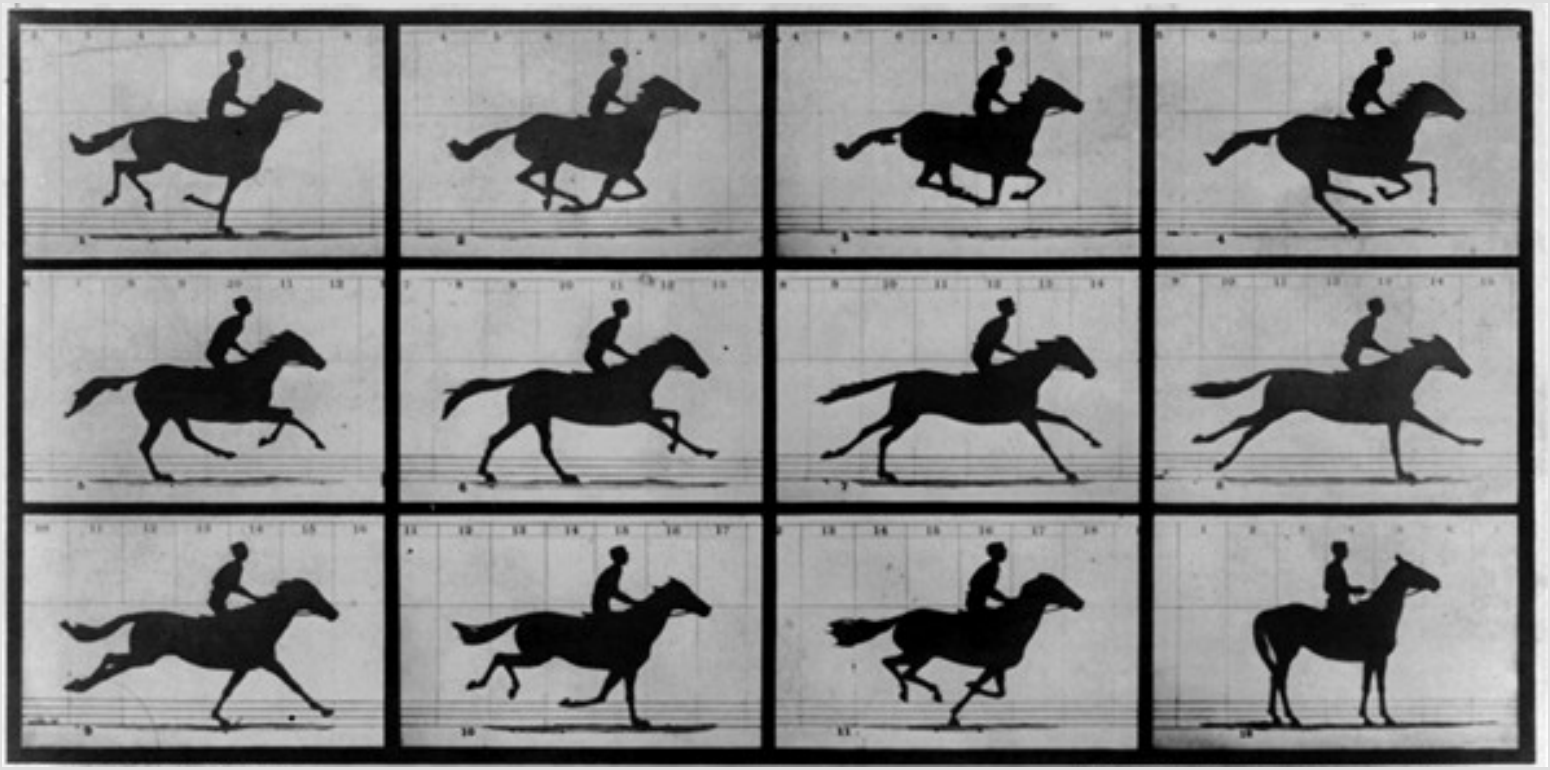
Motion Capture (Mocap)

- Process of translating a live performance into a digital performance

History of Mocap

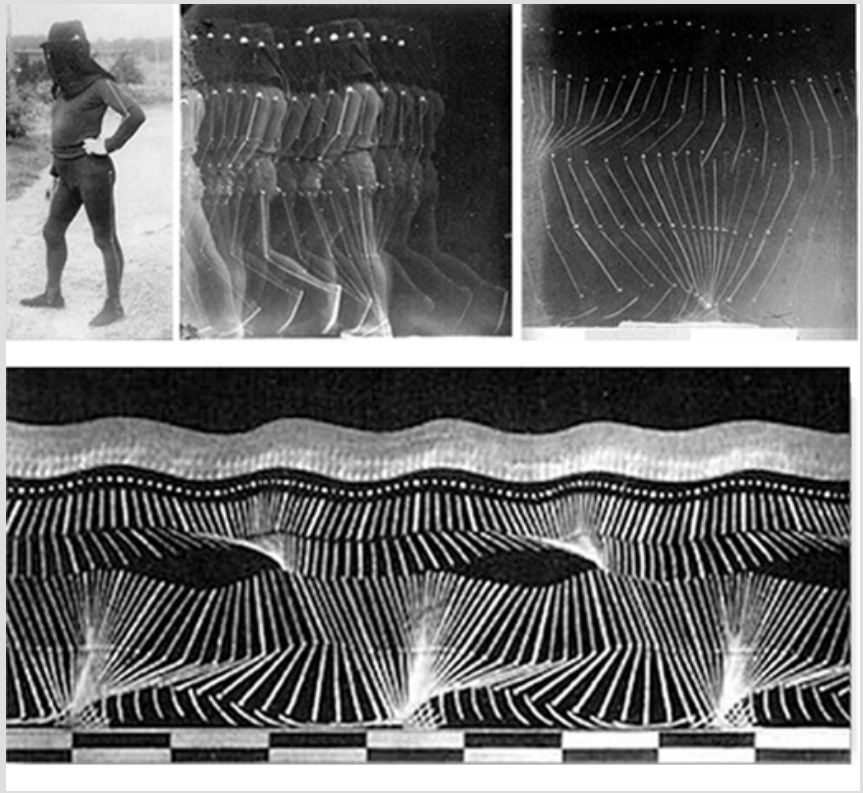
- Early attempts to capture motion long before computer technology became available
- Eadweard Muybridge (1830-1904)
  - Recorded sequential images on disks in rapid succession
  - One of the earliest motion picture devices
  - Developed to settle a bet on whether all four feet of a horse leave the ground simultaneously or not

