Motion Capture

CS 448D: Character Animation

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History: Rotoscope

Trace animated character over recorded actor, frame-by-frame

Invented by Max Fleicher in 1915 and used for Betty Boop

Used by Walt Disney for human characters in Snow White and the Seven Dwarfs in 1937

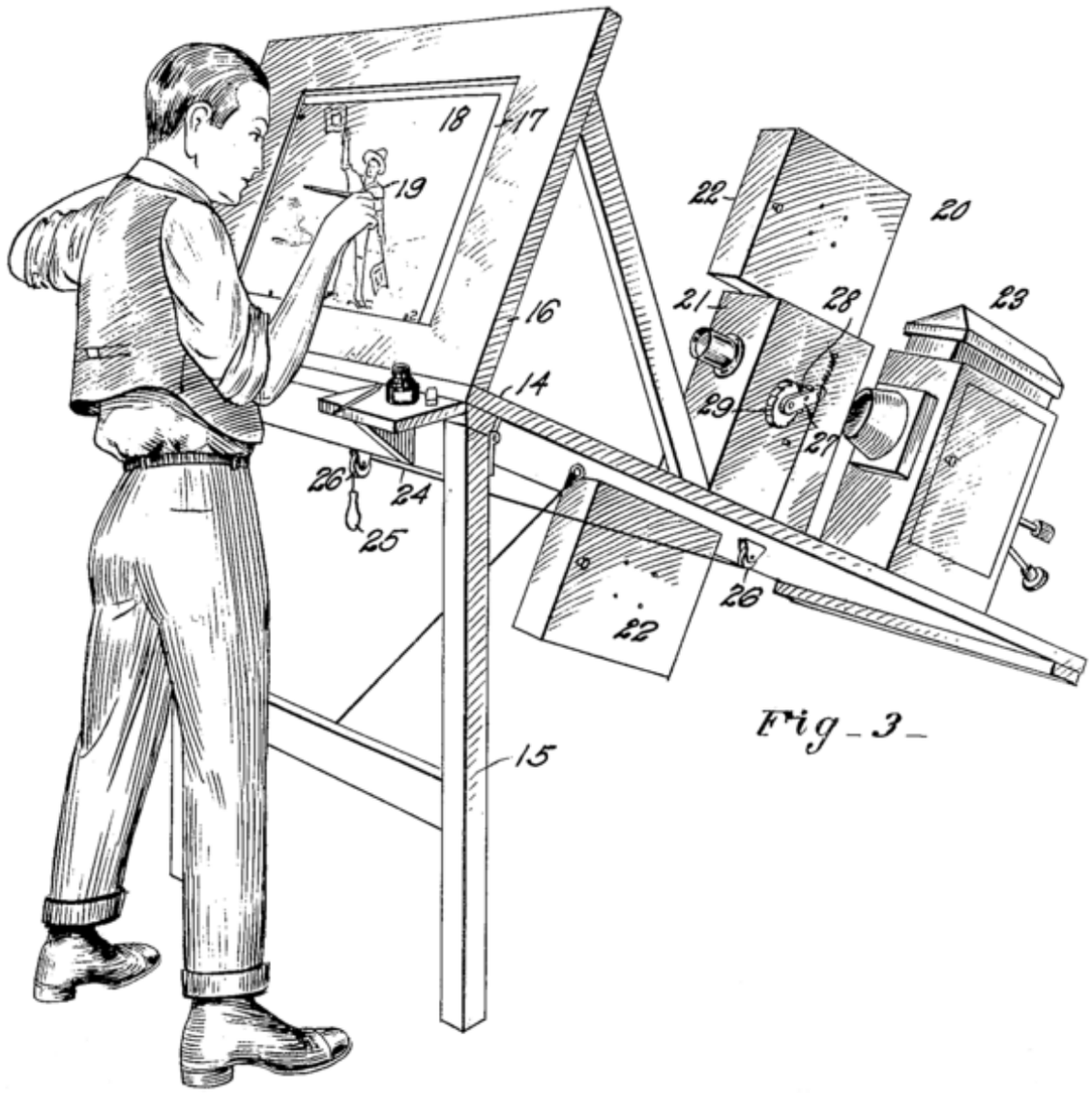


Fig_3_

History: Mike the Talking Head (1988)

