15-869

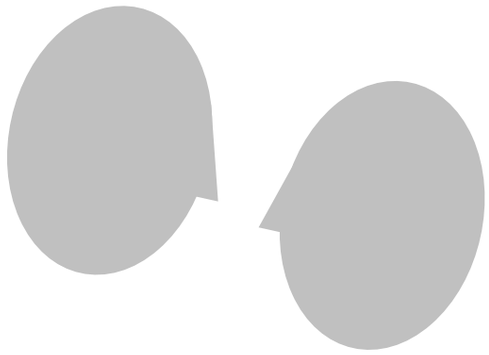
Lecture 1
Introduction: What is Human Motion?

Yaser Sheikh

Human Motion Modeling and Analysis

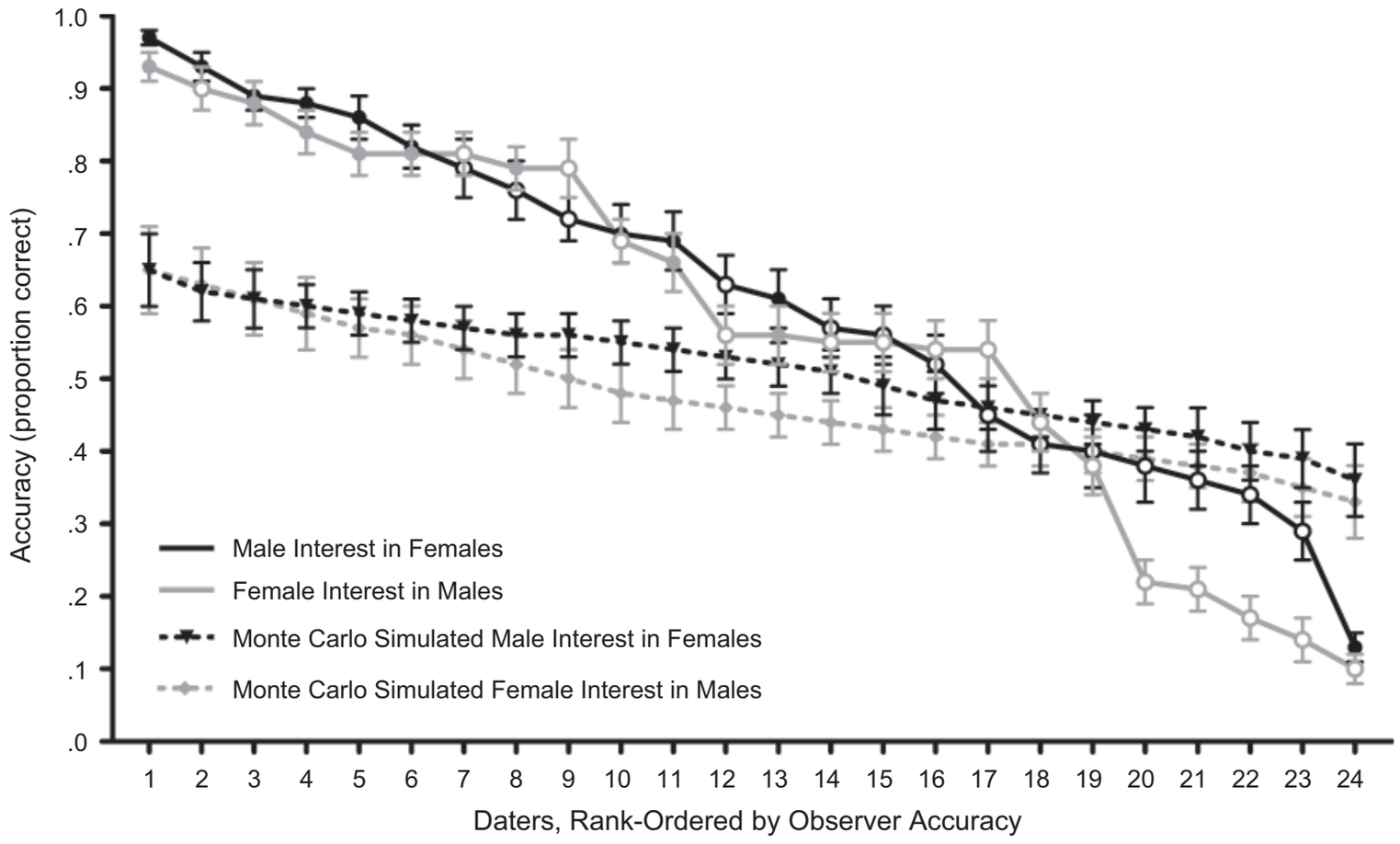
Fall 2012

Yoichi Okamoto (1915-1985) President Lyndon Johnson with Senator Richard Russell at the White House, December 7, 1963, Washington, DC.
1999 print. Lyndon Baines Johnson Library.



Yoichi Okamoto (1915-1985) President Lyndon Johnson with Senator Richard Russell at the White House, December 7, 1963, Washington, DC.
1999 print. Lyndon Baines Johnson Library.

Judging Romantic Interest

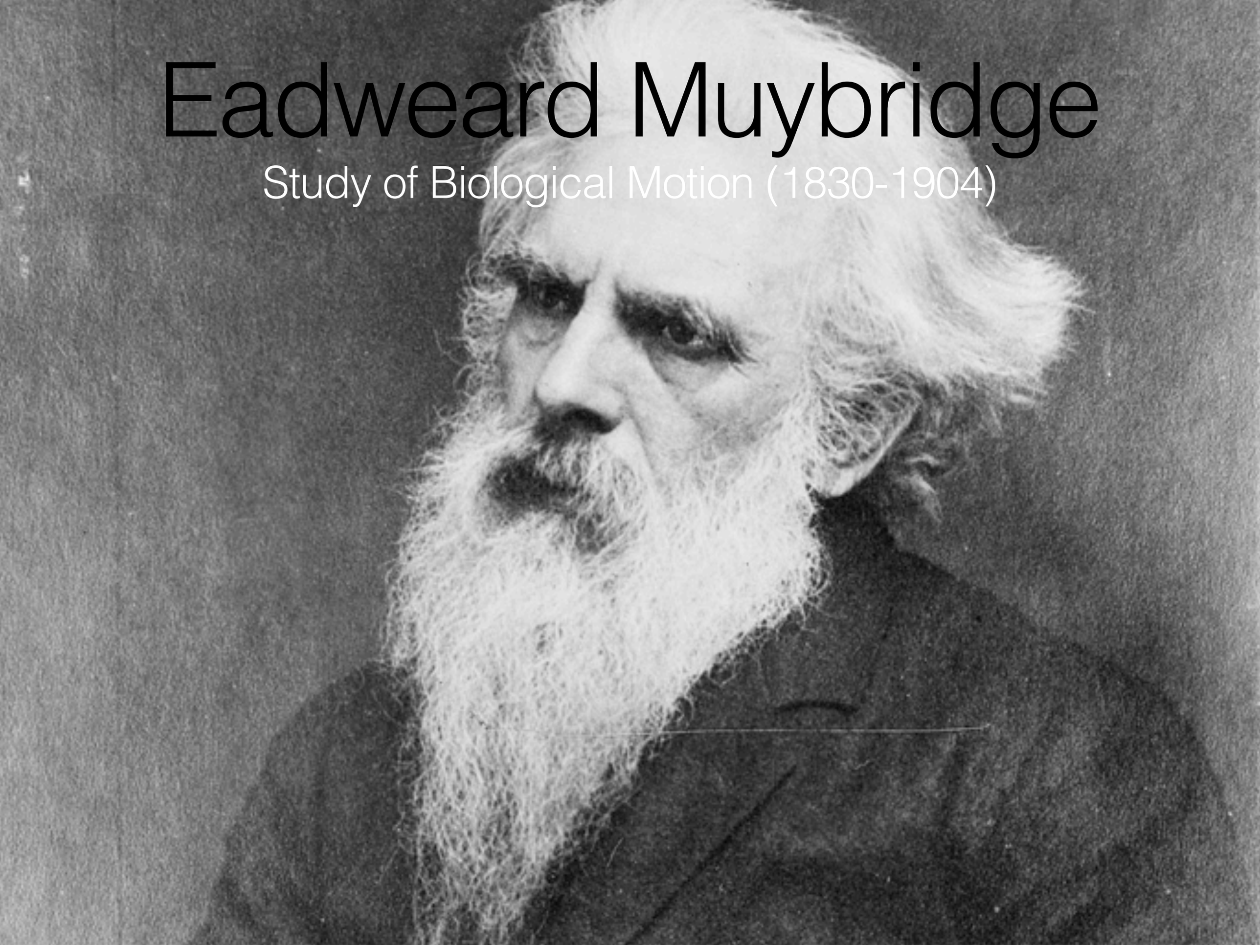


Place et al., The ability to judge the romantic interest of others, Psychological Science, 2009.

