. Kirk, James F. O'Brien, and David A. Forsyth. 2005. Skeletal Parameter Estimation from Optical Motion Capture Data. CVPR *2005*.
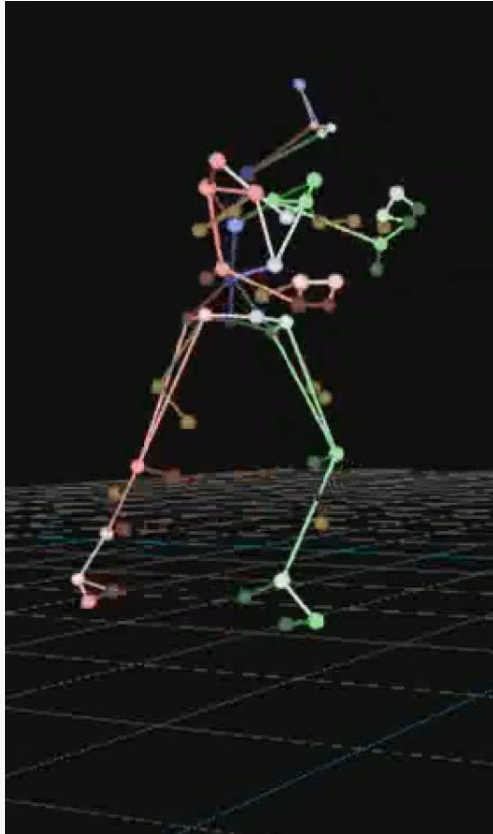
# Marker-based Motion Capture: Step 3

- Labeled marker sets (body segments).
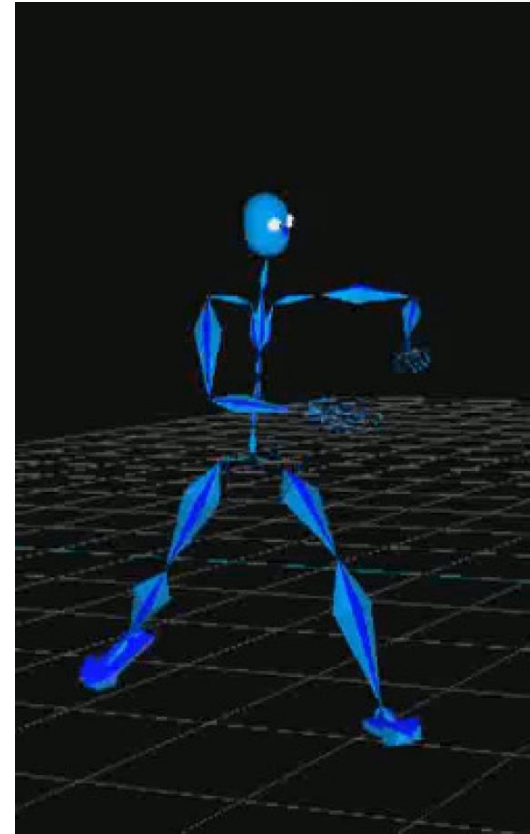- Most software – joint locations over time.



[Motion Capture Processing 103 - Youtube]

# Marker-based Motion Capture: Step 4
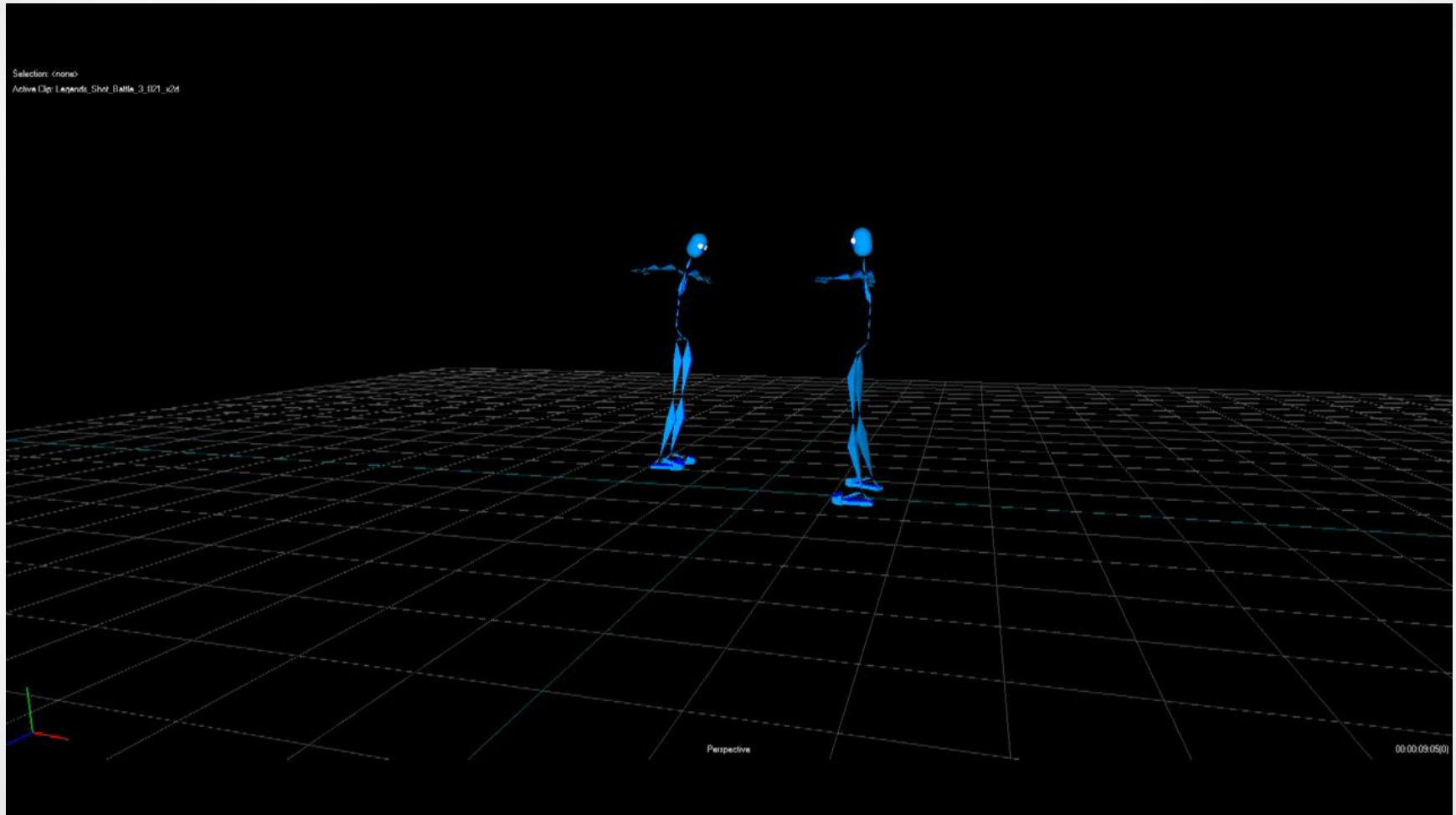
- Inverse kinematics / skeleton solve



- (labeled) marker trajectories.
- Joint positions.

- Bones.
- Parameters for all joints $(R_{\text{root}}, t_{\text{root}})$, $(R_1, t_1)$, …, $(R_n, t_n)$.

# Marker-based Motion Capture: Step 4



[Motion Capture Processing 105 - Youtube]

[Rise of the tomb raider]