A Horse in Motion



First motion capture suit

- Etienne-Jules Marey (1830-1904)



Rotoscoping

- 1917 Max Fleischer
- Rotoscoping is an animation technique in which animators trace over live-action film movement, frame by frame, for use in animated films

Rotoscoping

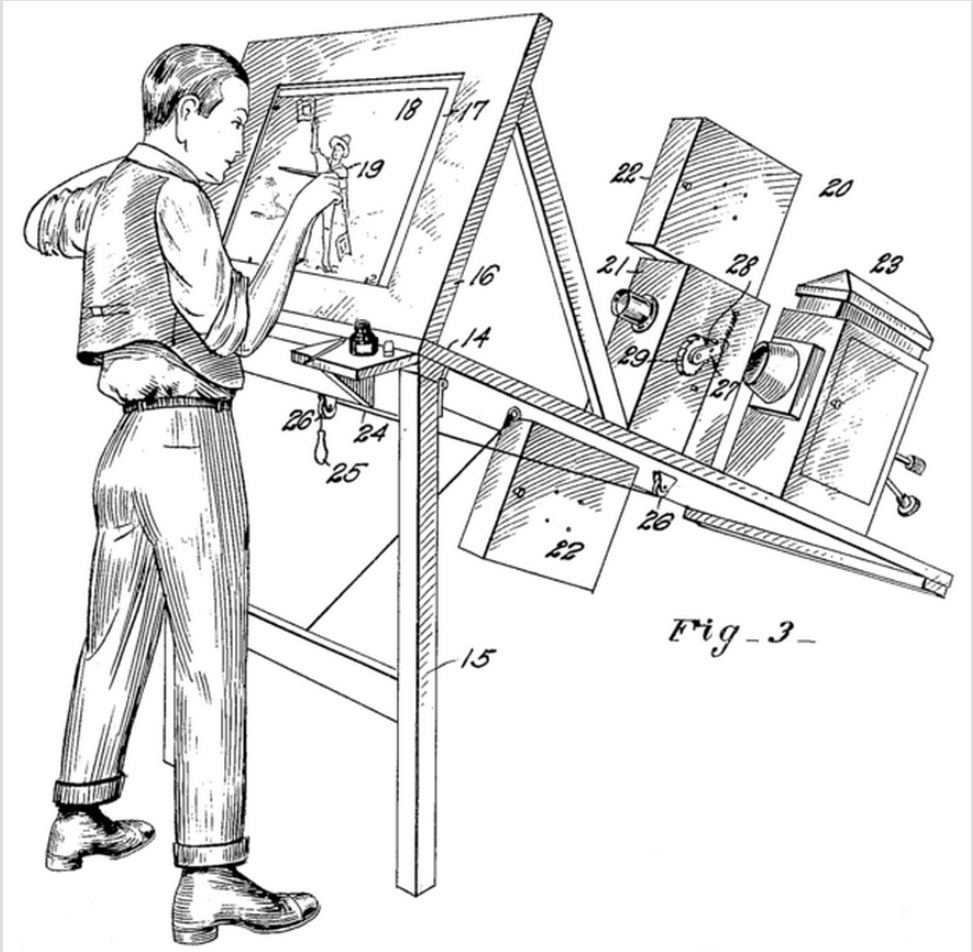
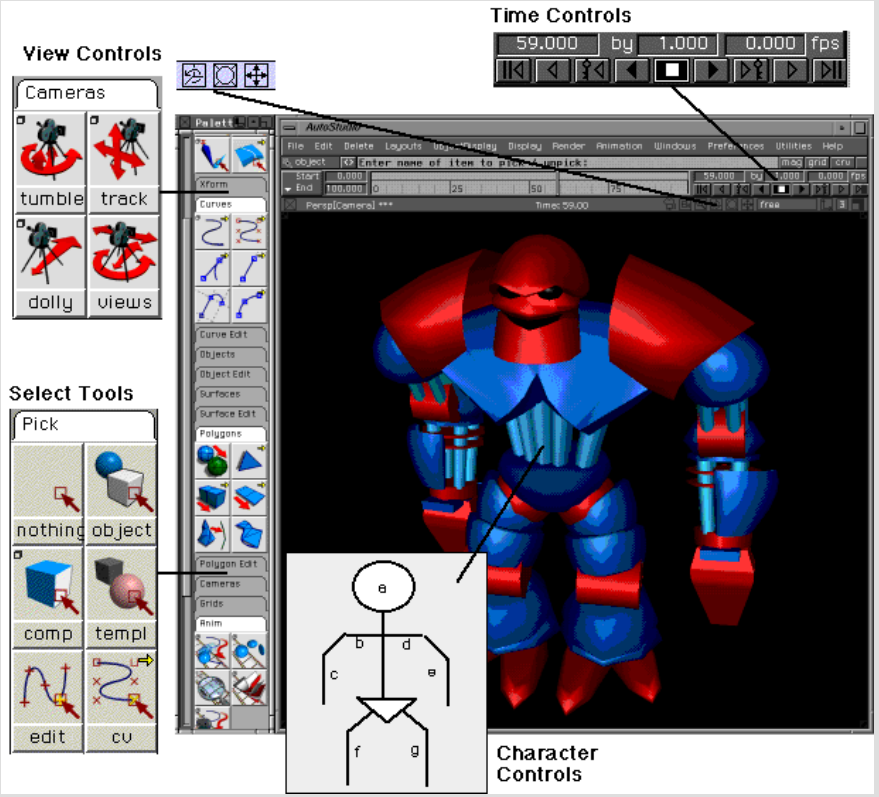