Live digital puppetry performance at SIGGRAPH 1988

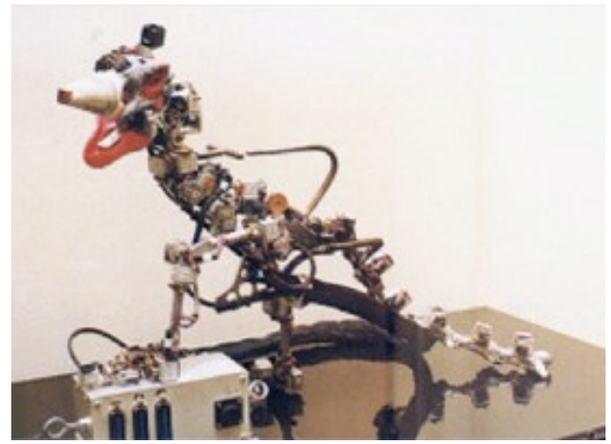
Promotional event for Silicon Graphics

Character driven in real time by human actor

Images from Robertson, "Mike, the talking head", Computer Graphics World, 1988

History: Jurassic Park (1993)

Dinosaurs animated using stop-motion armatures equipped with sensors that measured joint angles.



Computer graphics models driven with keyframes obtained from armatures.

More details in “Dinosaur input device”, CHI’95.

History: Late 90s

Motion capture takes off in Hollywood:

Titanic, The Mummy, ...

Uses of Motion Capture

Film, broadcast

Games, virtual environments

Live performance

Biomechanics, kinesiology, sports science, medicine

Robot control

Human-Computer Interaction

Miscellaneous (Andrew Ng's helicopter tracking)

Types of Motion Capture

Electromagnetic

Electromechanical

Inertial

Optical Marker-based (Passive, Active)

Optical Markerless

Electromagnetic motion capture

Transmitters establish magnetic fields within space

Sensors determine position and orientation

Data at each sensor, has to be transmitted over cables or wirelessly

Pros: 6DOF, no occlusion, unique sensor identification

Cons: Limited range, noise, interference from metal objects in the environment, extremely costly sensors

No need for post-processing if environment is carefully controlled

More popular in the past, especially for performance animation

Companies: Ascension

Image from Bodenheimer et al., "The process of motion capture: dealing with the data", 1997

Electromechanical motion capture

Exo-skeleton worn over subject

Rigid rods connected by potentiometers

Pros: Real-time recording, high accuracy,

affordable, self-contained,

no occlusion, unique sensor identification

Cons: Restrictive, restricted, no global position

Originally used with stop-motion animation

Companies: Animazoo

Image from Animazoo

Inertial motion capture

Inertial gyroscopes embedded in suit

Pros: Real-time recording, high accuracy,

affordable, self-contained, portable,

no occlusion, unique sensor identification

large number of simultaneous subjects

Cons: Restricted, no global position

Hybrid systems possible

Companies: Animazoo, Xsens

Image from Xsens

Optical

Most popular method currently

Surrounding stationary cameras see markers

Sensing at cameras

Cameras have to be calibrated

Pros: Highly adaptable

Cons: Limited resolution (capture volume, dynamic range, number of subjects), controlled lighting, occlusion, correspondence problems, etc.

Partial solution: Active markers

Companies: Vicon, MotionAnalysis (passive), PhaseSpace (active)

Image from House of Moves

Optical Markerless

No markers, just calibrated cameras

A detailed scan of the character

Research prototypes

Pros: Tracks minute surface deformations

Cons: Currently not ready for reliable deployment. Sometimes fails to reconstruct character. Hard to recover from failure.

Images from de Aguilar et al., "Performance Capture from Sparse Multi-view Video", 2008

Motion Capture Pipeline

The rest of the lecture is on optical motion capture with passive markers, the most widespread variety at present

Process:

1. Camera calibration
2. Subject calibration
3. Capture
4. 2D marker identification
5. 3D position reconstruction
6. Skeletal motion reconstruction

Camera calibration

Record a number of markers in 3D

Detect corresponding positions in camera's image plane

Solve linear system. Compute least-squares solution to deal with noise and discretization

Handled by software provided by motion capture equipment manufacturer

Subject calibration

Give identifiers to markers

Fit skeleton to markers:

- Express joint positions in terms of marker positions
- Bone lengths
- Joint limits

Useful trick: Place two markers on opposite sides of joint, express joint as average

Otherwise express joint in terms of at least three markers, to compensate for lack of orientation

Try to place markers so they move rigidly with joints

2D marker identification

Handled by software provided by motion capture equipment manufacturer.

