Motion Capture

Virtual Human Animation

- Problem #1: create realistic motions
  - Perceptual/visual realism
  - Behavioural realism (similar to what a real human would have done)
- Problem #2: controlling motions
- Problem #3: computation
  - e.g., for interactive applications

Virtual Human Animation

- Two main families of approaches
  - Kinematic models : based on joint trajectories
    - Descriptive models
    - Motion capture
    - …
  - Physical models: based on physical equations of motion (forces, accelerations, masses, etc)
    - Physical controllers
    - Dynamic filters
    - …

Descriptive models

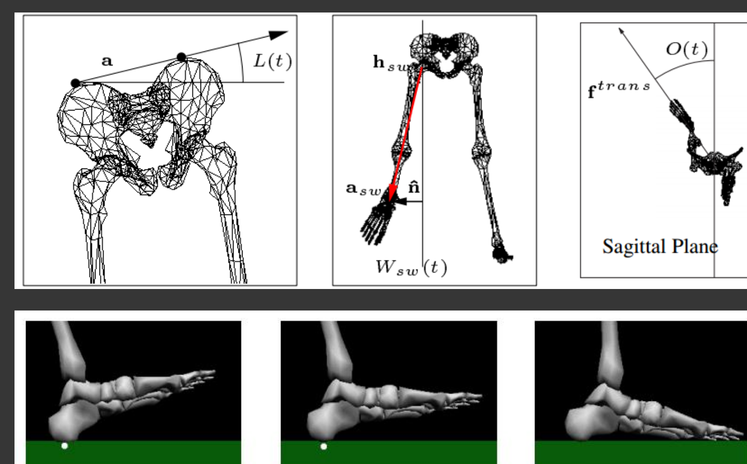
- For well known motions
- Based on knowledge of how joint trajectories are influence by know parameters
  - Based on data averaged over a population
  - New motion requires to determine new laws

Fitts' law

$$T = a + b.I_d = a + b.log_2(\frac{2D}{W})$$

T Average task time
D Distance to target
W Width of the target
a, b empirically estimated constants

Locomotion



E.g., *Automating gait generation*, SIGGRAPH 2001

Motion Capture

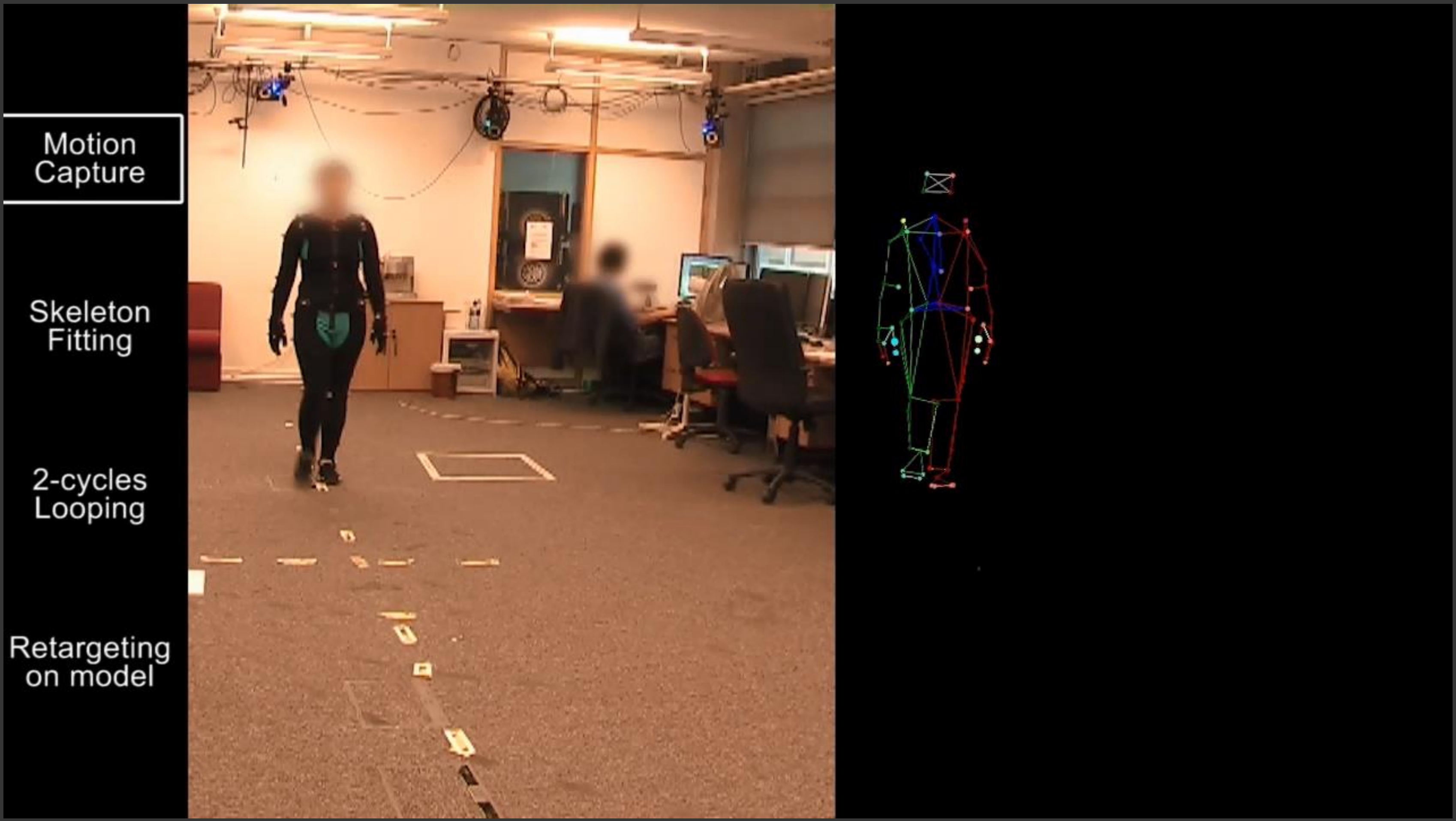
- Process of translating a live performance into a digital performance

Motion Capture

- Advantages
  - Realistic human motion
  - More rapid results can be obtained
  - Complex movement and realistic physical interactions can be easily re-created

