SM 14/15 – T5
Motion Capture Technology

LCC, MIERSI

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Slides taken and/or inspired by Leonid Sigal's course slides from CMU, and Vladen Koltun's from Stanford

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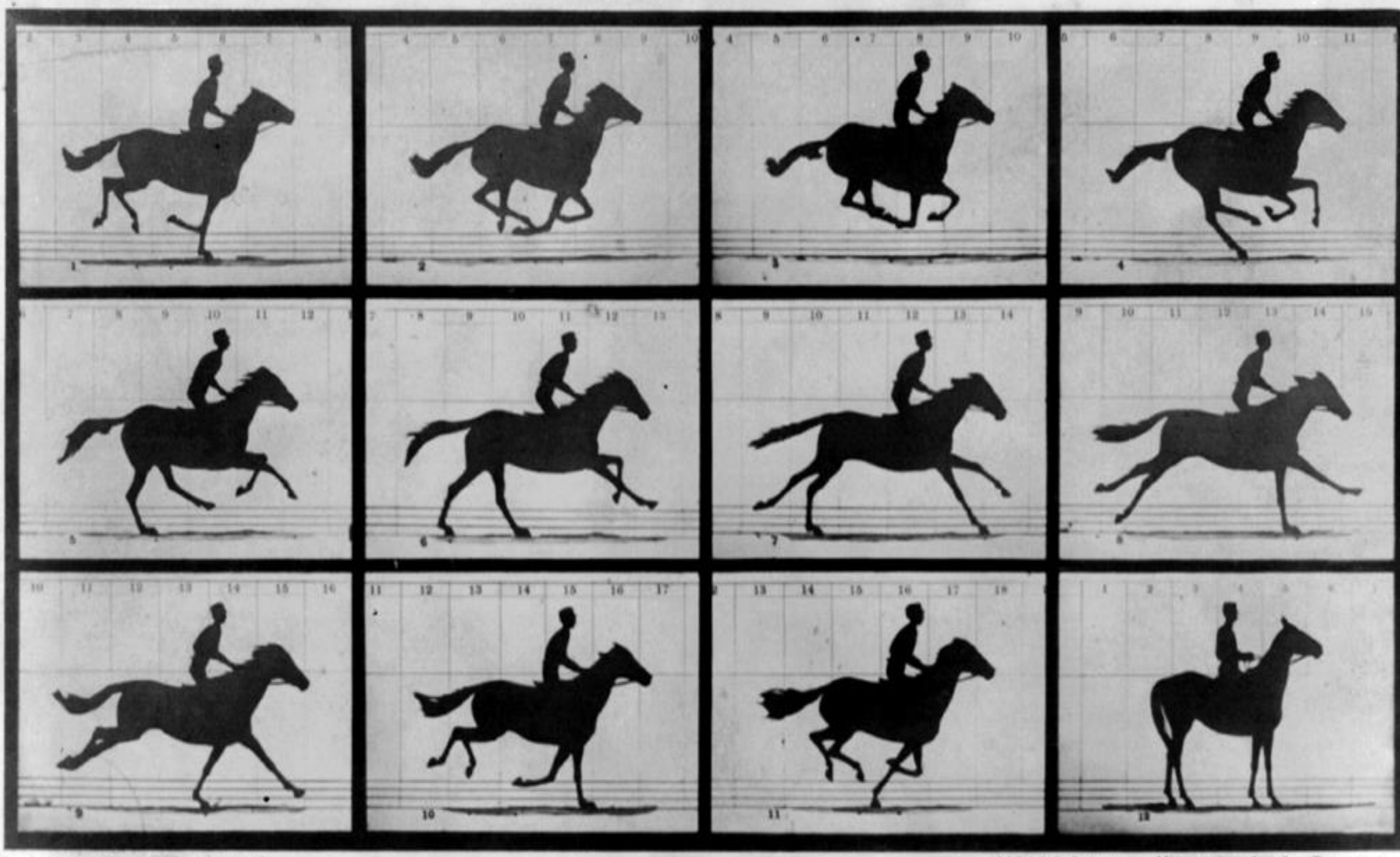
History of motion capture technology



MORSE'S Gallery, 417 Montgomery St., San Francisco.