Accuracy in predicting each dater's interest. Error bars for observed data show standard errors of the means. Error bars for simulated expected data show 95% confidence intervals. Open circles indicate daters who were not interested; closed circles indicate daters who were interested. (Place et al. 2009)

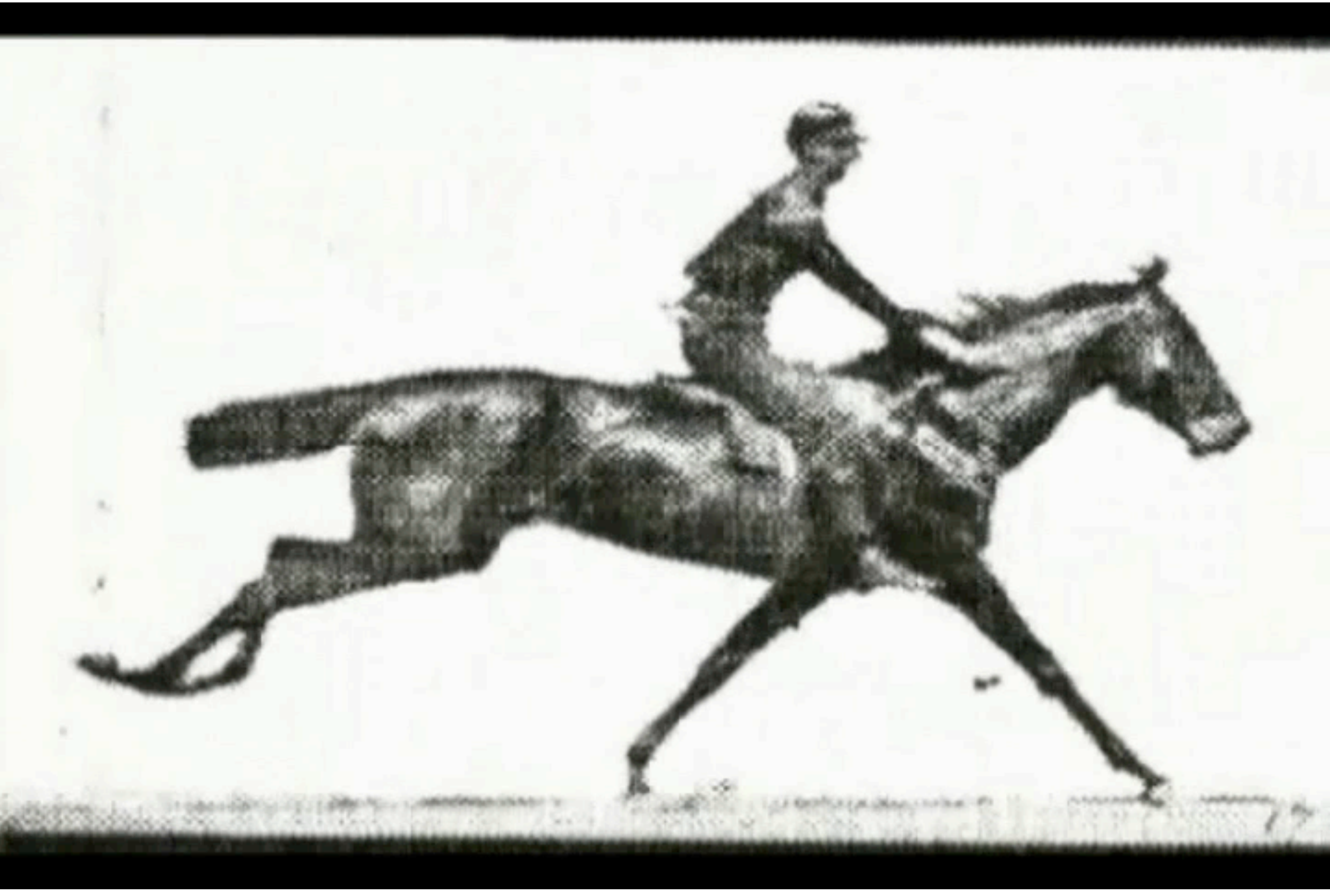
Eadweard Muybridge

Study of Biological Motion (1830-1904)



Do all four hooves leave the ground at the same time during a horse’s gallop?

A succession of “12 stereoscopic cameras spaced at 21-inch intervals over 20 feet to capture a single horse stride, taking pictures at one thousandth of a second.” [ref: http://lcls.slac.stanford.edu/VideoViewMuybridge.aspx]



THE HORSE IN MOTION.

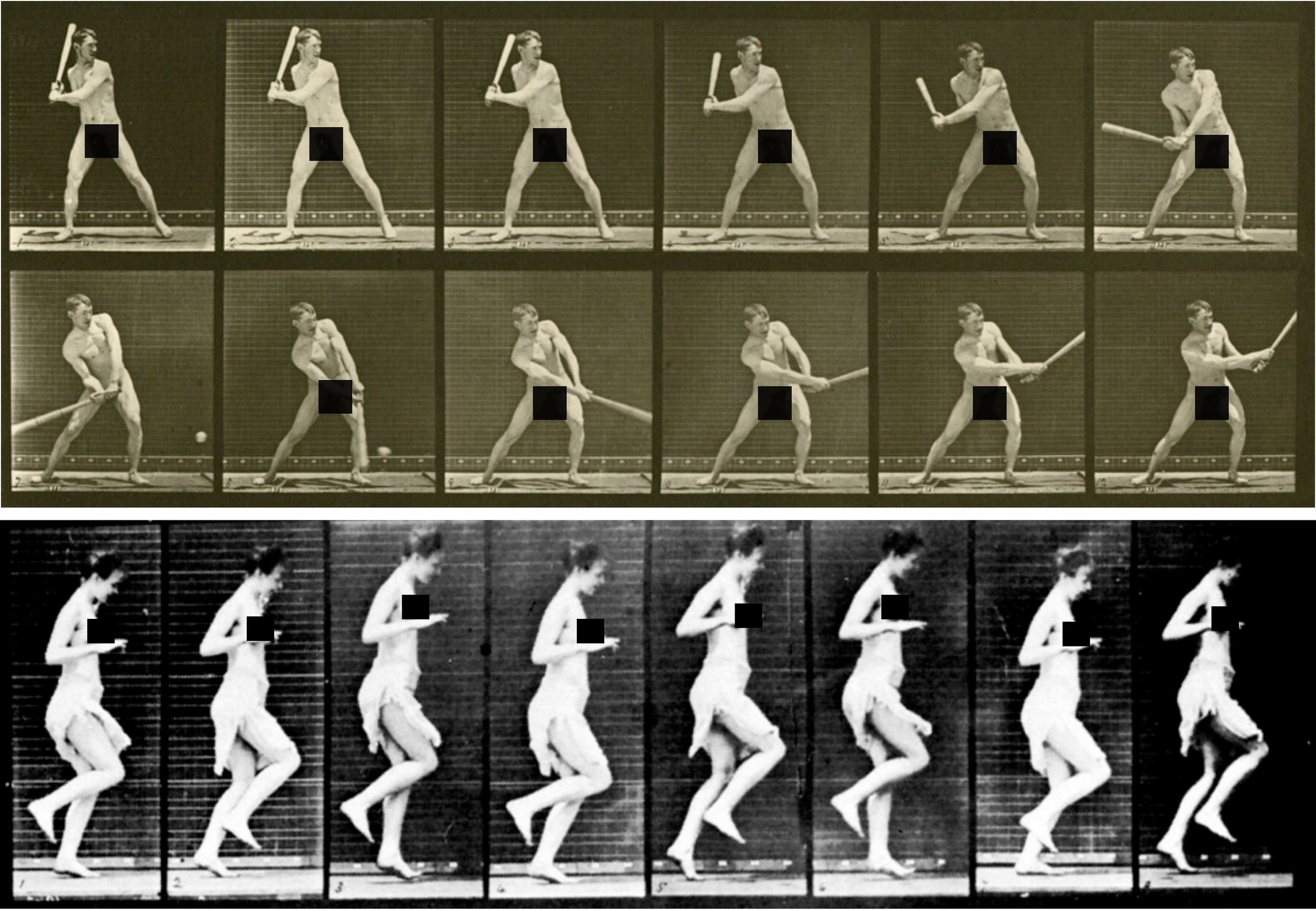
Illustrated by

MUYBRIDGE.