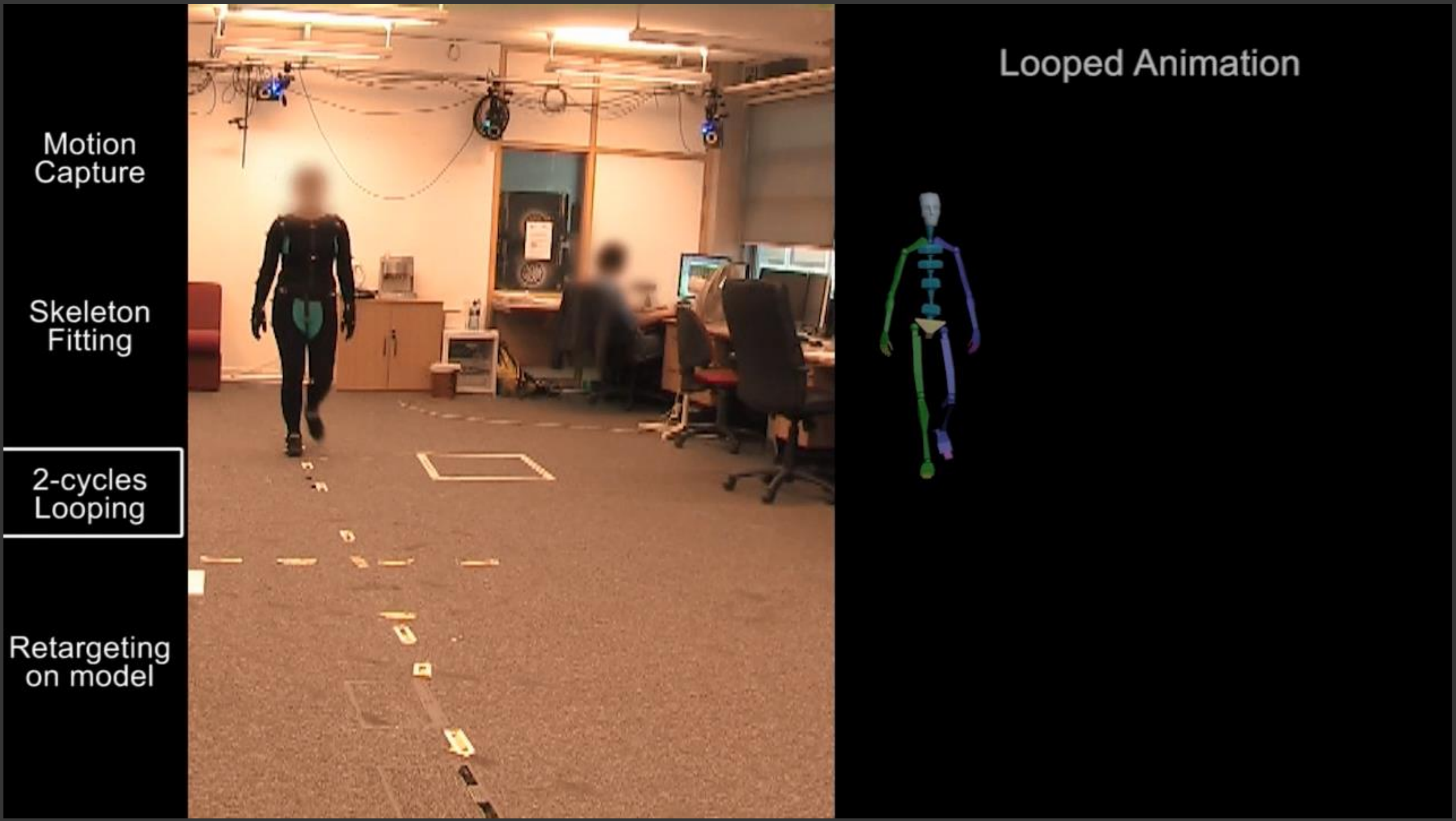
- Disadvantages
  - Proprietary hardware and programs
  - Cost & space requirements
  - Reshoot
  - Artifacts may occur if the computer model has different proportions from the actor
    - retargeting
  - The real life performance may not translate on to the computer model as expected