THE HORSE IN MOTION.

Illustrated by
MUYBRIDGE.

AUTOMATIC ELECTRO-PHOTOGRAPH.

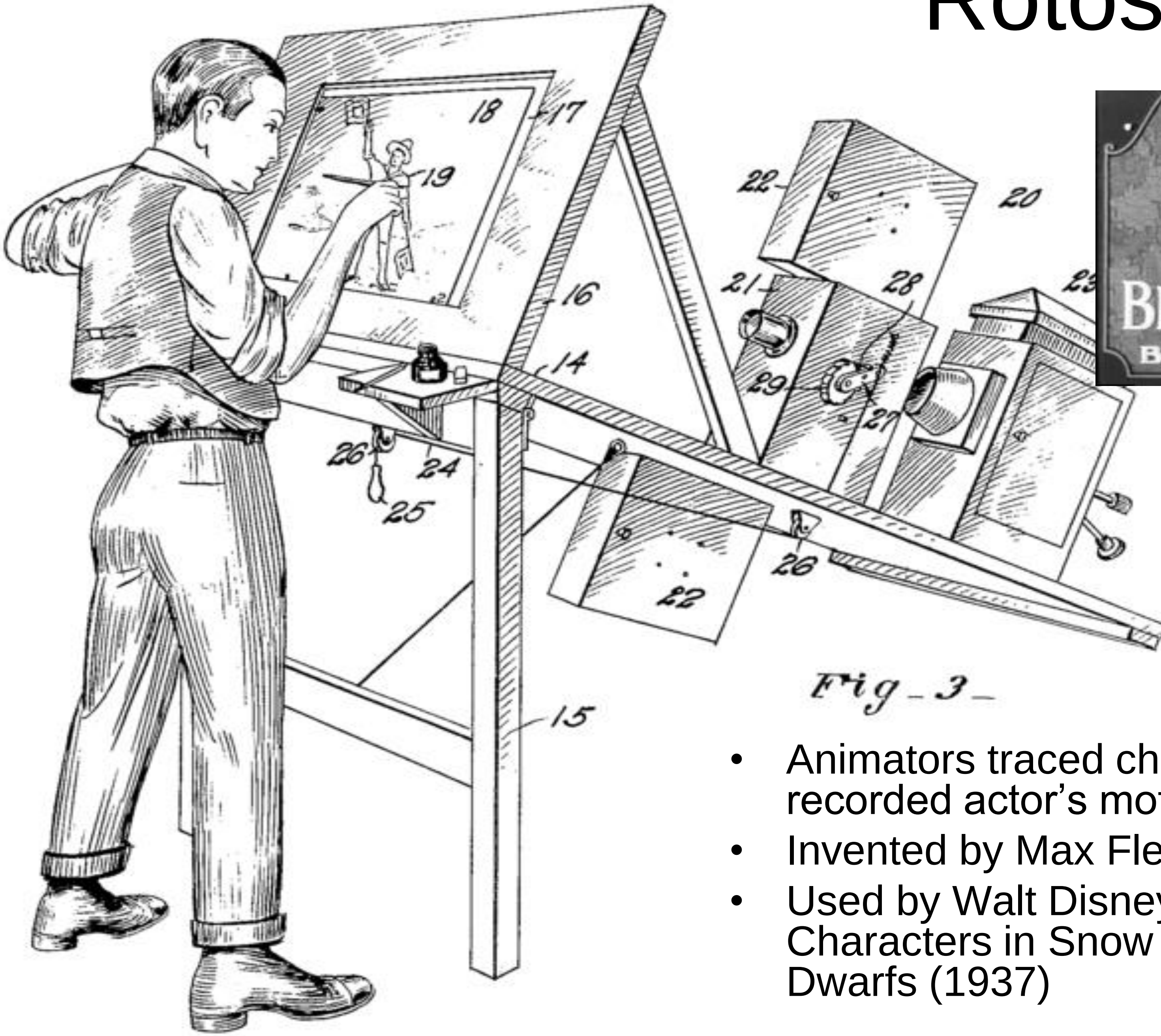
"SALLIE GARDNER," owned by LELAND STANFORD; running at a 1.40 gait over the Palo Alto track, 19th June, 1878.