AUTOMATIC ELECTRO-PHOTOGRAPH.

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

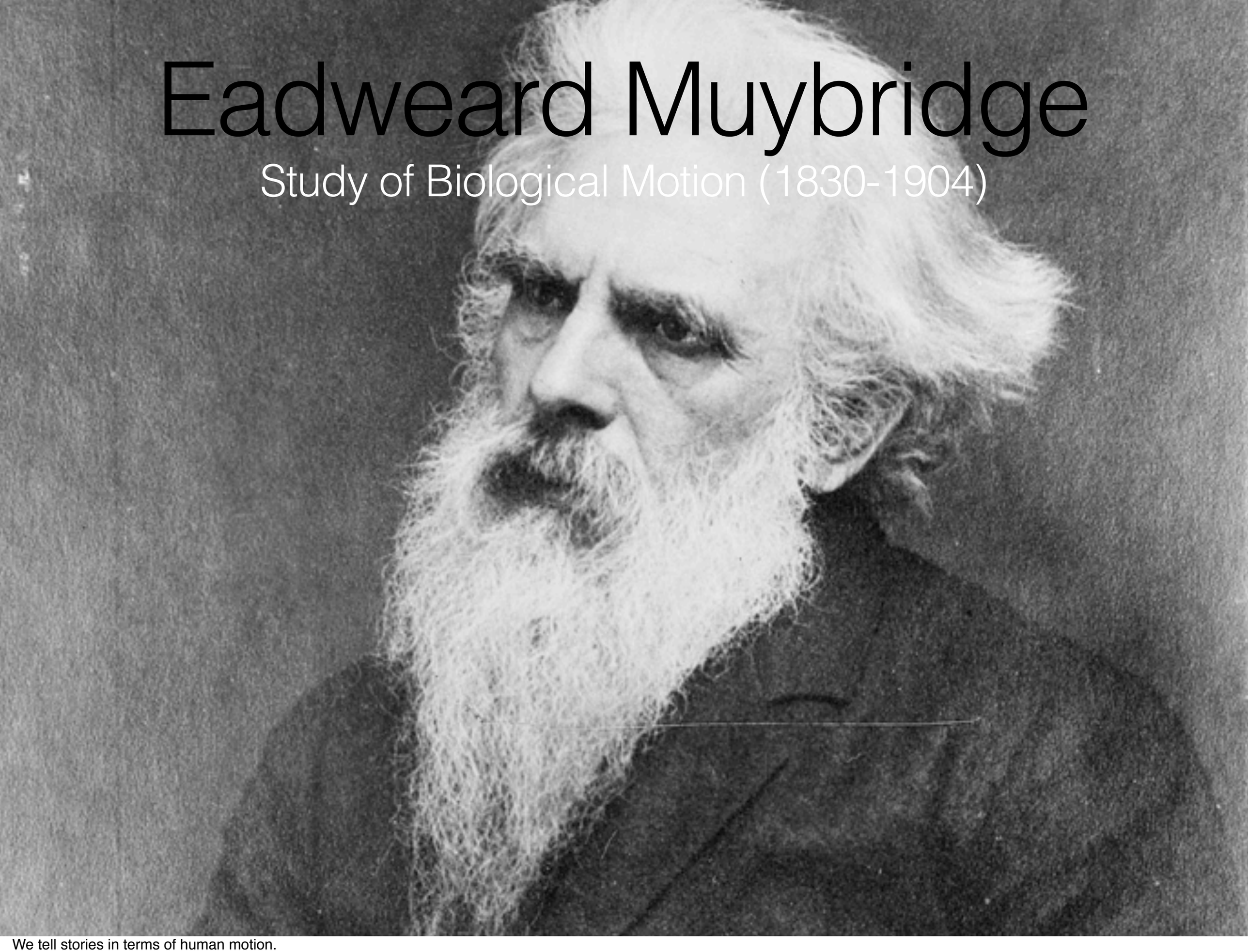
The negatives of these photographs were made at intervals of twenty-seven inches of distance, and about the twenty-fifth part of a second of time; they illustrate consecutive positions assumed in each twenty-seven inches of progress during a single stride of the mare. The vertical lines were twenty-seven 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.



...more than 100,000 images...

Eadweard Muybridge

Study of Biological Motion (1830-1904)



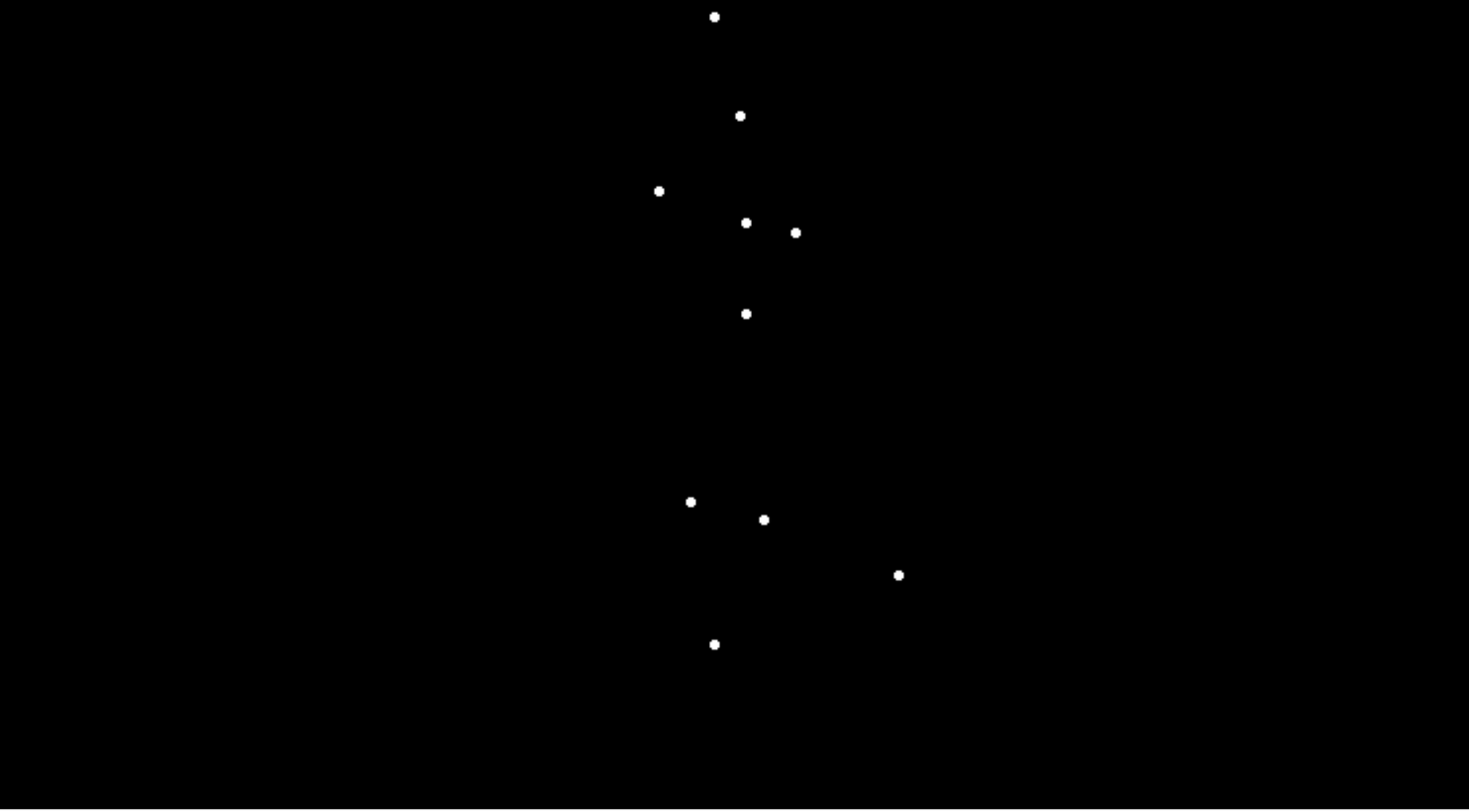
We tell stories in terms of human motion.