Fig - 3 -

Rotoscoping

- Disney
  - Stepmother <-> Eleanor Audley

Motion Data for Animation



Keyframe animation

Motion capture

Motion Capture in Games

- Game development is the largest market for motion capture.
- Generally there are two main types of 3D character animation used in games
  - Real-time playback allows the game player to choose from pre-created moves, thus controlling the character's moves in real-time.
  - Cinematics are the fully rendered 'movies' used for intros and 'cut-scenes'.

Motion Capture in Games

- Videogames' ability to tell stories has evolved rapidly over the last 20 years
  - Rolling text is gone, replaced with voice acting and near-photorealistic graphics
- Look and sound real, but don’t always feel real
  - Subtle body language missing

- Using motion capture, and in particular performance capture (dialogue is recorded at the same time), games can draw the players into the story more completely

Motion Capture in Games

- Meaning and **emotion** are conveyed not through dialogue, but through facial and body movements.
  - A curved lip suggests passion, a furrowed brow indicates fear, a raised arm, anger.

Enslaved: Odyssey to the West

Motion Capture in Games

Telling stories by having these games display complex emotions and ethical and moral choices that lead to significant consequences

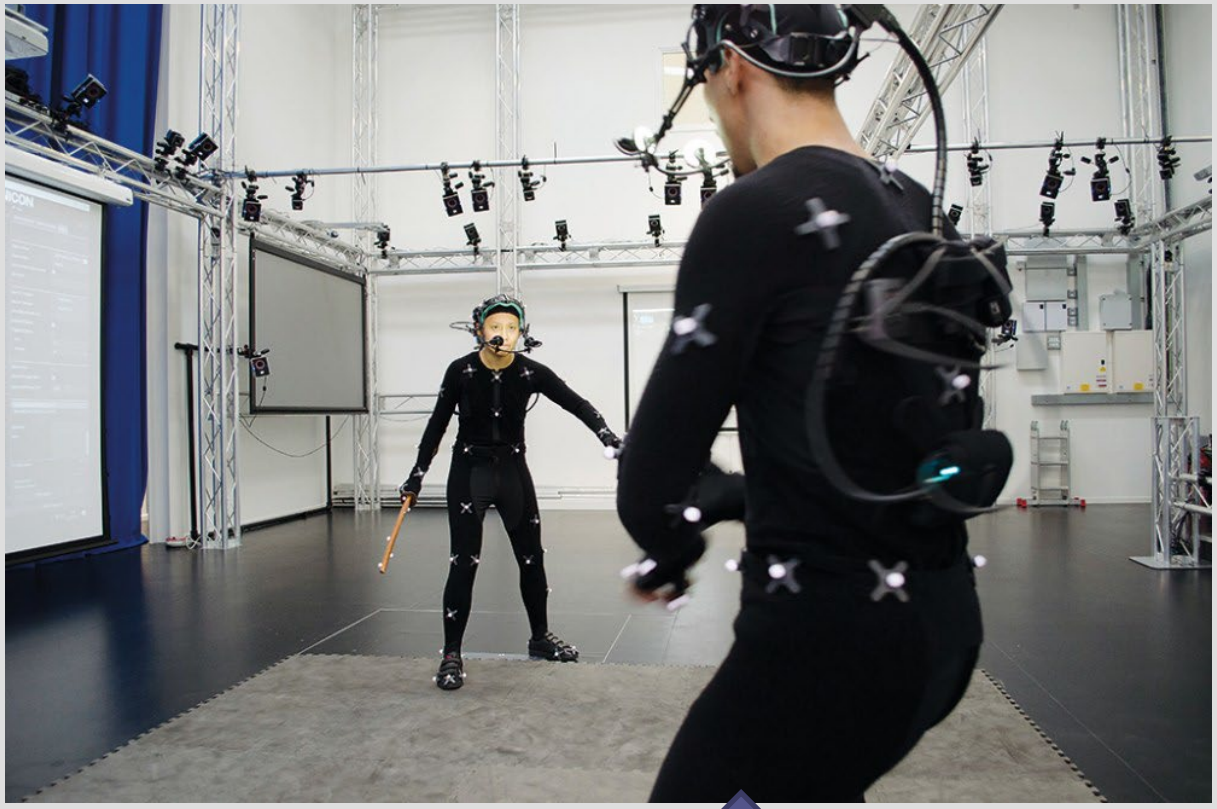
Beyond Two Souls

Motion Editing

- Most areas of computer animation have been pioneered by the research and special effects industries

- Motion editing, however, is one area where **video games** have made a lot of real progress towards achieving interactively controllable and AI characters in complex environments…