The negatives of these photographs were made at intervals of twenty-seven inches of distance, and about the twenty-fifth part of a second of time; they illustrate consecutive positions assumed in each twenty-seven inches of progress during a single stride of the mare. The vertical lines were twenty-seven inches apart; the horizontal lines represent elevations of four inches each. The exposure of each negative was less than the two-thousandth part of a second.

- In 1872, Leland Stanford, a businessman and race-horse owner, hired Muybridge for some photographic studies. He had taken a position on a popularly debated question of the day — whether all four feet of a horse were off the ground at the same time while trotting.
- In 1872, Muybridge settled Stanford's question with a single photographic negative showing his Standardbred trotting horse Occident airborne at the trot.
- Stanford also wanted a study of the horse at a gallop. Muybridge planned to take a series of photos on 15 June 1878. He placed numerous large glass-plate cameras in a line along the edge of the track; the shutter of each was triggered by a thread as the horse passed.

Source: http://en.wikipedia.org/wiki/Eadweard_Muybridge

Rotoscoping



- Animators traced characters over recorded actor’s motion
- Invented by Max Fleicher in (1915)
- Used by Walt Disney for Human Characters in Snow White and Seven Dwarfs (1937)

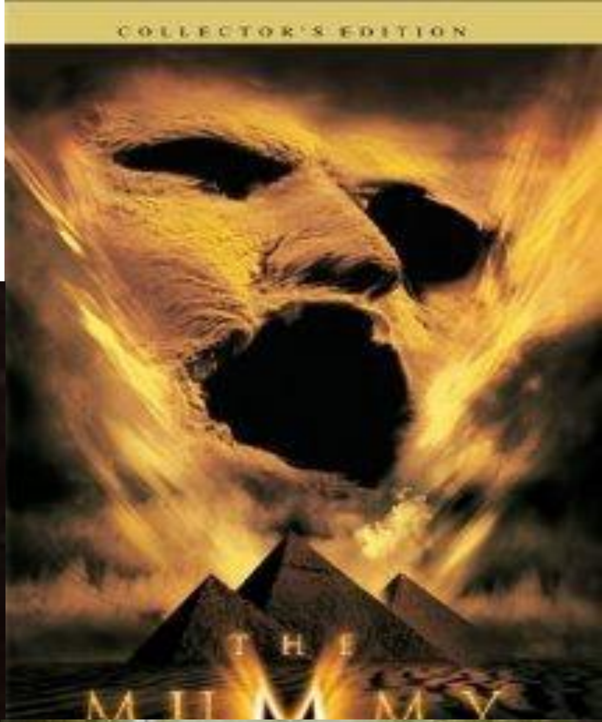
Jurassic Park

- Dinosaurs animated using armatures equipped with sensors that measured angles
- CG models driven with keyframes created by armatures

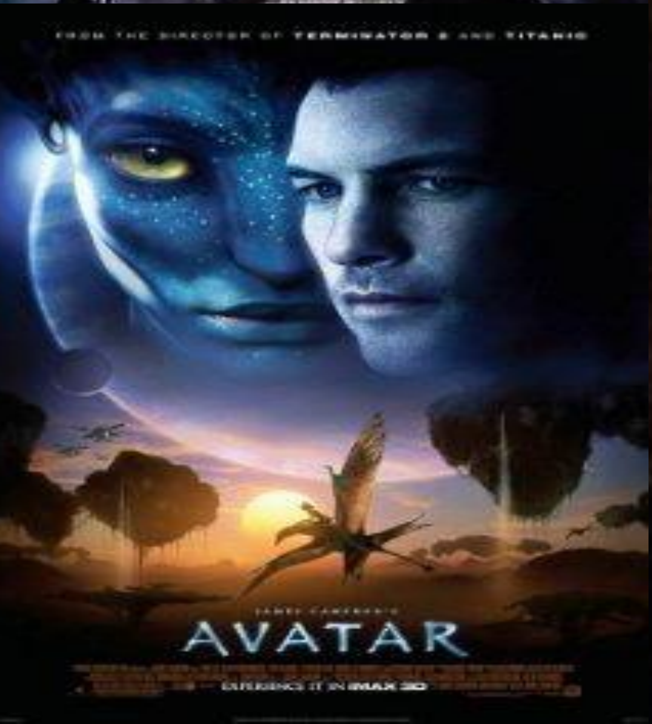
[Knep, Hayes, Sayre, Williams, ILM, 1995]