Hugely problematic: Markers disappear, appear, merge, swap. Need to examine data frame-by-frame. The most time-consuming stage.

3D position reconstruction

In every frame, identify all cameras that see a particular marker

Construct corresponding lines in 3D

Find least squares solution

Cameras must be synchronized. Can use clap-board.

Must have enough cameras at enough angles. At least 8 for full-body motion, sometimes over 30 if multiple subjects. Occlusion still a problem in many settings.

Skeletal motion reconstruction

Place joints based on 3D marker positions and subject calibration

Markers slip and slide. Other errors. Leads to inaccurate joint positions that do not fit bone lengths.

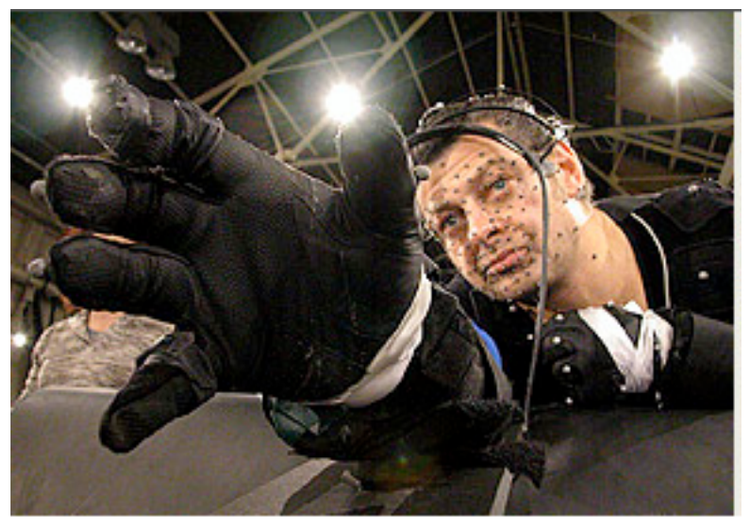
End effectors often end up in undesirable configurations. (Feet penetrate floor or skate.) Need to correct using inverse kinematics.

Motion Capture Debate: Pro

Captures natural movement in minute detail. Biomechanic subtleties and dynamics.

Human actors can be directed at a high level. Rapid iterations. Detailed emotional states and subtle movement styles.

Recent uses: Star Wars prequels, Lord of the Rings, Polar Express, Beowulf, King Kong



Motion Capture in King Kong (2005)

video

Video from www.kongisking.net

Motion Capture Debate: Con

Mapping motion to character with different biomechanics and dynamics forfeits the realism advantage. Characters with different proportions move differently.

Sometimes character movement combines aspects that cannot coexist in reality. (Shrek, Godzilla.)

Animated characters are perceived differently. Exaggerated motions can be more appropriate. (Discussed in Lasseter paper next week.)

Animators still spend significant work modifying mocap data, adding subtle details and expressivity.

Not used: Pixar movies, Shrek, Kung Fu Panda, etc.

Motion Capture Debate: Con

This is only my personal opinion, but motion capture is not animation. To me animation is an art. It's putting a little bit of yourself into the character. With motion capture, you're capturing a live action performance. And, I think, the difference in the quality of motion between a live action performance and good key frame is huge. Motion capture has a very realistic look. For example, if someone is clapping their hands, motion capture will give you a very accurate recreation of someone clapping. But, when you actually look at it, I think it would feel kind of stiff and lifeless, even though it's an exact replica of how a human claps. I think that to really sell the idea of someone clapping, you want to exaggerate it a little bit. You want to dilate the motion, so you really feel the contact of the hands slapping together.

Glenn McQueen, Pixar (responsible for animation of Woody in “Tory Story” and Boo in “Monsters, Inc.”)

Motion Capture Debate: Pro

Lower budget productions

Interactive applications

Research theme

Motion capture specifies the entire configuration (all joint angles) at every frame. No "key" frames, no information on what is important and what is not. A "flat" description of motion in complete detail.

Very unwieldy if want to change something!

Techniques needed for editing and combining motion capture data in various ways. Also for mapping data onto different characters. Major theme in research papers we will read starting next week.