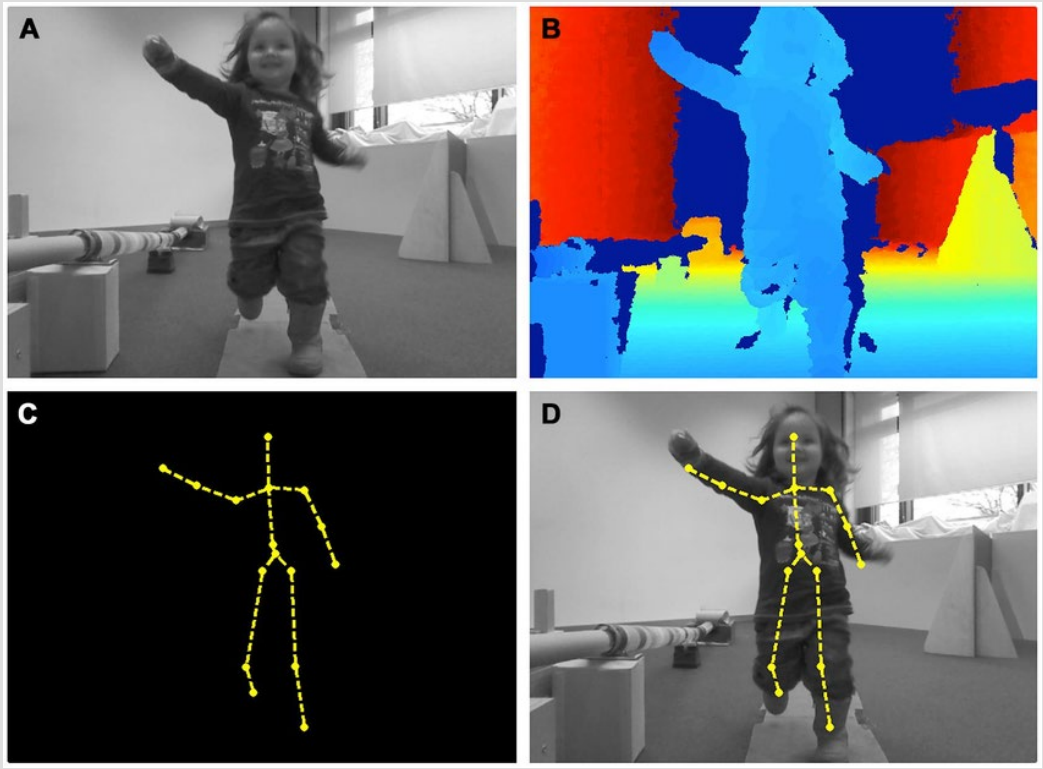
Types of Motion Capture



Optical

Inertial

Types of Motion Capture



Markerless motion capture

Types of Motion Capture

The Relightables: Volumetric Performance Capture of Humans with Realistic Relighting

Volumetric capture

Mocap vs Traditional animation

- Advantages
  - **Realistic** human motion
  - More **rapid** results can be obtained
  - The amount of work does not vary with the complexity or length of the performance
  - **Complex movement** and realistic **physical** interactions can be easily re-created
  - Mocap technology allows one actor to play multiple roles within a single film.

Mocap vs Traditional animation

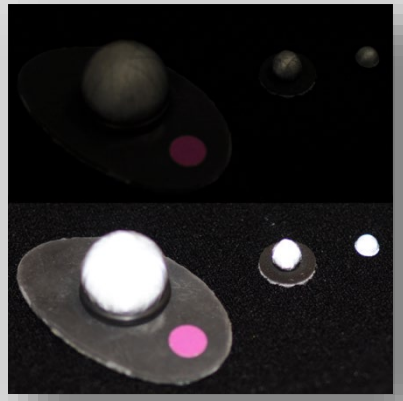
- Disadvantages
  - Specific **hardware** and special programs are required to obtain and process the data.
  - **Cost**
  - **Space** requirements
  - Reshoot
  - If the computer model has different proportions from the capture subject artifacts may occur
  - The real life performance may not translate on to the computer model as expected.

Applications

- Medicine
  - Gait analysis
  - Prosthetic design
- Sports
  - Improve performance of athletes
  - Golf swing analysis
- Entertainments industry
  - Video games, television, feature films

Optical Motion Capture Systems

- Single computer controller
- No wires or electronic equipment necessary
- Cameras have own light sources
  - Infrared to avoid visual distortion to user
- Marker spheres
  - Range in size depending on capture area
  - Reflective material
- Cameras adjusted so
  - Narrow range of sensitivity to light
  - Only the bright markers will be sampled ignoring skin and fabric



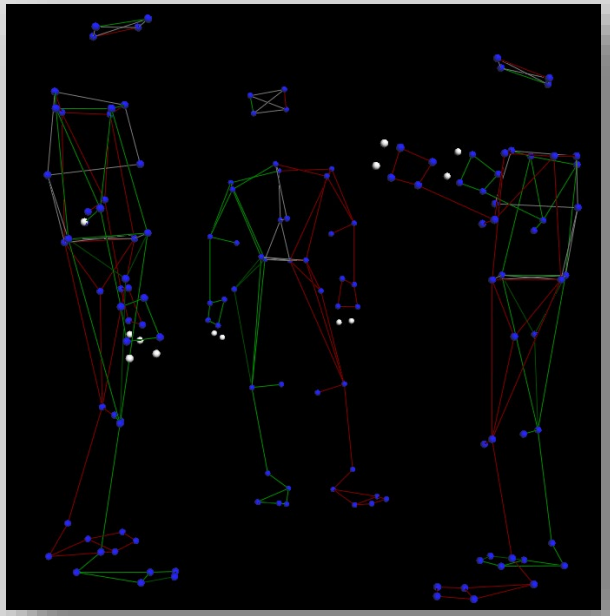
Planning & Directing Mocap

- Is motion capture necessary for project?
  - Do you want realistic motion?
  - Is character human shaped?
  - Motions beyond physical boundaries?
  - Will shot fit within capture volume?
  - Blend shots after capture?
- Goal:
  - To end up with hundreds of individual moves that connect perfectly to one another