Late 90s


KEANU REEVES
LAURENCE FISHBURNE
MATRIX


COLLECTOR'S EDITION
THE


KING KONG


AVATAR


THE LORD OF THE RINGS
THE FELLOWSHIP OF THE RING

Motion Capture Systems

Inside In	Inside Out	Outside In
Electromechanical Suites	Electromagnetic	Marker-based Optical (active, passive markers)
Optical Fiber	Semi-passive	Marker-less Optical
Accelerometer Based	Optical	

Benefits

Portable	Could be portable	Not very portable
Can capture any motion anywhere	Low accuracy	Can be very precise

Inside In

Systems have their sources and sensors placed on the body

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Electromechanical Suites

- Exo-skeletons/armatures worn over the subject
- Rods connected by potentiometers
- Potentiometers: record analog voltage changes (like nobs on the radio) and convert to digital values; are only able to record change from the original orientation (calibration is critical)

[Gypsy]

Pro:

- Real-time
- High accuracy
- Inexpensive
- Self-contained
- No correspondences

Con:

- Restrictive
- Needs to match body proportions
- No global position

Optical Fiber

- Typically used for data gloves
- Fiber-optic sensors along the fingers
  - Finger bending, bends fiber
  - Bent fiber attenuates light
  - Attenuated light converted to measurement

Pro:

- Real-time
- Inexpensive
- Self-contained
- No correspondences

Con:

- Low quality
- Only used for hands

Inertial Suites

- Inertial sensors (gyros)
  - Accelerometer: measures acceleration
  - Gyroscope: measures orientation
  - Ultrasonic: measures distance

[Xsens]

Pro:

- Real-time
- Inexpensive
- Self-contained
- No correspondences

Con:

- Restrictive
- No global position
- Can drift

Practical Motion Capture in Everyday Surroundings

Daniel Vlasic - MIT
Rolf Adelsberger - MERL, ETH Zurich
Giovanni Vannucci - MERL
John Barwell - MERL
Markus Gross - ETH Zurich
Wojciech Matusik - MERL
Jovan Popović - MIT

Inside Out

Systems have sensors placed on the body that collect external sources

Electromagnetic

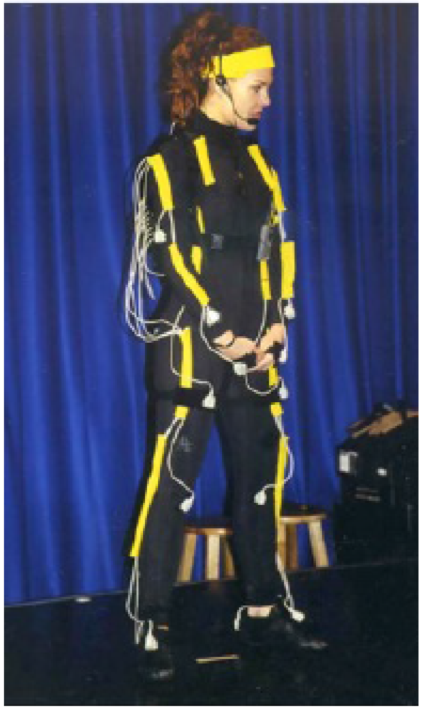
- External transmitters establish magnetic fields in space
- Sensors can then measure the position and orientation
- Data from sensors transmitted back wirelessly or across wire

Pro:

- Real-time
- No correspondences

Con:

- Limited range
- Noise
- Interference from metal objects
- Expensive



[JZZ Technologies]

Semi-passive

- Multi-LED IR projectors in the environment emit spatially varying patterns
- Photo-sensitive marker tags decode the signals and estimate their position

Pro:

- Real-time
- Inexpensive
- High speed
- No correspondences

Con:

- Accuracy (?)
- No global position

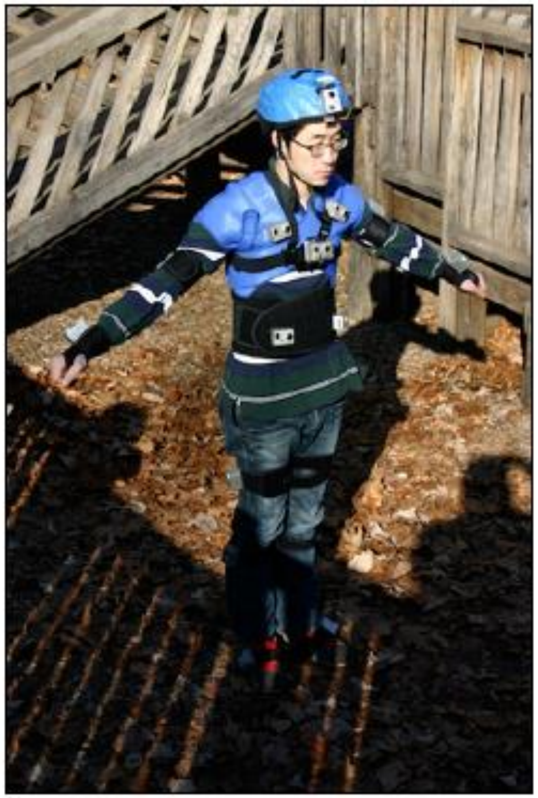
High Speed Scene Point Capture

and Video Enhancement using Photosensing Markers and Multiplexed Illumination

R Raskar, H Nii, B de Decker, Y Hashimoto, J Summet,
D Moore, Y Zhao,J Westhues, P Dietz, M Inami, S Nayar,
J Barnwell, M Noland, P Bekaert, V Branzoi, E Bruns

SIGGRAPH 2007

Optical Inside-Out System



HD Hero by
GoPro
720p at 60 fps
~260 dollars/camera

[Shiratori, Park, Sigal, Sheikh, Hodgins, Siggraph 2011]


Motion Capture Inside Out
0:38 / 1:55

Optical Inside-Out System

Structure from Motion

...

...

[Tomasi and Kanade, IJCV 1991], [Hartley and Zisserman, 2004], [Snavely et al., SIGGRAPH 2006]

[Shiratori, Park, Sigal, Sheikh, Hodgins, Siggraph 2011]