Motion Capture example

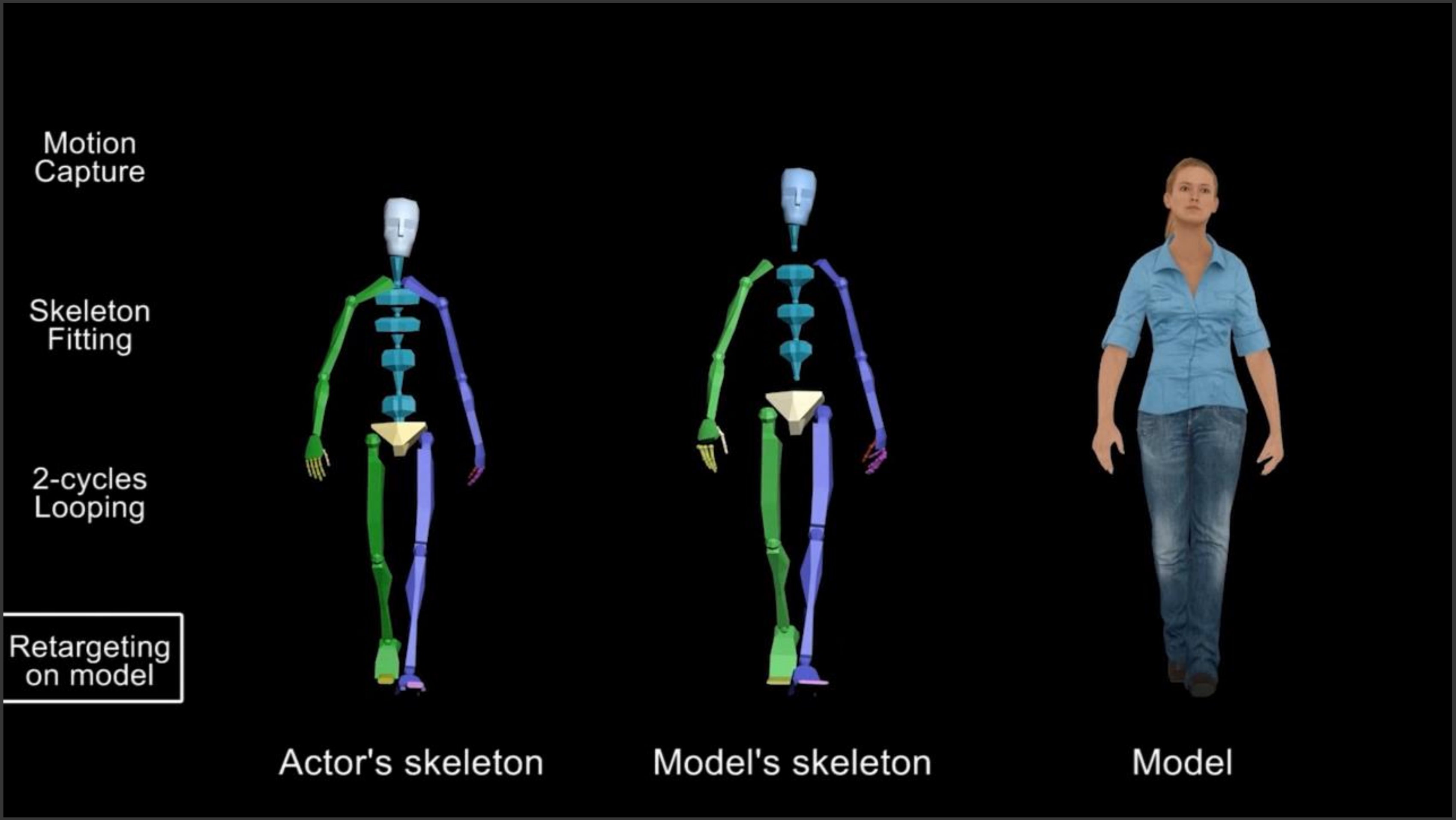


Motion Capture example

Motion Capture example

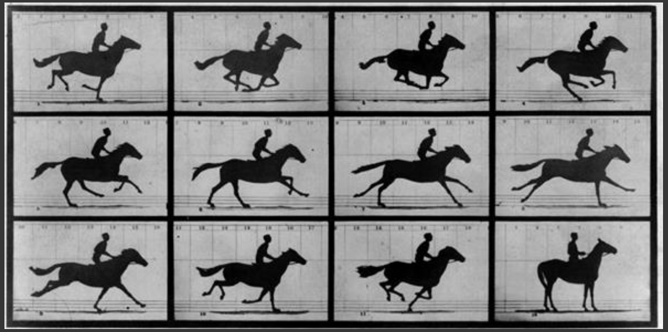


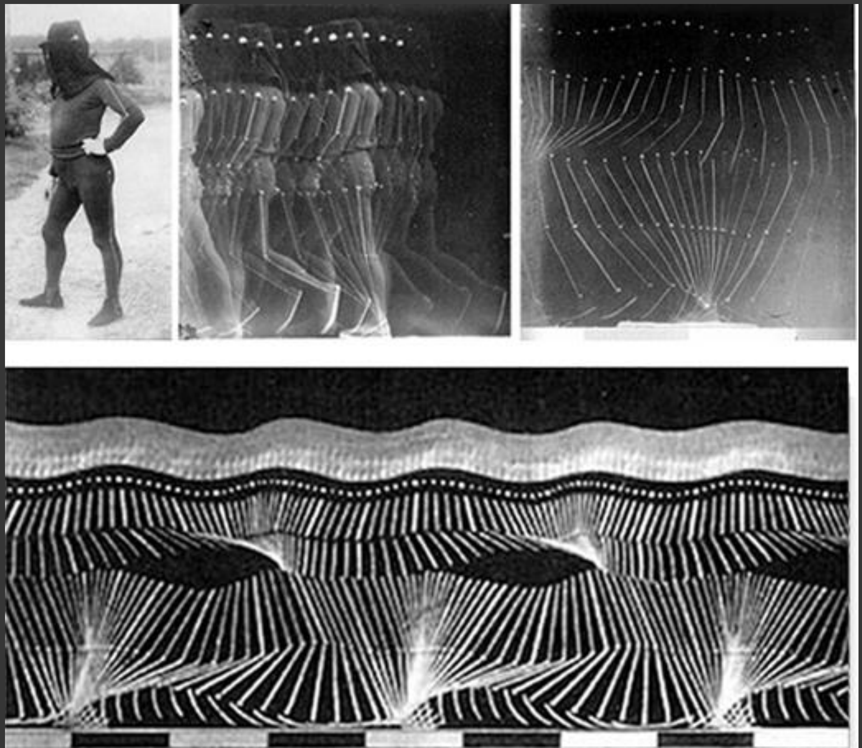
Motion Capture example



History of Mocap

- Early attempts to capture motion long before computer technology became available
  - Eadweard Muybridge (1830-1904)
  - Etienne-Jules Marey (1830-1904)