Gunnar Johansson

Gestalt of Biological Motion (1970)

Point Light Displays

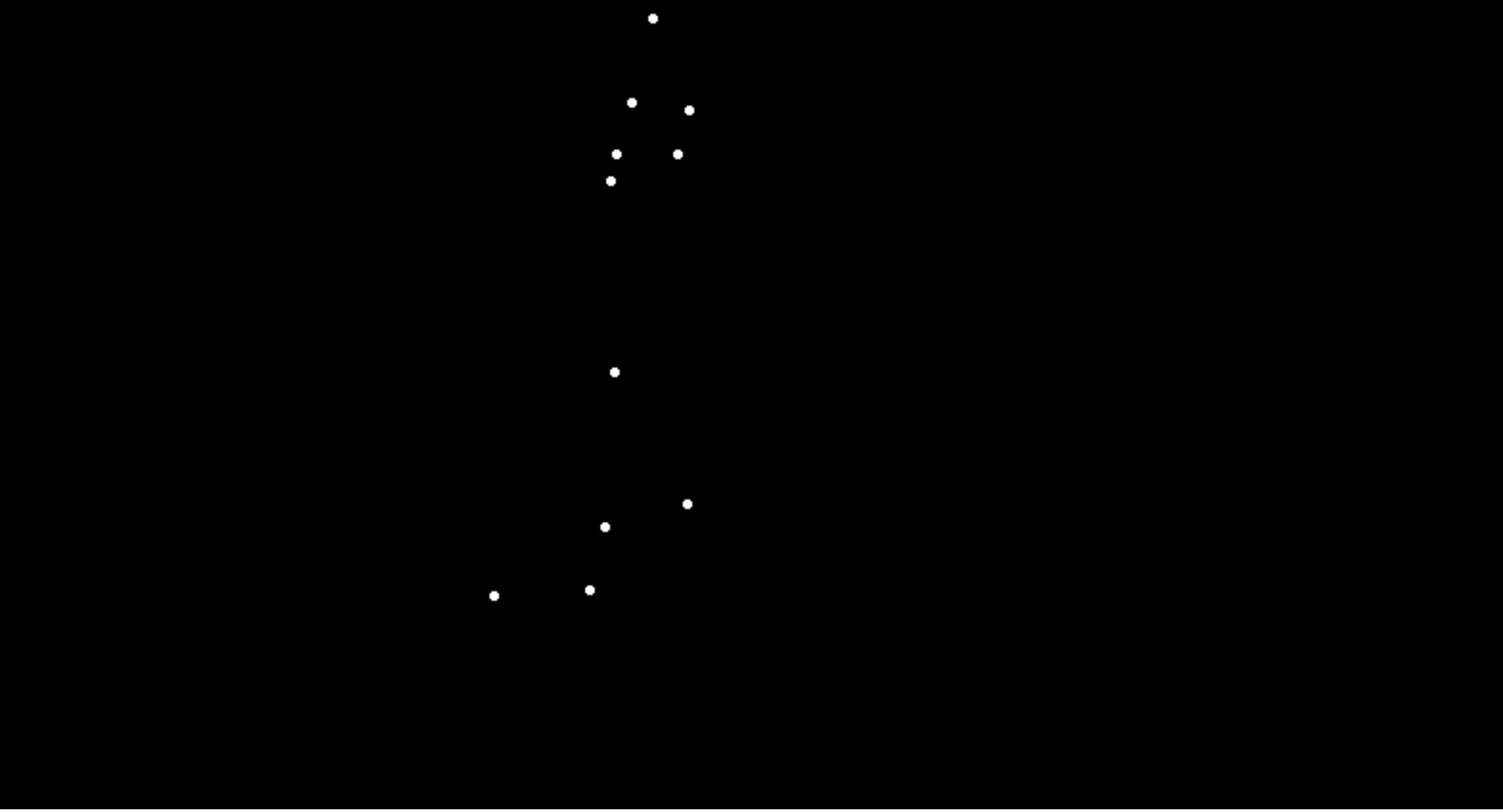
Johannson (1973)



[Ref: Thomas F. Shipley]

Point Light Displays

Johannson (1973)



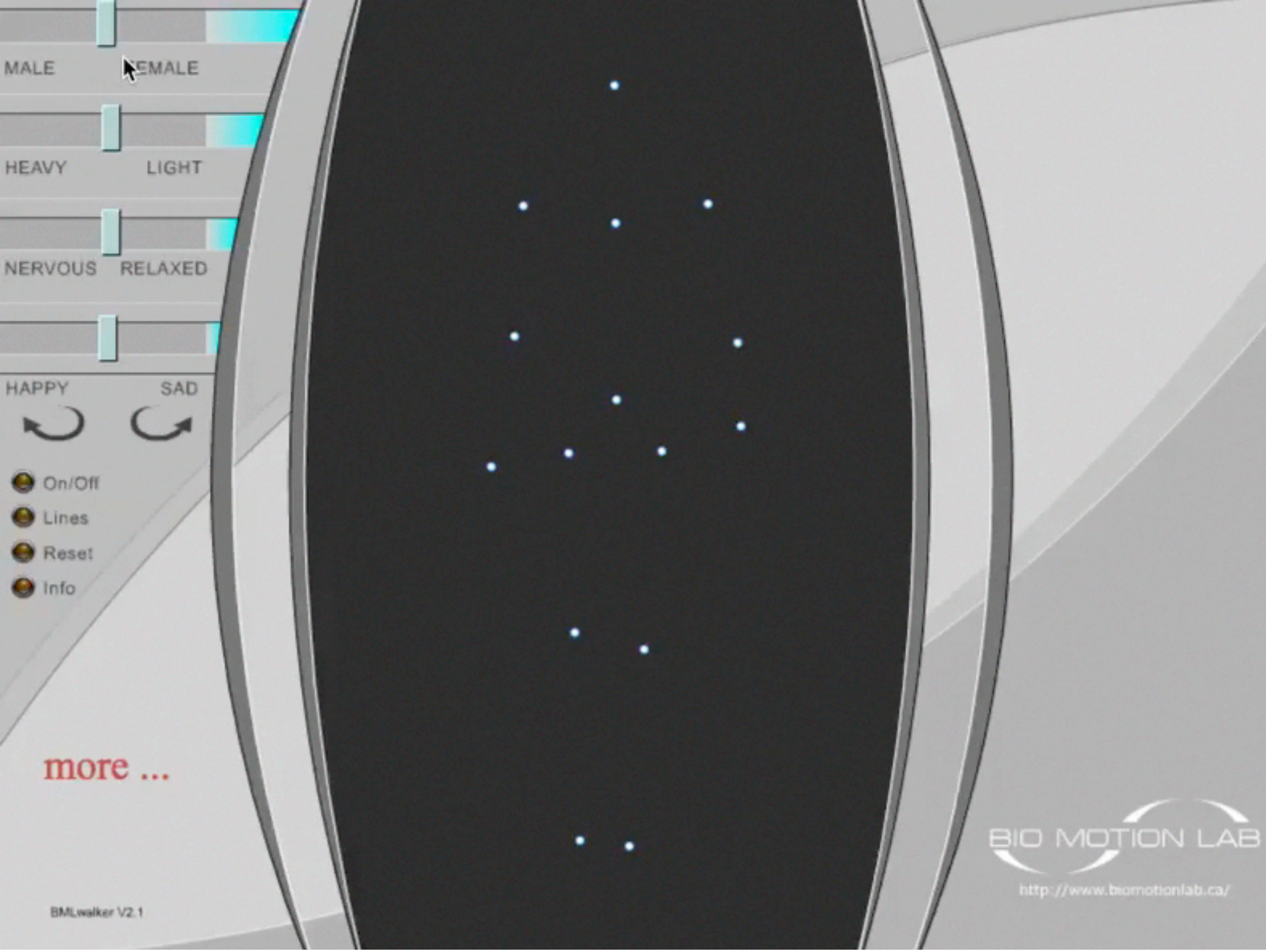
[Ref: Thomas F. Shipley]

