

# Motion Capture

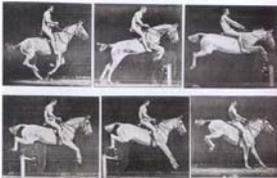
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## What is Motion Capture ?

- Motion Capture of an object involves sensing, digitizing, and recording that object in motion
  - Whole body
  - Hands
  - Face
- One way of acting out an animation

## History of Motion Capture

- Eadweard Muybridge (1830-1904)
  - Animal locomotion
  - Zoopraxiscope
  - <http://www.kingston.ac.uk/Muybridge>



## History of Motion Capture

- Harold Edgerton (1903-1990)
  - Stroboscope and electronic flash
  - High-speed, stop-motion photography
  - Popular images
    - Coronet of drop of milk
    - Bullet through an apple
  - <http://web.mit.edu/edgerton/main.html>



## History of Motion Capture

- Rotoscope
  - Max Fleischer in 1915
  - Allowed animators to trace cartoon characters over photographed frames of live performances
  - [http://www.geocities.com/SunsetStrip/Ciub/9199/Animation/Fleischer\\_Rotoscope.html](http://www.geocities.com/SunsetStrip/Ciub/9199/Animation/Fleischer_Rotoscope.html)



## History of Motion Capture

- Military, medical, biological purposes
- In computer graphics
  - Brilliance (Sexy Robot) in 1985 Super Bowl commercial
    - 18 Black magic markers on joints
  - Mike the talking head (Siggraph 88)
    - <http://mambo.ucsc.edu/psl/mike.html>



## History of Motion Capture

- Recent feature films
  - Titanic (1997)
  - Batman and Robin (1997)
  - The Mummy (1999)
  - Gladiator (2000)
  - The Patriot (2000)
  - The Mummy Returns (2001)
  - Star Wars Episode 1 – the Phantom Menace (2001)
  - Final Fantasy: The Spirits Within (2001)
  - The Enemy at the Gates (2001)
  - Pearl Harbor (2001)

## Why Motion Capture ?

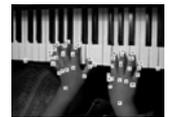
- All the fine details of human motion will be reproduced
- Naturalness of human motion is in its subtle details
  - Style
  - Mood
  - Weight shift, and so on
- Applications
  - Animation / Interactive characters
  - Feature films / video games
  - Medicine
  - Sports
  - Robotics

## What is captured ?

- What we need is
  - Position and orientation of the root segment
  - Joint angles
  - Length of each link (is it possible ?)
  - Skeleton connectivity
  - Skin deformation
- The mocap system actually provides
  - Marker positions on the skin, or
  - The positions and orientations of markers

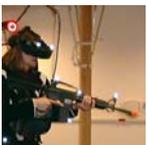
## What is Captured ?

- Full body
- Face
- Hands



## What is Captured ?

- Props



## What is Captured ?

- Flexible objects



[Titanic]

## What is Captured ?

- Skin deformation



[Sand, McMillan, Popovic]

## What is Captured ?

- Texture



[Carranza, Theobalt, Magnor, Seidel]

## Motion Capture Technologies

- Optical passive
- Optical active
- Electromagnetic
- Electromechanical
- Accoustic
- Optical fiber

## Optical Passive

- High resolution, high speed cameras
  - 120-1000 Hz, 1000x1000 pixels
  - Infrared or visible light strobe
  - Retro-reflective markers
- Pros
  - High quality
  - Flexible marker placement
  - Not seriously constrained by markers
- Cons
  - Extensive post-processing
  - Controlled environments (Indoor only, no sunlight)
  - Correspondence problem
  - Occlusion



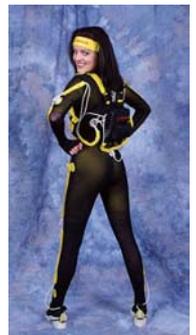
## Optical Active

- ReActor, Optitrak, Visualeyze
- Markers emit electric signal
- No correspondence problem



## Electromagnetic

- Electromagnetic field transmitter
  - Both position and orientation information
- Pros
  - Realtime
  - No occlusion/correspondence
- Cons
  - Limited accuracy
  - Smaller workspace
  - Heavier sensors and wires on body
  - Sensitive to electromagnetic interference
- Ascension, Polhemus



## Electromechanical

- Exoskeleton
- Mechanical skeleton attached on body
- Pros
  - Truly realtime (500 Hz)
  - No range limit
  - No occlusion/correspondence problem
- Cons
  - Restriction of movement
  - Fixed sensor positions
- Sacros, Gypsy



## Optical Fiber

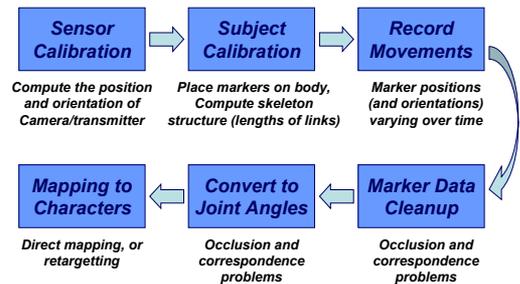
- Bending the fiber attenuates the transmitted light
- Recently used for full-body capture



## Acoustic

- The multiple transmitters trigger “click”
- The receivers on the body measures the time taken for the sound travel
- Pros
  - No occlusion
- Cons
  - Limited range
  - Limited number of sensors
  - Cables on body
  - Acoustic interference

## Production Pipeline



## Process of Motion Capture

- **Marker placement**
  - Markers should move rigidly with links and joints
  - Magnetic: on links
  - Optical: on both joints and links
- **Sensor calibration** (fully automatic)
  - Magnetic: relative locations of multiple transmitters
  - Optical: L-shape bar and wand movements
- **Subject calibration** (automatic, but not precise)
  - Neutral pose
  - Limb lengths
  - Joint limits



## Process of Motion Capture

- **Sensor data cleanup** (optical only)
  - 3D marker position reconstruction from 2D images
  - Labeling
  - Gap filing
  - Noise removal
  - A lot of manual processing
- **Convert to joint angles**
  - Magnetic: pretty obvious
  - Optical: sensitive to marker placement
- **Mapping to skeletons**
  - Fitting to the skeleton (measurement error, or cartoon characters)
  - Interaction with environment objects

## Example

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- Shadow boxing
  - [Take 17.avi](#)
- Playground
  - [Friday 27.mpg](#)

## Eric Darnell, codirector of Antz

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“The main problem with motion capture associated with characters has to do with mass-distribution, weight and exaggeration. He says that it is impossible for a performer to produce the kind of motion exaggeration that a cartoon character needs, and the mass and weight of the performer almost never looks good when applied to a character of different proportions.”

## Richard Chuang, VP at PDI

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“The mapping of human motion to a character with non-human proportions doesn’t work, because the most important things you get out of motion capture are the weight shifts and the subtleties and that balancing act of the human body. If the proportions change, you throw all that out the door, so you might as well animate it.”

## Karen Goulekas, Visual effect specialist at Godzilla

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“The reason that we pulled the plug on using the motion capture was, very simply, because the motion we captured from the human actor could not give us the lizard-like motion we were seeking. The mocap could also not reflect the huge mass of Godzilla either. During our keyframe tests, we found that the Godzilla motion we wanted was one that maintained the sense of huge mass and weight, while still moving in a graceful and agile manner. No human actor could give us this result.”

## Summary

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- There are many research topics to be addressed
  - Marker placement
  - Skeleton estimation
  - Occlusion (optical)
  - Electromagnetic Interference (magnetic)
  - Correspondence problem
  - Retargetting