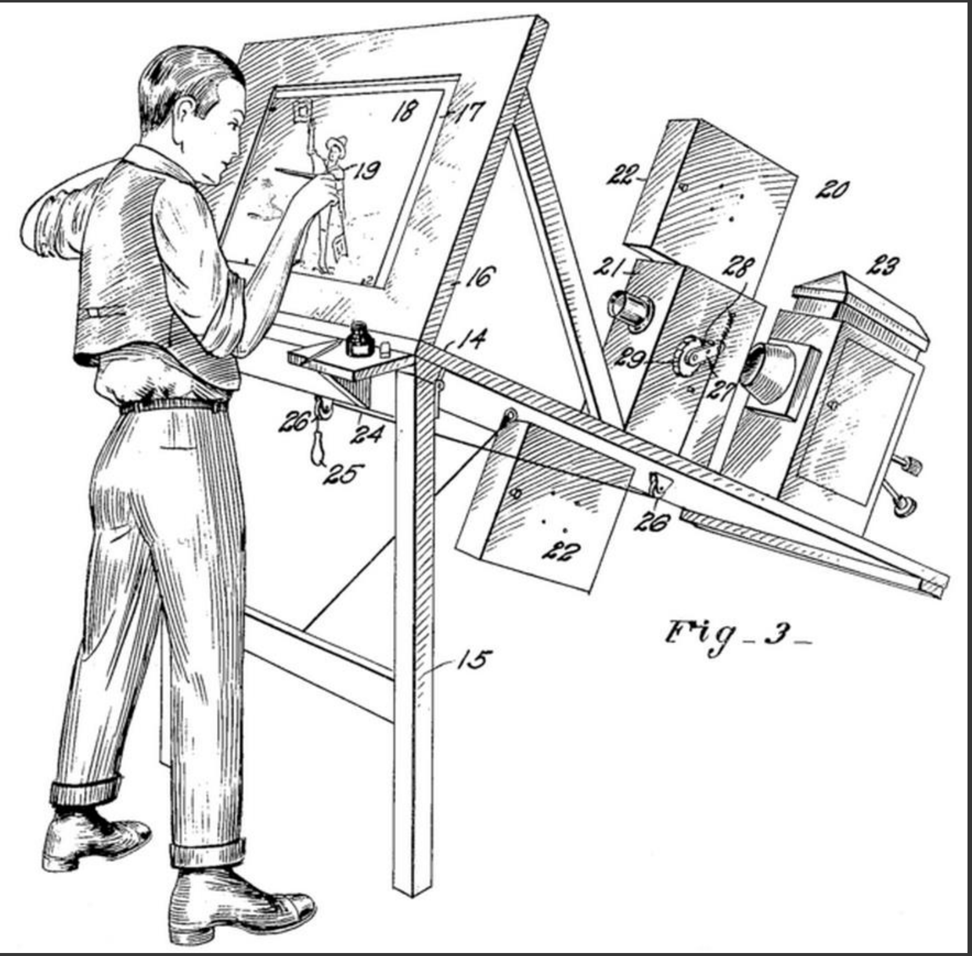




Rotoscoping

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

Rotoscoping



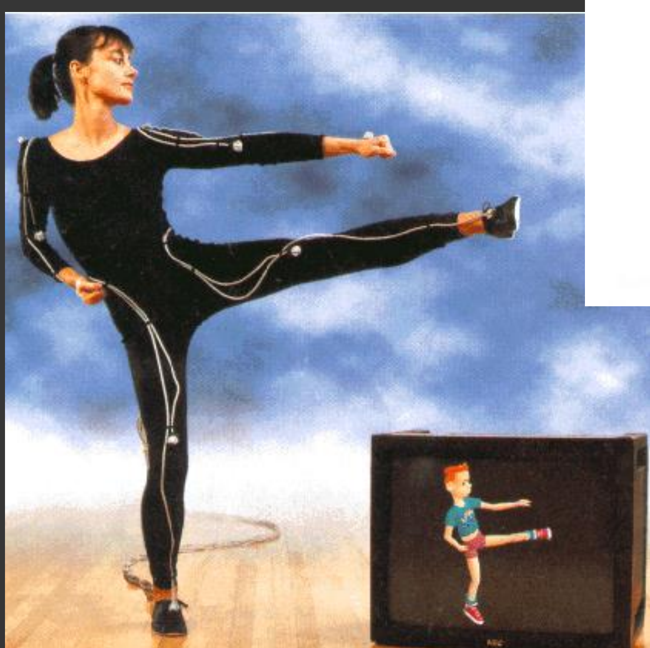
Rotoscoping

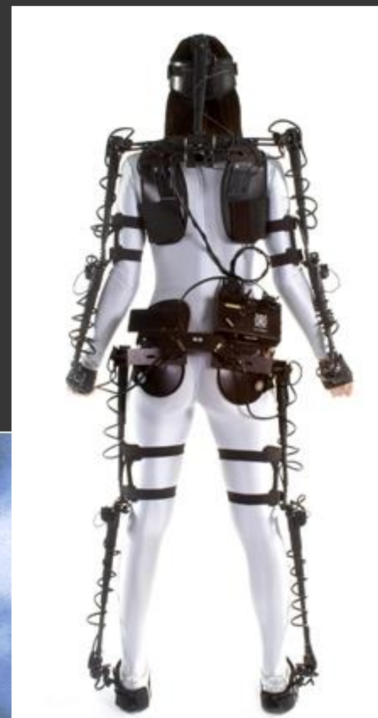
- Disney
  - Stepmother <-> Eleanor Audley

Applications

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

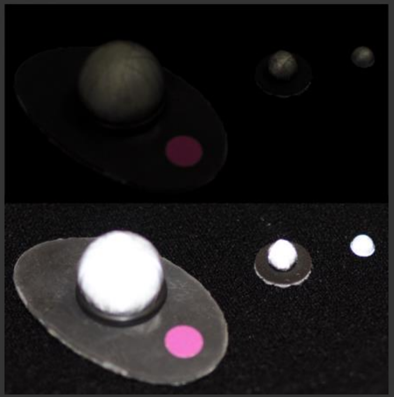
Types of Motion Capture





Optical Motion Capture Systems

- Single computer controller
- No wires or electronic equipment necessary
- Cameras have own infrared light sources
- 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