Perception of Human Motion

Blake and Shiffrar (2007)

Observers can distinguish

- Identity (Cutting and Kozlowski 1977; Fani et al. 2005; Troje et al. 2005)
- Activities (Mass et al. 1971)
- Animal motion (Mather and West 1993)
- Social Cues (Ambady et al. 1999; Brown et al. 2005)


MALE
FEMALE
HEAVY
LIGHT
NERVOUS
RELAXED
HAPPY
SAD
On/Off
Lines
Reset
Info
more ...
BML walker V2.1
BIO MOTION LAB
http://www.biomotionlab.ca/

Perception of Social Cues

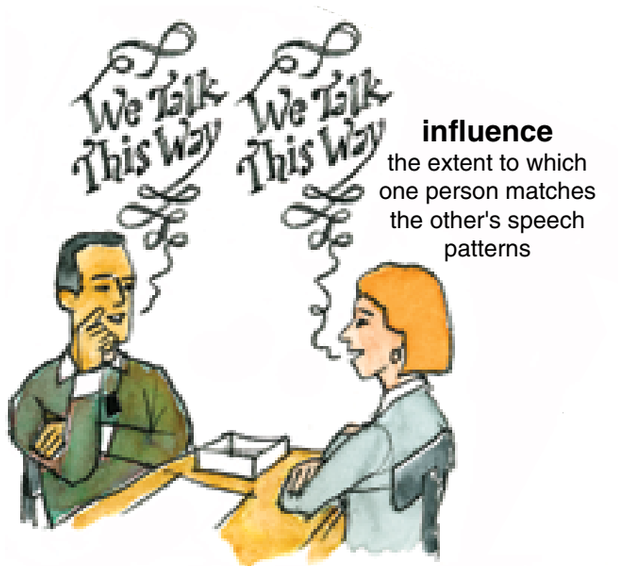
Blake and Shiffrar (2007)

Observers can distinguish

- Sex (Barclay et al. 1978)
- Sexual Orientation (Ambady et al. 1999)
- Dancing Ability (Brown et al. 2005)
- Social Dominance (Montepare and Zebrowitz 1988)
- Vulnerability to attack (Gunns et al. 2002)
- Intent to deceive (Runeson and Frykholm 1983)

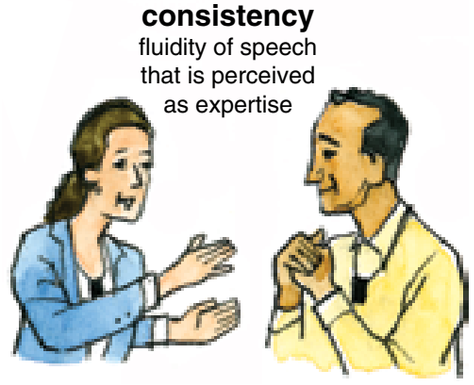
Honest Signals

Pentland (2010)



influence
the extent to which one person matches the other's speech patterns

activity
movement that indicates interest and excitement



consistency
fluidity of speech that is perceived as expertise

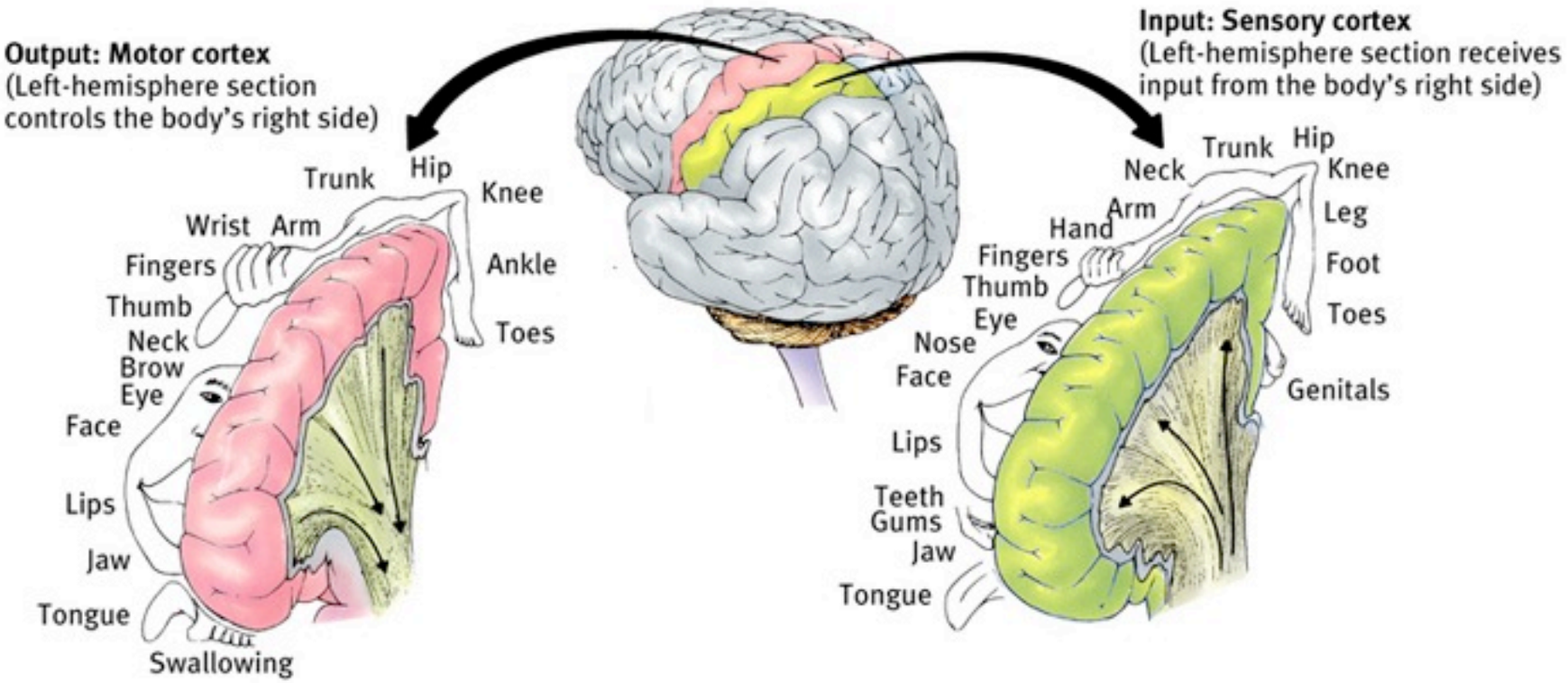
mimicry
reflexive copying of one person by another

Motion is a form of communication much older than language

Pentland, To Signal is Human, American Scientist, 2010.
Iacoboni, Imitation, Empathy, and Mirror Neurons, Annual Review of Psychology, 2009.

Motor Control

From Intent to Muscle Activation



Visual feedback and muscle activation are linked

Sea Squirts

Motion and Intelligence

Tunicates. These sea creatures begin life as a tadpole like creature, with a primitive eye and brain, and ends it’s larval stage by attaching itself to a rock. Once motion is no longer required, it ingests its cerebral ganglion. It’s ability to perceive motion and to move itself necessitated intelligence.