Capture Session

- Calibrate cameras
- Volunteer suits up
- Markers on
- T pose to allow system to figure out joints
- Name the markers on the system
- Capture some motions
- Postprocess
- Export to 3D Studio Max
- Apply to character
- Make State Machine
- Export to real-time system for playback

Capture & Post-processing

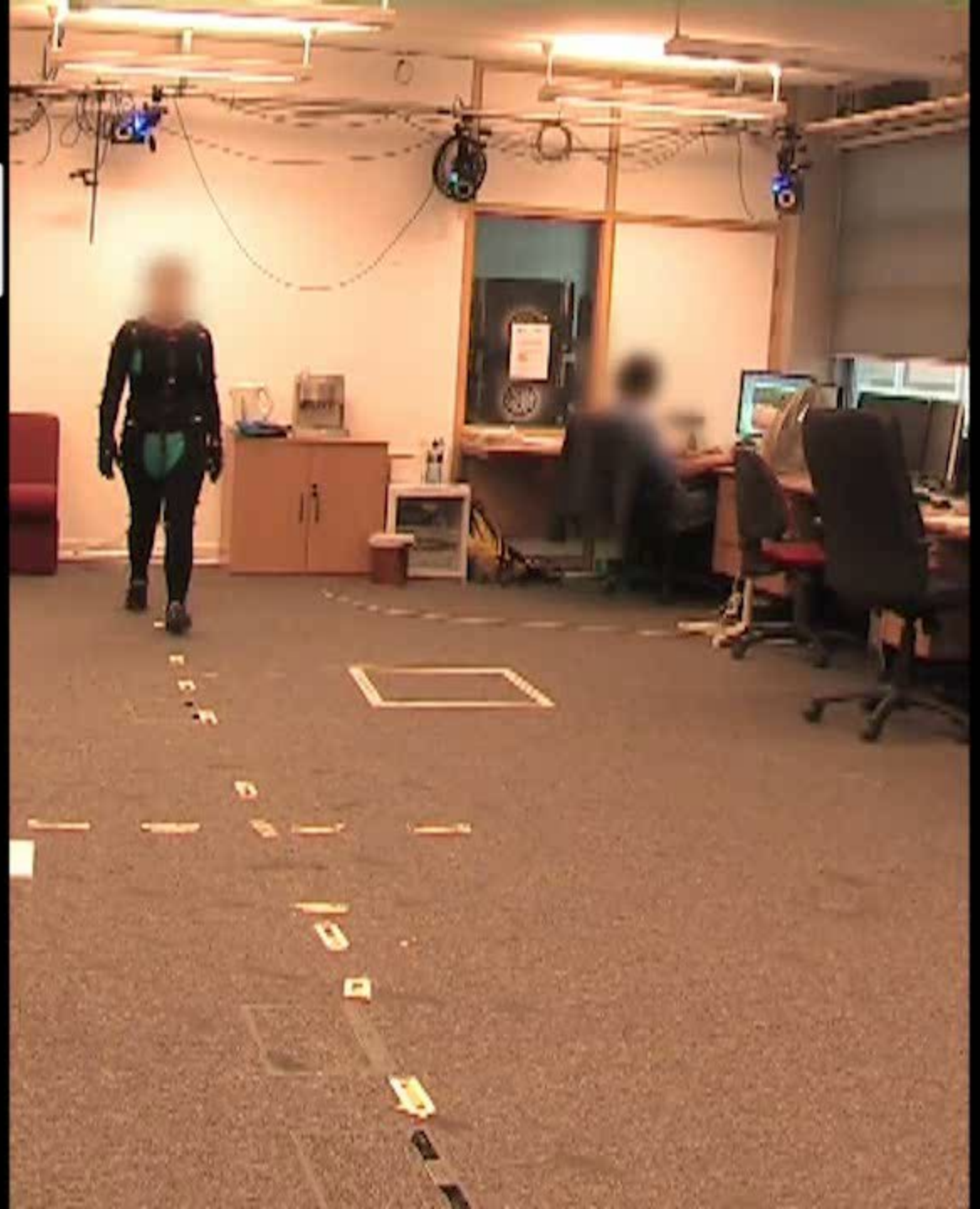


Motion Capture

Skeleton Fitting

2-cycles Looping

Retargeting on model



Apply to Virtual Character

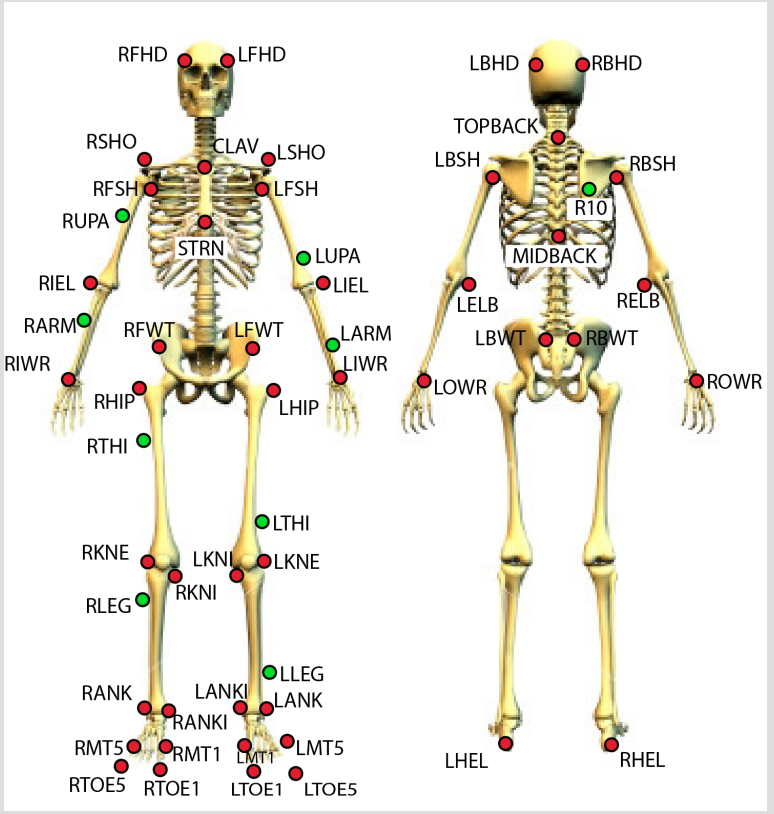
Calibration

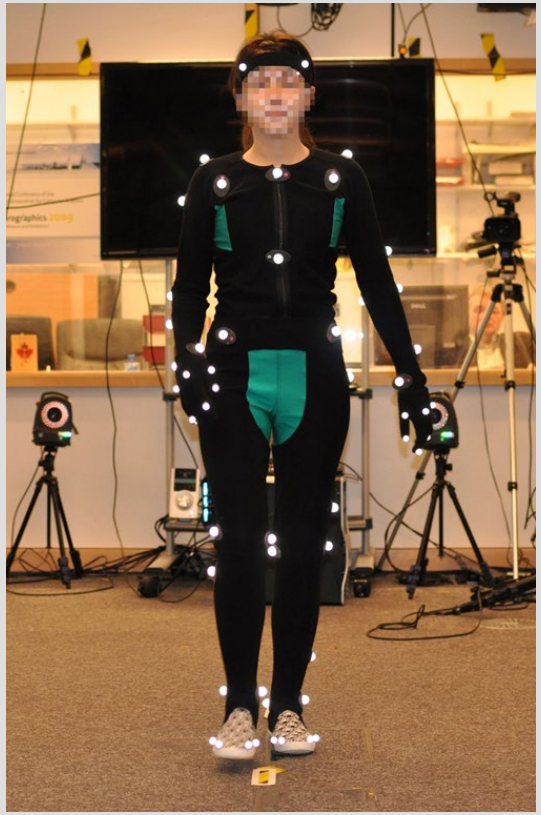
- Object of known dimension
- Tracked by all cameras
- Combines view of object from all cameras
  - Exact position of each camera in space can be calculated

Markers

- Placing markers
  - Set of 45+ placed on the body of the actor

- Rotational information must be inferred from the relative orientation of three or more markers