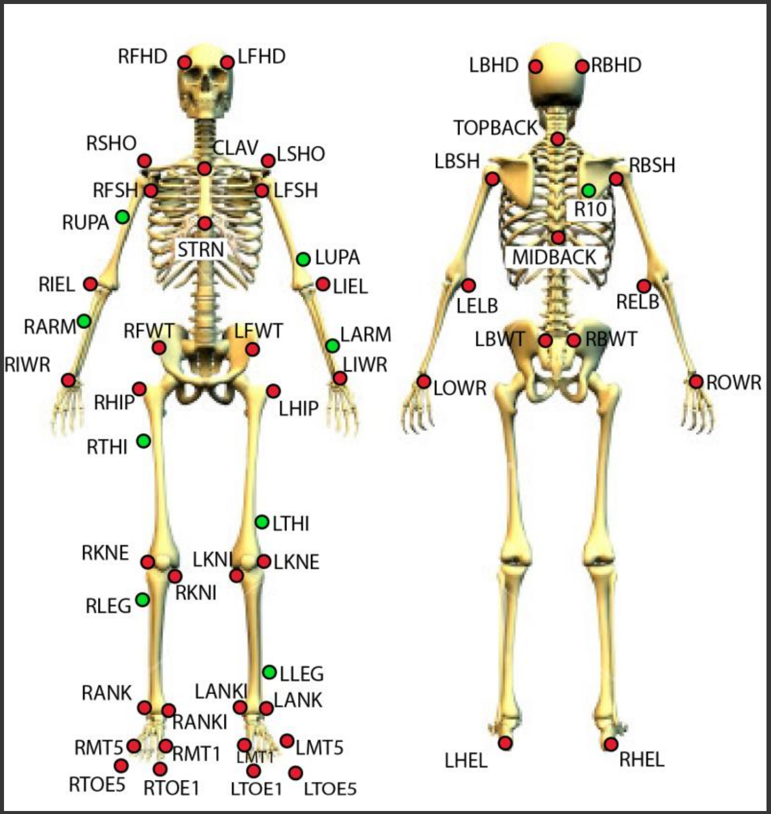


Calibration

- 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



Markers

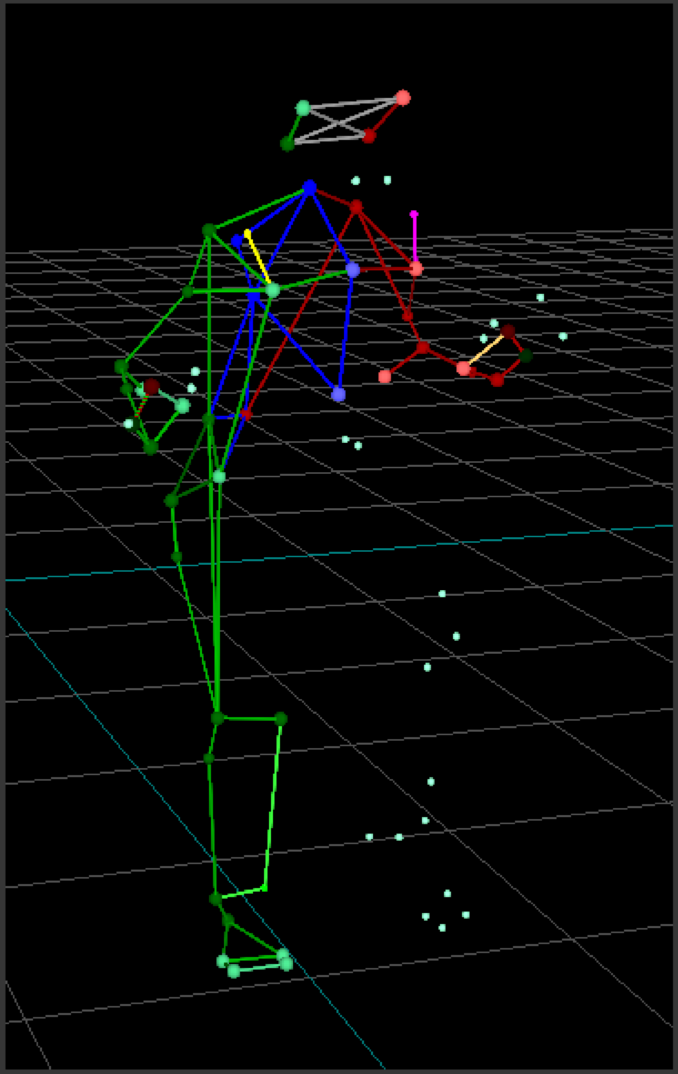
- Set of 45+ markers placed on the body of the actor
  - Usually positioned on anatomical locations
  - Markers define local coordinate system of each segment
  - At least 3 non-aligned markers per segment (define plane)
  - Hypothesis that markers belong to rigid bodies
    → constant distances, but in reality there are skin ovements
  - Standards exist: H-ANIM (International Society of Biomechanics)
  - Compute coordinate system of each segment
    - Defines local coordinate systems in hierarchy

Markers

- Detecting markers
  - Separate all the groups of pixels that exceed a predetermined luminosity threshold
  - Fit a circle to identify marker center
  - Rotational information must be inferred from the relative orientation of three or more markers

Markers

- Identifying markers
  - Requires operator assistance
  - Label each marker



Joint Centers & Skeleton

- Define local coordinate system of each segment
  - At least 3 non-aligned markers per segment (define plane)
  - Hypothesis that markers belong to rigid bodies

RWT = 0.5* (RFWT + RBWT)
LWT = 0.5* (LFWT + LBWT)

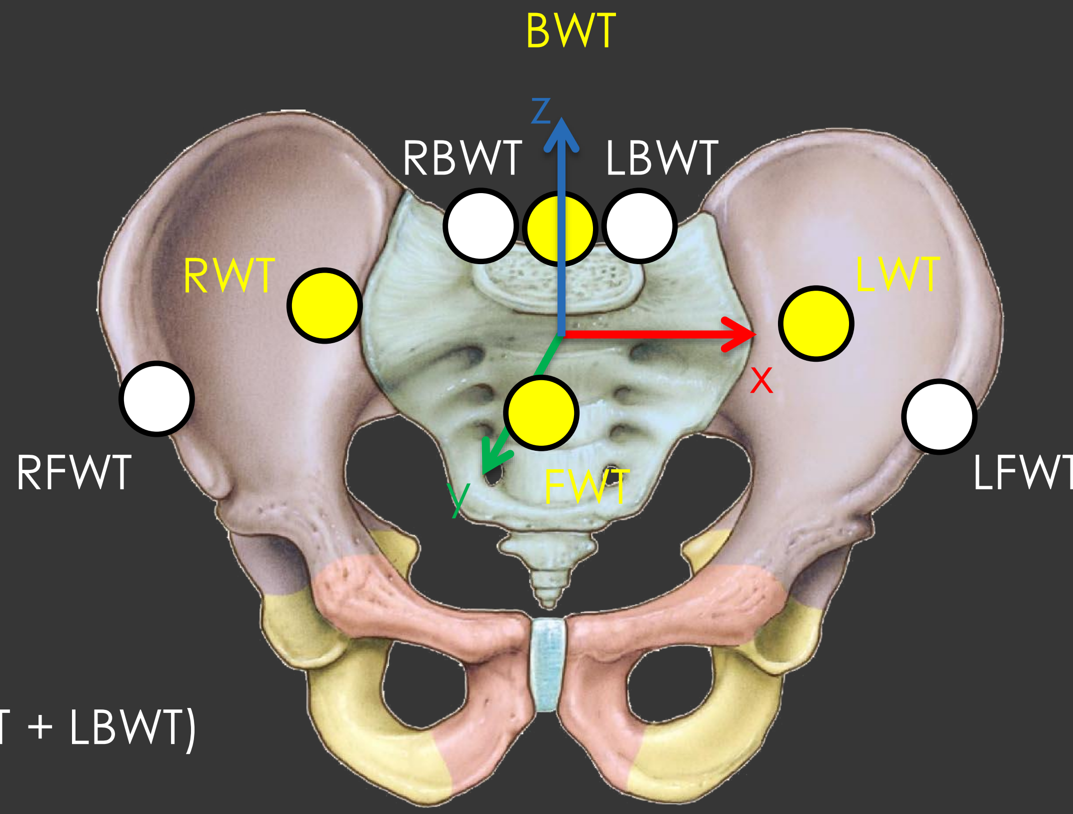
X = normalize(LWT – RWT)