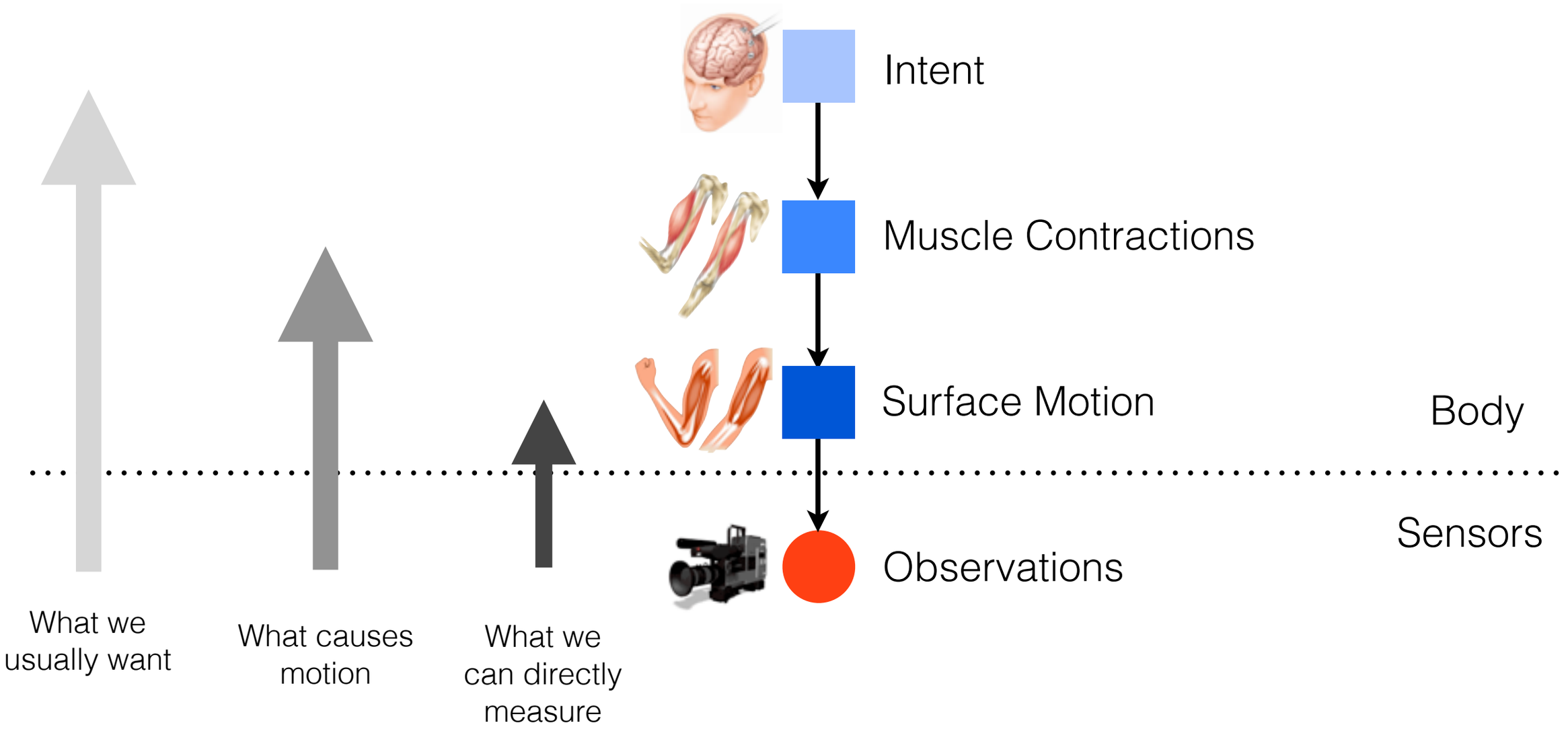
Human Motion can be studied from many perspectives

We will be interested in the **computational** perspective:

1. What can we quantify about human motion?
2. What models capture the structure in measurable human motion?
3. What sort of algorithms can we develop to use measurements and models of human motion?

What is Human Motion?

What makes Human Motion Hard to Analyze?



It’s impossible to kiss your elbow

What is Human Motion?

What makes Human Motion Hard to Analyze?

- Human Motion is any muscular contraction of the human body
- Hard to measure because muscular contractions are **hidden**
- Intent is also **hidden**

Biomechanics/Kinesology
Human Kinematics

Course Promise

At the end of this course, you will know...

1. The state of the art in human motion **capture**
2. Current **models** of human motion
3. **Applications** of human motion capture

Course Map

Syllabus and Evaluation Rubric

15-869 Human Motion Modeling and Analysis

Instructors: Yaser Sheikh **(CMU),** Leonid Sigal **(Disney Research),** Iain Matthews **(Disney Research)**
MW 3:00-4:20 GHC 5222

Office Hours
Yaser Sheikh: EDSH 221 Tuesday 2pm-3pm

Human motion analysis is used in applications as varied as special effects in movies, animation, sport training, physical rehabilitation for the disabled, and human-robot/human-computer interaction. This course will survey state-of-the-art techniques, in the industry and academia, to capture, model, and analyze human motion. The course will be a mix between lectures and seminar-style paper reading of recent research into human motion modeling and analysis. The course evaluation will be project-based, in which students will capture their own body and face motion, and build projects around the data they collect individually and as a group.

In particular, we will cover:
Capture Techniques: We will describe and use various systems including motion capture, video-based capture, depth sensors, scanners, and eye-gaze trackers.
Modeling and Representation: We will cover classic and contemporary representations of face and body pose and motion, including statistical and physics-based techniques.
Applications: As human motion analysis becomes increasingly mature, new applications are emerging. We will study recent progress in animation, synthesis, classification, and rehabilitation.

Course blog

http://15-869-f12.blogspot.com/

Course webpage

http://www.cs.cmu.edu/~yaser/Fall2012_15869.html

Part I: Capture

What can we measure about human motion?

Part II: Pose

How do we represent human pose?

Part III: Motion

How do we model human motion?

Part IV: Analysis

What sort of applications can we use human motion for?

Instructors

Yaser Sheikh (Robotics Institute)

Office Hours: Tuesdays 2pm-3pm

Office: EDSH (Smith Hall) 221

Leonid Sigal (Disney Research)

Office Hours: Thursdays 1pm-2pm

Office: CIC (Lower Level)

Iain Matthews (Disney Research)

Student Introductions

Name

Area of Research/Interest

What can human motion do for you?

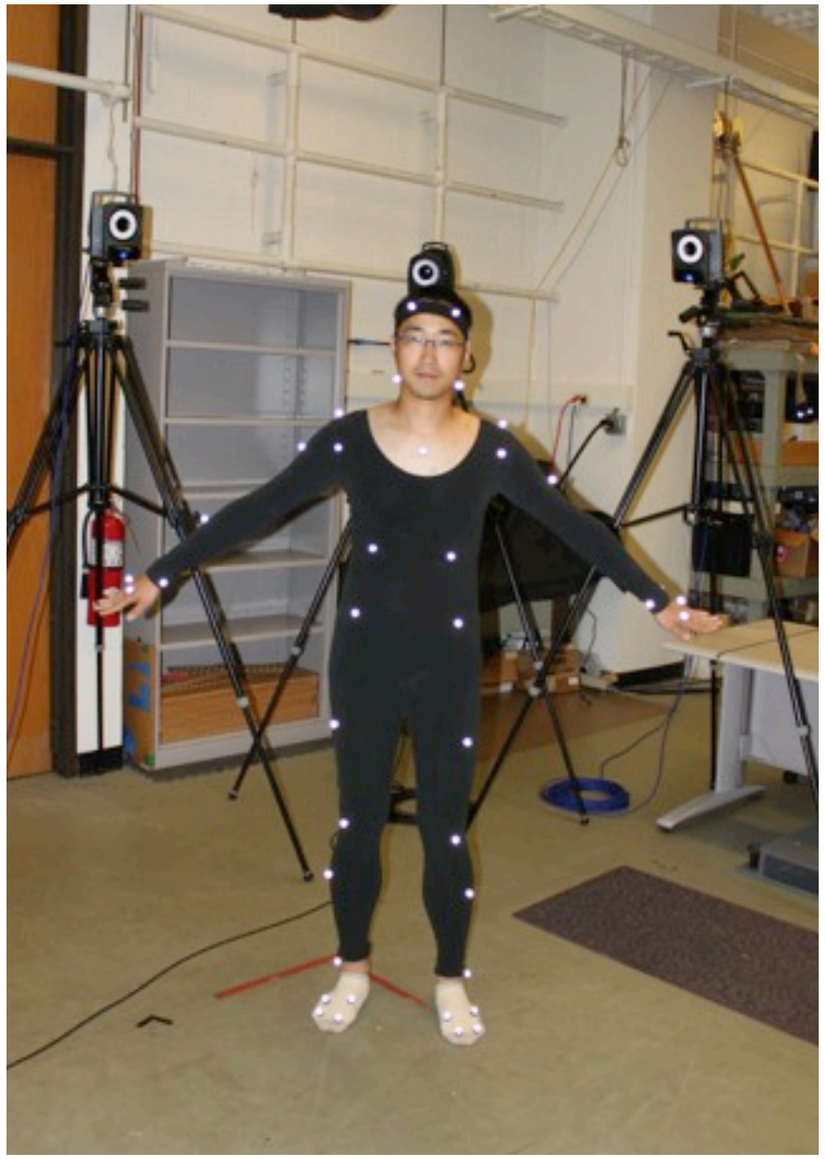
Capture Project

Hands on experience with Human Motion Data

20% of course grade

Four types of data:

1. Motion Capture
2. Surround Vision
3. Face Scans
4. Face Motion

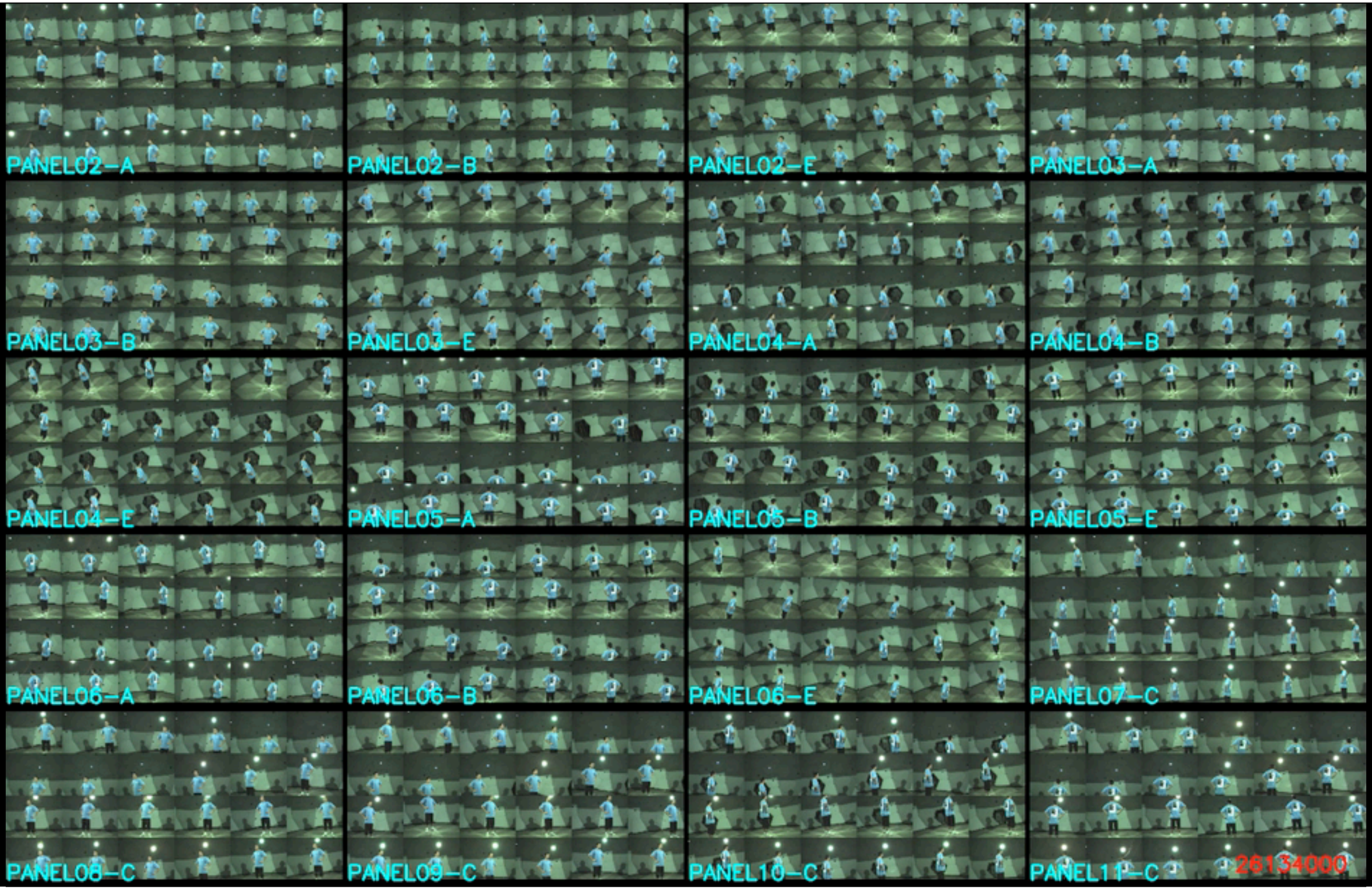


Motion Capture

Marker-based Human Motion Capture

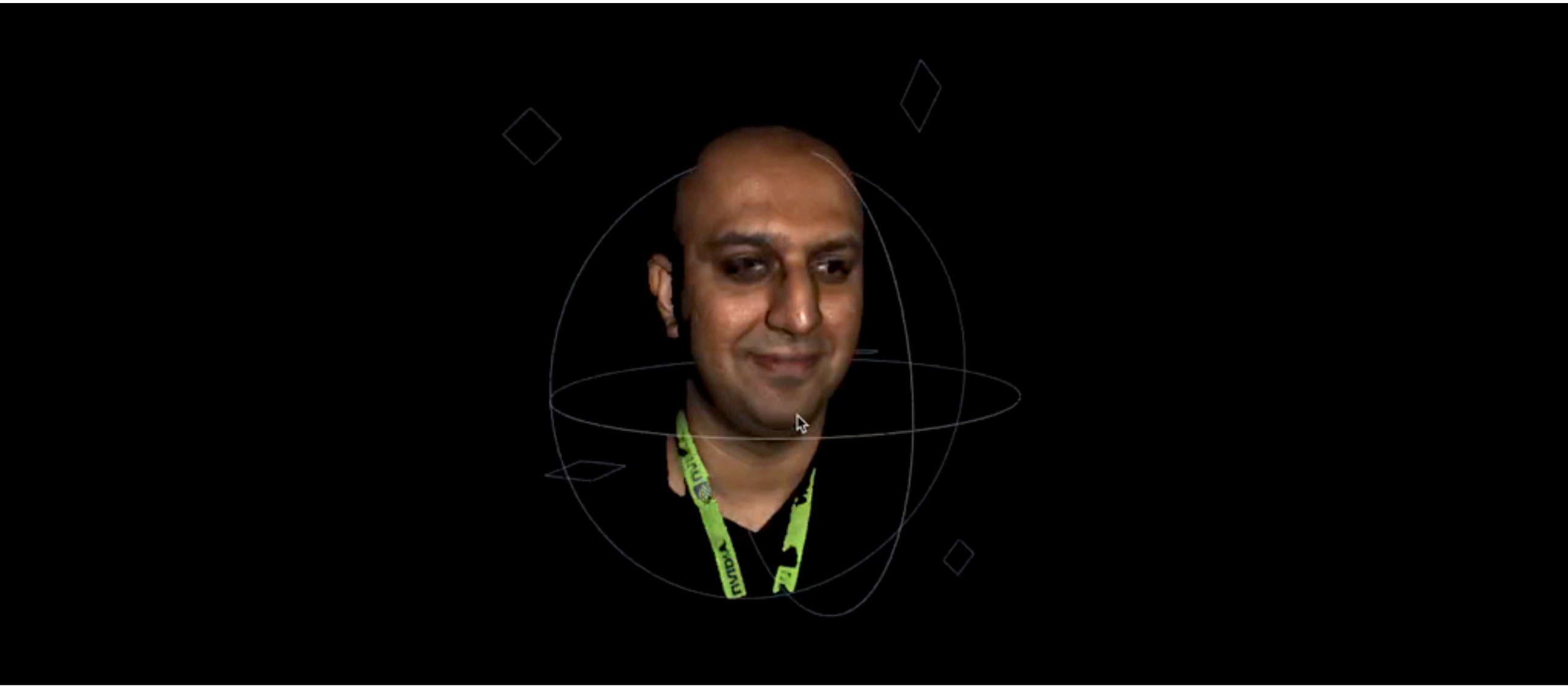
Surround Vision

Multiple Perspective Video



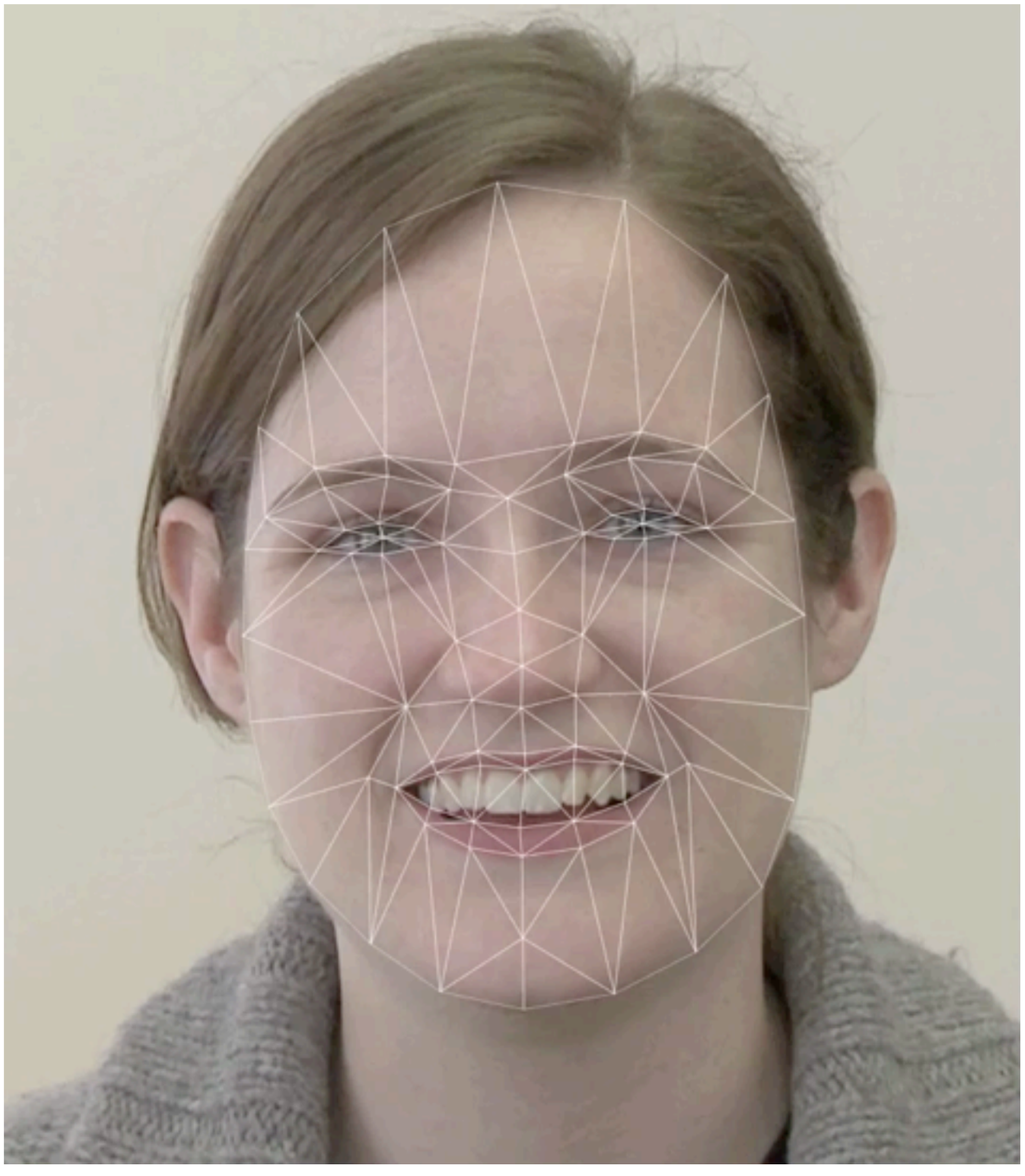
3D Face Scans

Capturing the 3D Structure of Faces



Facial Motion

Active Appearance Models



Teams

Four Captures

Sign up on the course blog by Sep-12

1. **Motion capture**: Capture and Clean-up
2. **Surround vision capture**: Capture and Organization