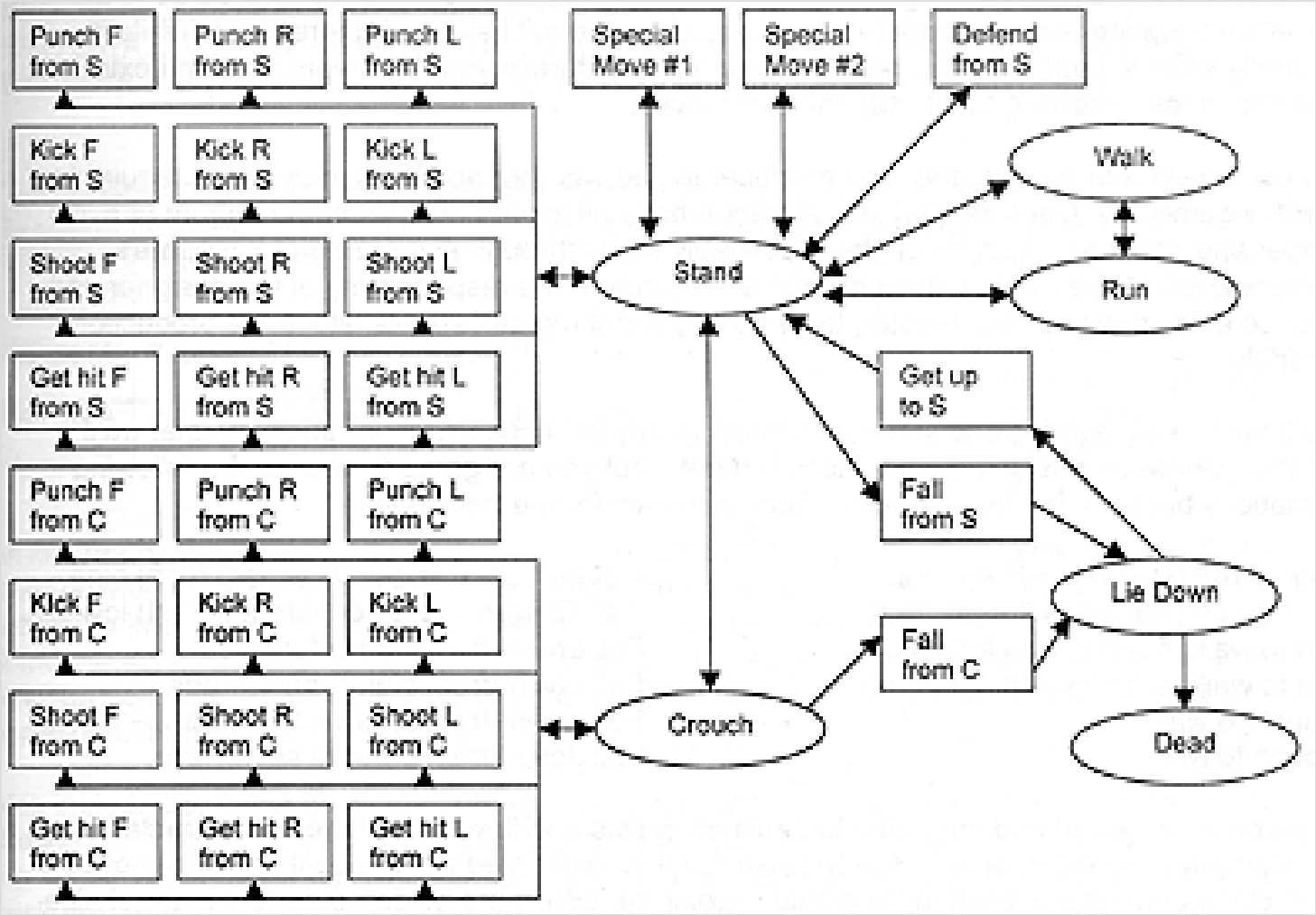




Flow charts

- List characters in game
- List motions for each character
  - Stand (rest frame)
  - Walk
  - Run Defend (from stand)
  - Punch forward/right/left (from stand)
  - Get hit forward/right/left (from stand)
  - Kick forward/right/left (from stand)
  - Get hit forward/right/left (from crouch)
  - Shoot forward/right/left (from stand)

Flow Chart

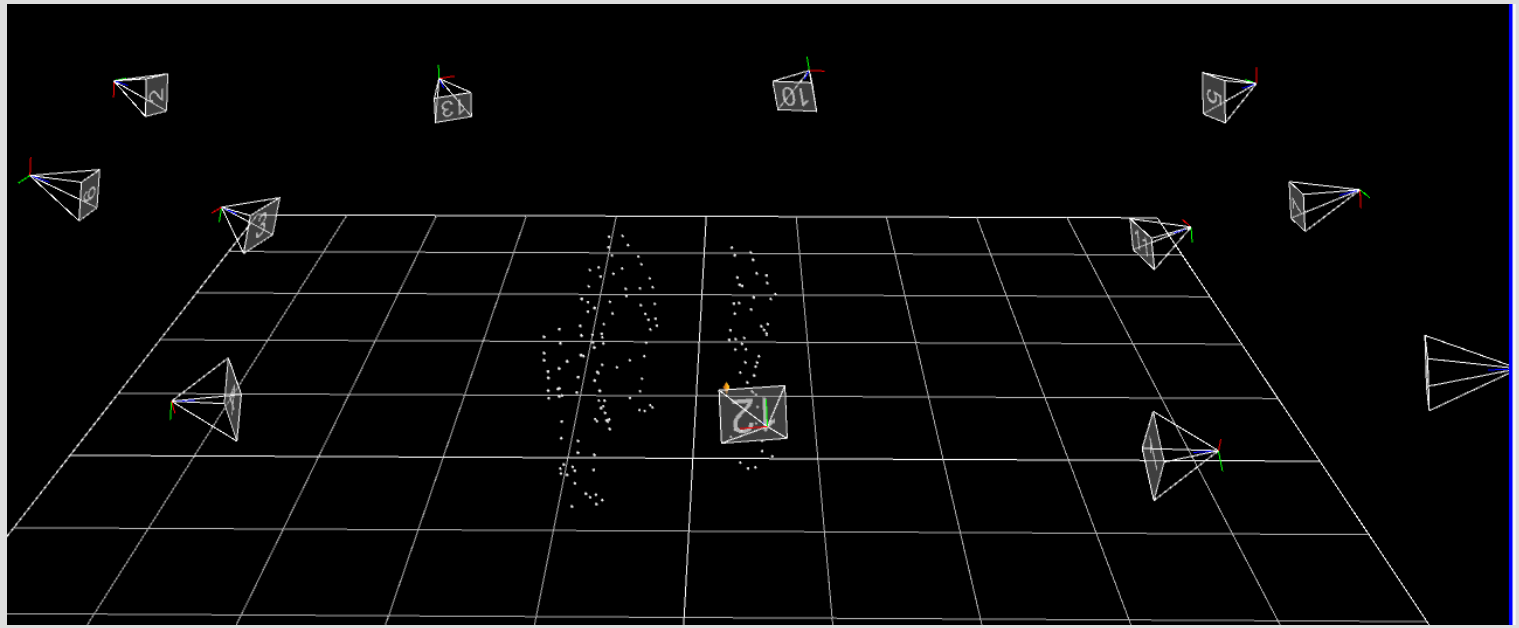

Punch F from S
Punch R from S
Punch L from S
Special Move #1
Special Move #2
Defend from S
Kick F from S
Kick R from S
Kick L from S
Walk
Shoot F from S
Shoot R from S
Shoot L from S
Stand
Run
Get hit F from S
Get hit R from S
Get hit L from S
Get up to S
Punch F from C
Punch R from C
Punch L from C
Fall from S
Kick F from C
Kick R from C
Kick L from C
Lie Down
Fall from C
Shoot F from C
Shoot R from C
Shoot L from C
Crouch
Dead
Get hit F from C
Get hit R from C
Get hit L from C

Transitions

- Transition list
  - Walk to run (starting with left foot)
  - Get hit from stand (forward/right/left) high
  - Walk to run (starting with right foot)
  - Get hit from stand (forward/right/left) low
  - Run to walk (starting with left foot)
- Estimated frame count for each move

Labelling

- All markers need labels or identifications associated with them
- System needs to know which markers belong where
- Rely on user to give this information