FWT = 0.5* (RFWT + LFWT)
BWT = 0.5* (RBWT + LBWT)

Y = normalize(FWT – BWT)

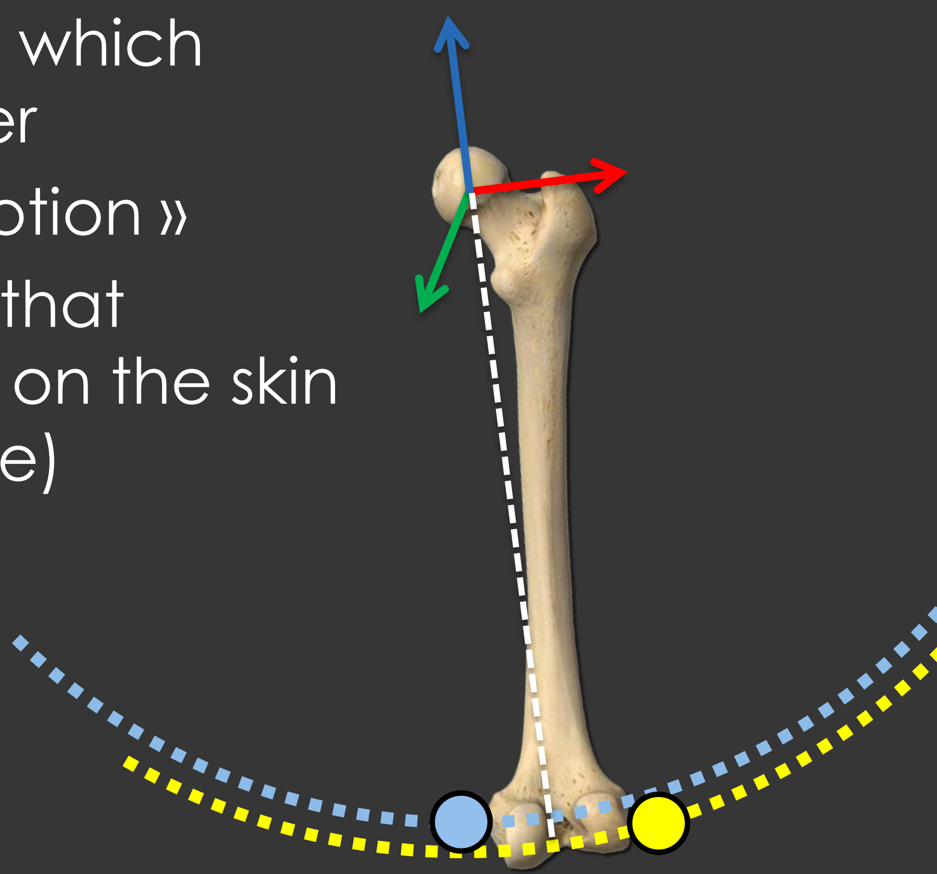
Z = cross(X, Y)

P_{pelvis} = 0.5* (RFWT + RBWT + LFWT + LBWT)



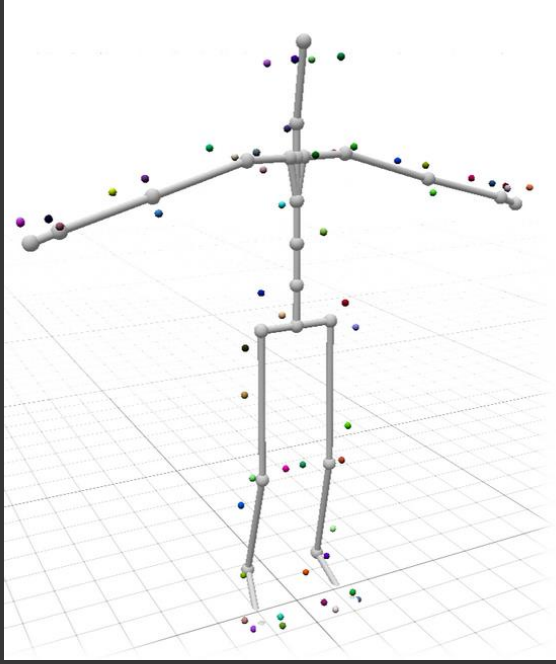
Joint Centers & Skeleton

- Optimisation with assumption of articulated rigid bodies (constant length)
  - Markers lie on a sphere which center is the joint center
  - Based on « range of motion »
  - Influenced by the fact that markers are positioned on the skin (and can therefore slide)



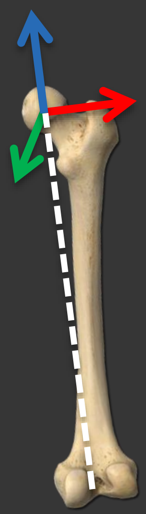
Fitting a Skeleton

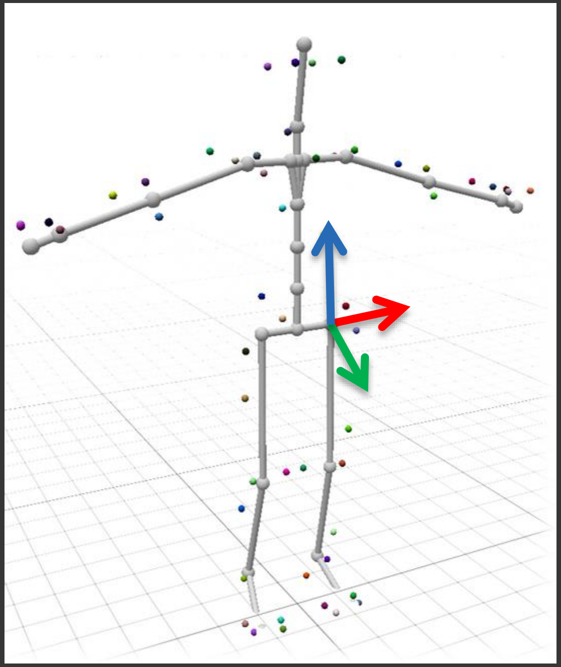
1. Learn/define a skeleton (morphology)
2. Fit skeleton in the data
   - 2 Main approaches
     - Complex optimisation: learning skeleton morphology and relations between segments and markers
       - Least square error optimisation
     - Or done using IK where joint angles are computed based on marker positions