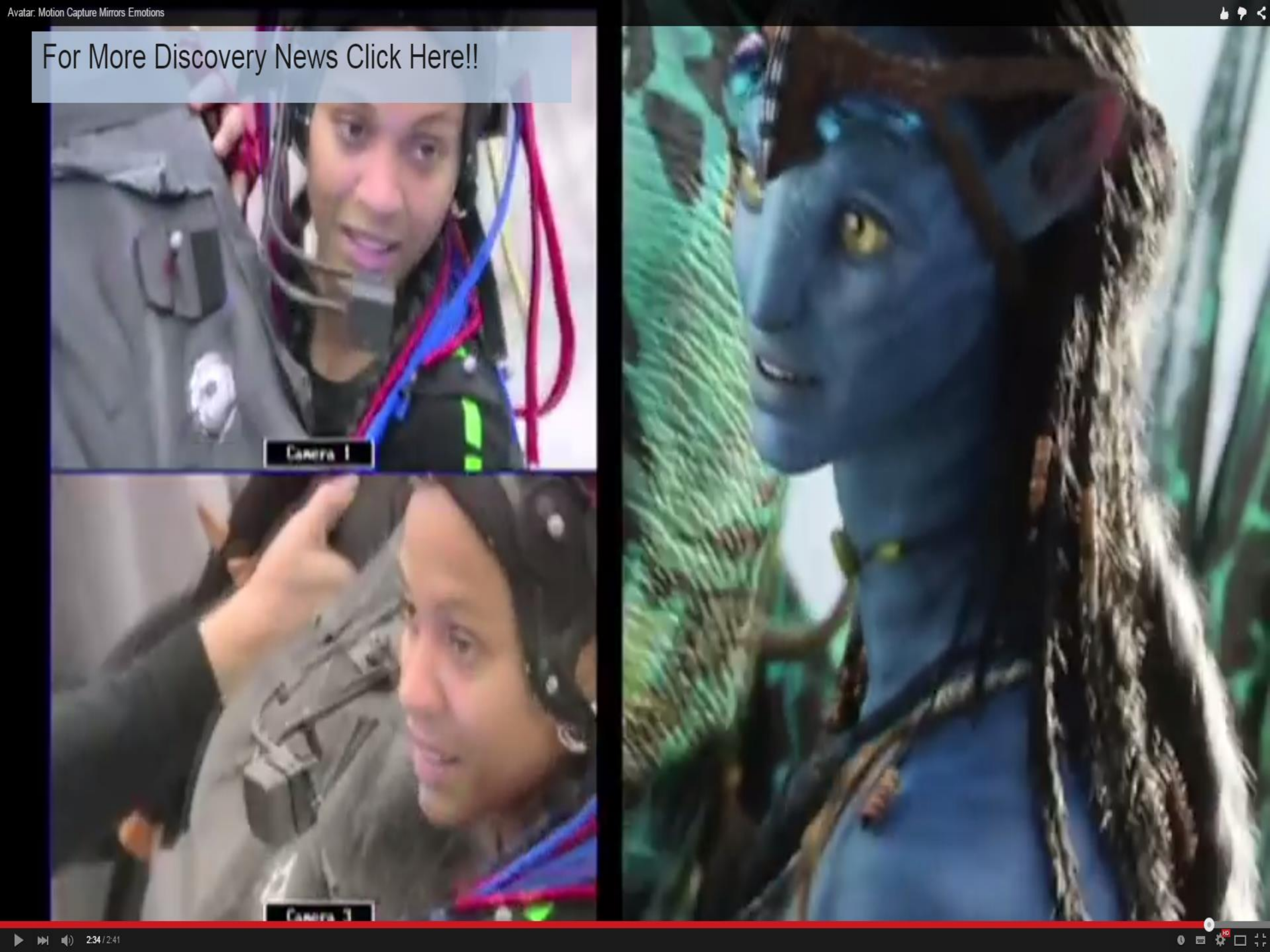
Optical Inside-Out System

Pro:

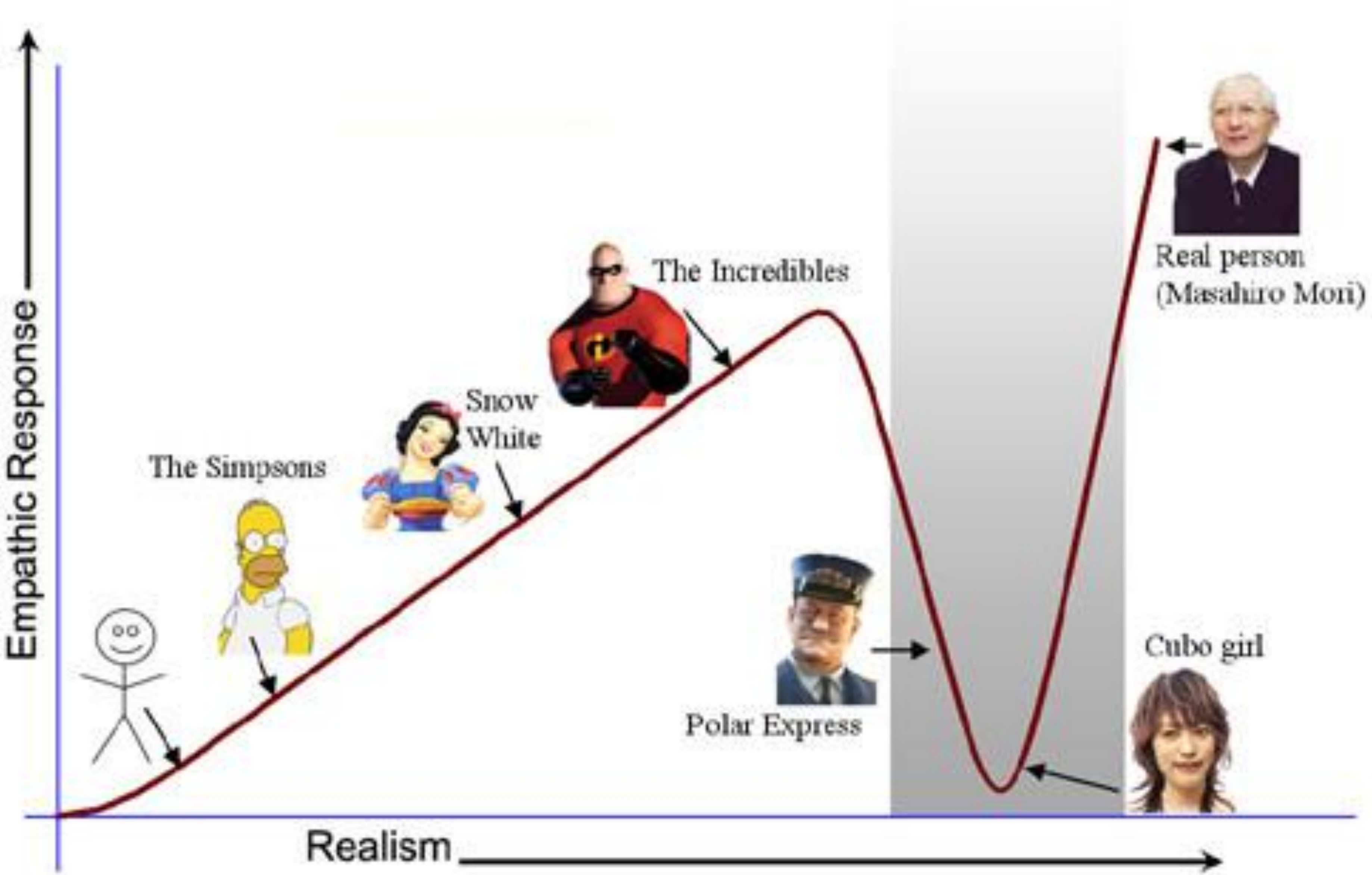
- Portable
- Inexpensive
- Gives global position