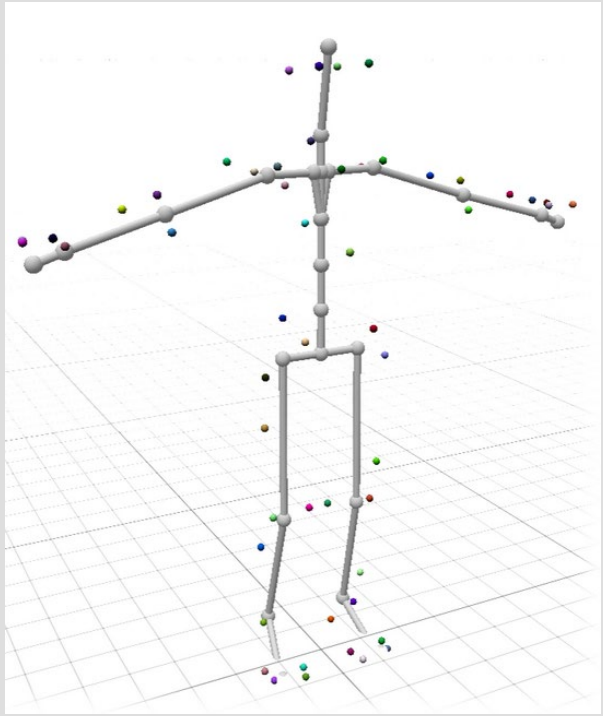


Output from Mocap Systems

- Marker formats
  - Marker trajectories over time
  - Examples: .c3d, .trc
- Skeleton format
  - Static information for joint hierarchy
  - Time-varying information containing the values for each DOF for each joint
  - Examples: .asf, .asm, bvh

Fitting a Skeleton

- 2 Main approaches:
  - Complex optimisation (learning skeleton morphology and relations between segments and markers)
  - Or done using IK where the joint angles are computed, based on the marker positions



Static Joint Hierarchy Information

Example: Biovision Hierarchy (BVH) character animation file format

```
HIERARCHY
ROOT Hips
{
    OFFSET 0.0000 0.0000 0.0000
    CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
    JOINT Chest
    {
        OFFSET 0.0415 6.2451 0.0203
        CHANNELS 3 Zrotation Xrotation Yrotation
        JOINT Chest2
        {
            OFFSET 0.0118 22.5192 -0.7792
            CHANNELS 3 Zrotation Xrotation Yrotation
            JOINT LeftCollar
            {
                OFFSET -0.3300 25.0202 0.8579
                CHANNELS 3 Zrotation Xrotation Yrotation
                ……
```

DOFs

Indentation for parent-child relationship

Time-Varying Data

Example: Biovision Hierarchy (BVH) character animation file format

Time Varying data: used to reconstruct joint angles over some number of frames

Number of values on a line corresponds to the total DOF of the figure, in order specified in hierarchy

Each line is one time sample

MOTION

Frames: 249

Frame Time: 0.033333

222.8010 100.6304 -172.3542 -0.32 -1.59 0.83 0.33 6.47 -1.53 0.31 6.46 -1.51 -4.54 -0.04 0.51 17.00 5.39 -47.37 3.99 -12.71 -3.05 -9.59 -4.69 13.09 7.12 0.20 1.74 -21.16 5.75 46.06 -8.54 -11.38 2.88 3.42 -7.60 -25.13 0.18 -5.85 -15.86 0.19 -5.86 -15.85 2.79 -7.77 15.17 0.79 17.94 -0.93 -0.79 -8.34 7.07 0.72 -6.75 0.14 0.00 15.56 0.36 -0.82 -7.29 -14.72

1.

222.8698 100.5967 -172.4173 -0.10 -0.94 0.51 0.19 6.09 -1.34 0.17 6.08 -1.32 -4.52 -0.04 0.55 16.94 5.54 -47.53 3.98 -12.79 -3.07 -9.58 -4.22 12.65 7.13 0.18 1.52 -21.19 5.80 46.07 -8.53 -11.55 2.91 2.74 -7.14 -24.68 0.13 -5.99 -15.75 0.13 -6.00 -15.74 2.56 -8.56 15.13 0.79 18.27 -0.94 -0.76 -8.53 7.49 0.32 -7.83 -0.74 -0.00 16.33 0.43 -0.79 -7.64 -13.59

2.

222.9346 100.5648 -172.4255 0.11 -0.51 0.29 0.07 5.81 -1.22 0.05 5.81 -1.21 -4.51 -0.04 0.58 16.86 5.68 -47.65 3.98 -12.78 -3.07 -9.64 -4.23 12.38 7.13 0.16 1.40 -21.22 5.82 45.84 -8.52 -11.67 2.93 2.71 -7.13 -23.82 0.08 -6.07 -15.63 0.09 -6.08 -15.63 2.33 -9.06 15.08 0.79 18.49 -0.95 -0.73 -8.68 7.80 -0.06 -8.57 -1.59 -0.01 16.93 0.50 -0.76 -7.94 -12.59

3.

Applying mocap to a skeleton

- Skeleton-based motion capture
  - Apply directly joint angles
    - If actor and character have different sizes, visual artefacts can appear (footsliding)
  - Use **retargeting**

- Some software use markers directly with retargeting to drive characters (e.g., MotionBuilder)
  - Animation usually less natural
- Controllable animation?
- How to manipulate/edit motions → next lecture






Resources

- BVH files available online
  - http://mocap.cs.cmu.edu/
- Maya Files:
- https://www.motionlibrary.com/
  - "Motion Capture File Formats Explained" Meredith and Maddock

http://www.dcs.shef.ac.uk/intranet/research/public/resmes/CS0111.pdf