Animating character

- Can require mapping between motion and character hierarchy



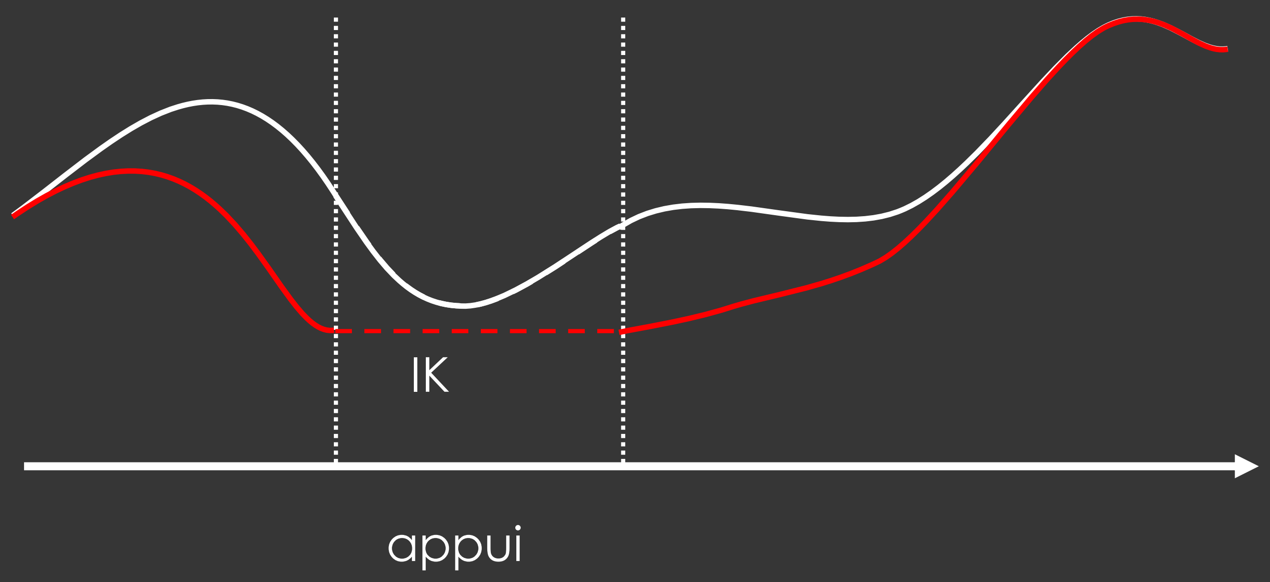


Retargeting

- Problem if the character skeleton morphology does not match the motion's
  - Correction of the error = retargeting