Con:

- Low quality
- Very long processing time


Avatar: Motion Capture Mirrors Emotions
For More Discovery News Click Here!!
Camera 1
2:34 / 2:41

The Uncanny Valley



Outside In

Systems use external sensors to collect data from sources placed on the body

Optical Systems

(most popular and practical method at the moment)

- Subject surrounded by cameras
- Sensing is done at the cameras (and/or connected computers)
- Cameras need to be calibrated

Pro:

- Adaptable
- Minimally intrusive
- Highly accurate

Con:

- Limited in use (space need to be outfitted)

Optical Marker-less Systems

Pro:

- Non-intrusive
- Should be accurate (every pixel on the body is, in a sense, a measurement)

Con:

- Still in research phase
- Many difficulties exist
- Reliable spatio-temporal correspondences is key challenge

Active Marker-based Systems

- Resolve correspondence by activating one LED marker at a time (very quickly)
- LEDs can be tuned to be easily picked up by cameras

[PhaseSpace]

Passive Marker-based Systems

- Markers are retro-reflective balls (instead of LEDs)
- Markers are illuminated using IR lights mounted on the cameras

Why lights need to be mounted on the cameras?

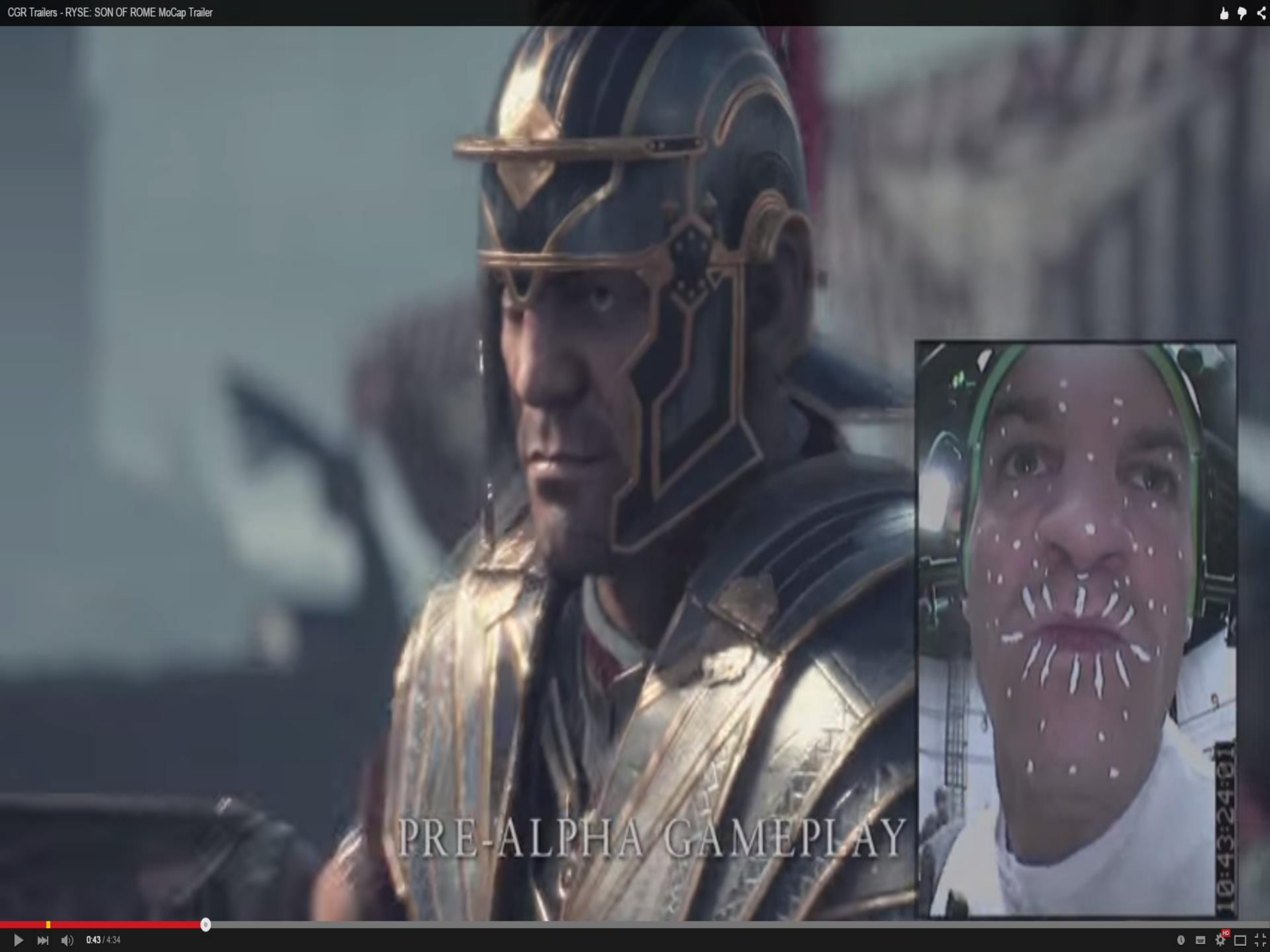
Ensures that every marker visible from each camera is well illuminated


VICON House of Moves: SIGGRAPH 2010 "Beyond: Beyond the Norm" (Making of) REVISED
0:44 / 4:23

Passive vs. Active Systems

- Active systems are MUCH better at finding correspondences
- Passive systems must rely on unique relative placement of markers and temporal continuity for disambiguation
- Passive systems typically rely on more manual cleanup after captures

Passive Calibration Wand


CGR Trailers - RYSE: SON OF ROME MoCap Trailer
PRE-ALPHA GAMEPLAY
10:43:24:01
0:43 / 4:34

Discussion

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Motion Capture Benefits

- Captures natural motion in high detail
- Relatively inexpensive (depending on the system)
- Easy to get data even for very complex motions and with subtle emotional content

[Lord of the Rings]

- Proved very beneficial for:
  - Visual FX
  - Games
  - Biomechanical analysis

Motion Capture Pitfalls

- Captures natural motion in high detail
- Difficult to edit

[Polar Express]

- Proved very unpopular for:
  - Feature animated films (e.g., Polar Express)
- Animated characters tend to be highly stylized (because of uncanny valley), and require highly stylized motion.
- Motion capture can potentially be a reference, but needs to be exaggerated; since editing is unintuitive, animators often prefer to start from scratch