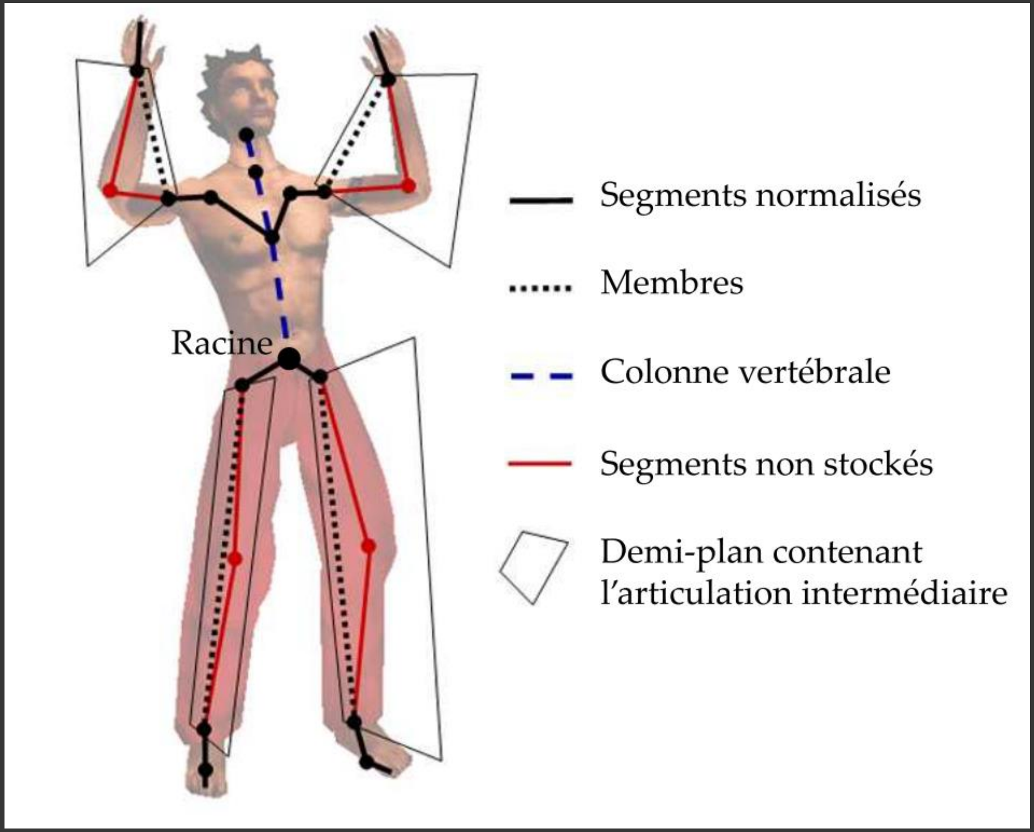
Retargeting

- Possible solution: use Inverse Kinematics on ankle position

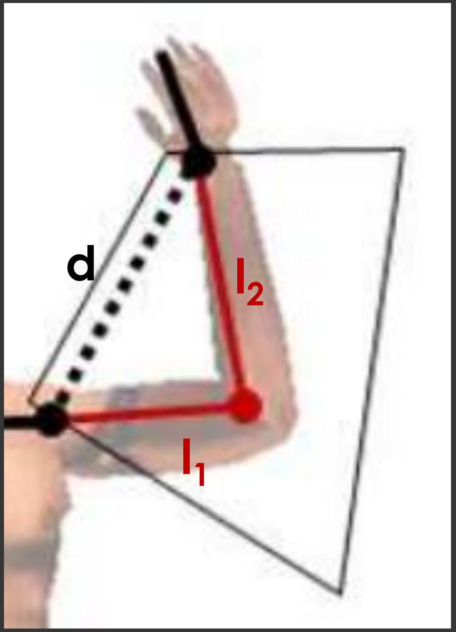


Retargeting

- Or use representation independent of morphology

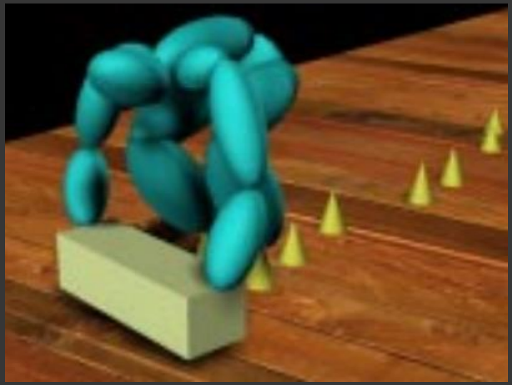


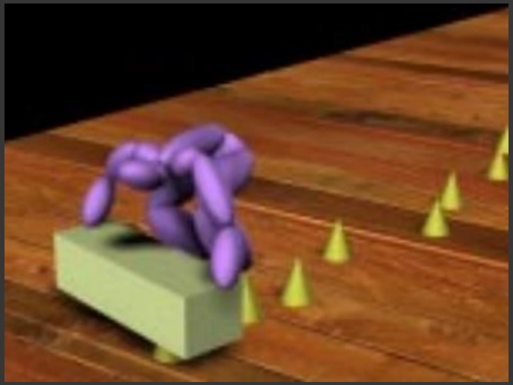
Facteur d'extension r
Longeur l_1 et l_2
$d = r*(l_1 + l_2)$

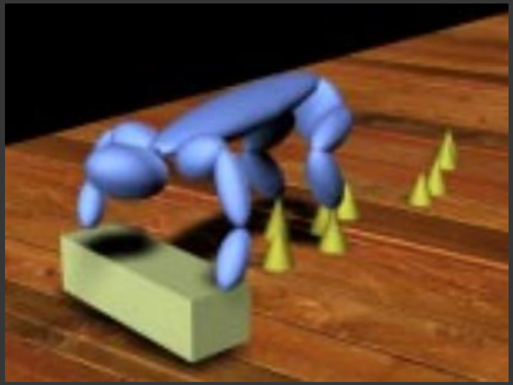


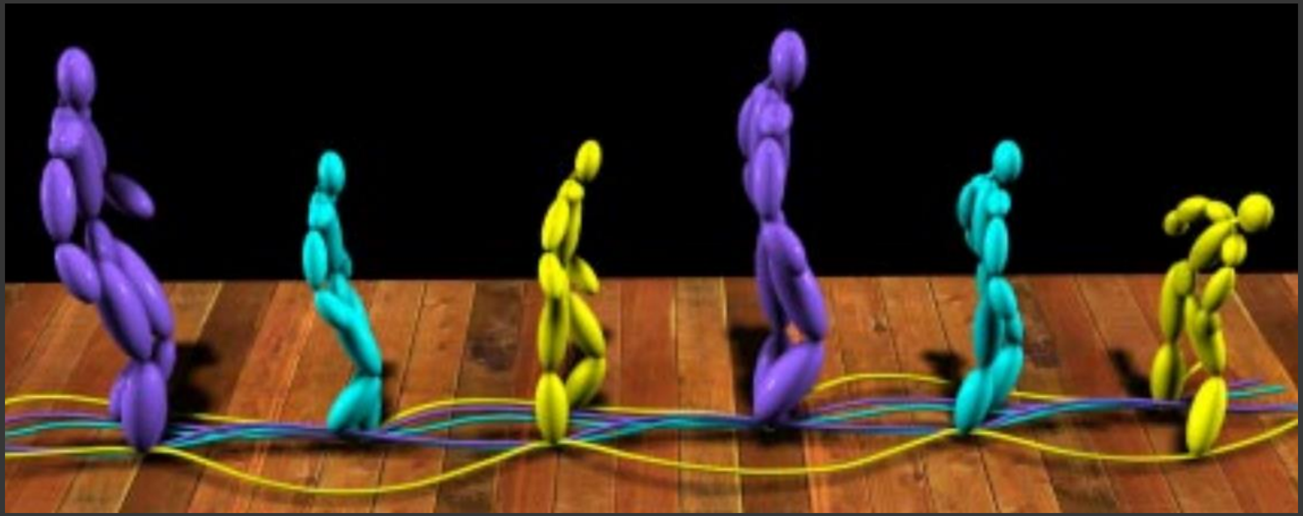
Retargeting

- Or optimise a set of constraints









Summary of Optical systems

- Advantages
  - Extremely accurate
  - Large number of markers can be used
  - Easy to change marker configurations
  - Performers not constrained by cables
  - Large area
  - High frequency of capture (up to 2000fps)
- Disadvantages
  - Hardware is expensive €100,000
  - Occlusions
  - Post-processing necessary

New Motion Capture Gaming

- Wii uses a combination of built-in accelerometers and infrared detection to sense its position in 3D space when pointed at the LEDs within the Sensor Bar
- Kinect is a motion sensing input device by Microsoft for the Xbox 360
  - RGB camera, depth sensor and multi-array microphone running proprietary software

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 only 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

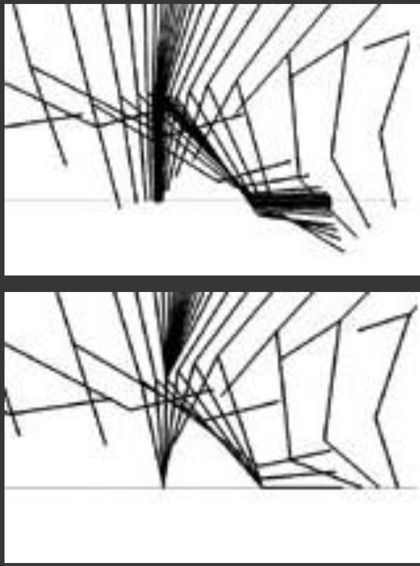
Planning & Directing Mocap

- 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

Controlling motion capture

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

    → retargeting



- Some software use markers directly with retargeting to drive characters (e.g., MotionBuilder)
  - Animation usually less natural

- How to control motions
  → manipulations/edition in next lecture ;)