3. **Face 3D Scans**: Capture and Alignment
4. **Face Motion**: Capture and Setup

Course Project

Do Something Cool with Human Motion Data!

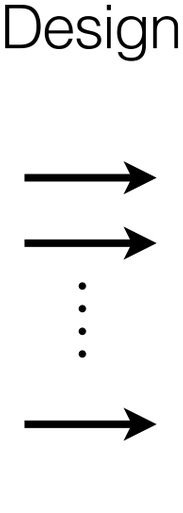
- **50% of the class grade**
- Incorporate your research into your project
- Pick a project and mentor early

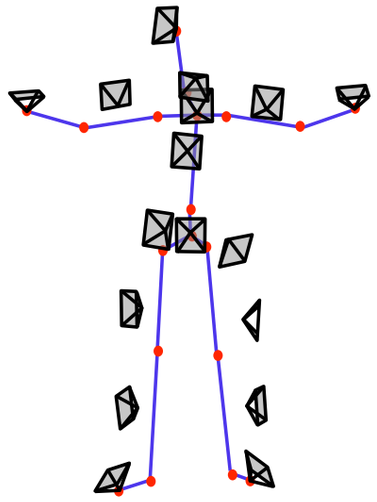
Course Project

General Structure

1. Capture Design

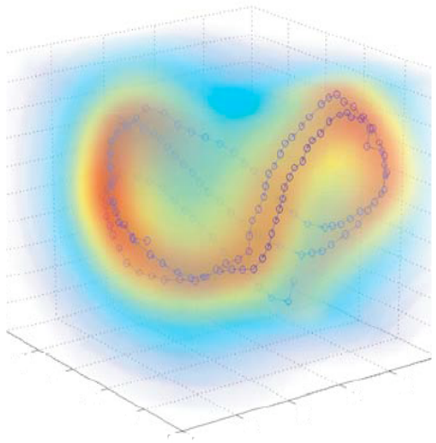
Human Motion





Human Pose Representation

2. Analysis Design



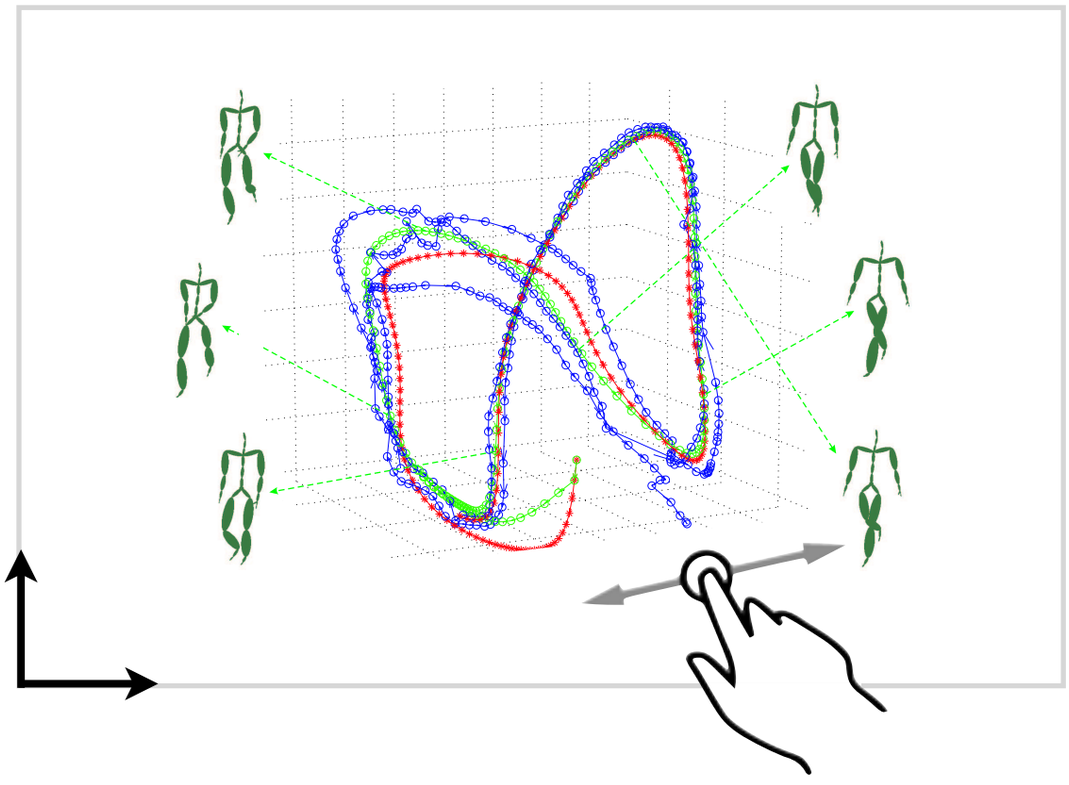
Human Motion Representation

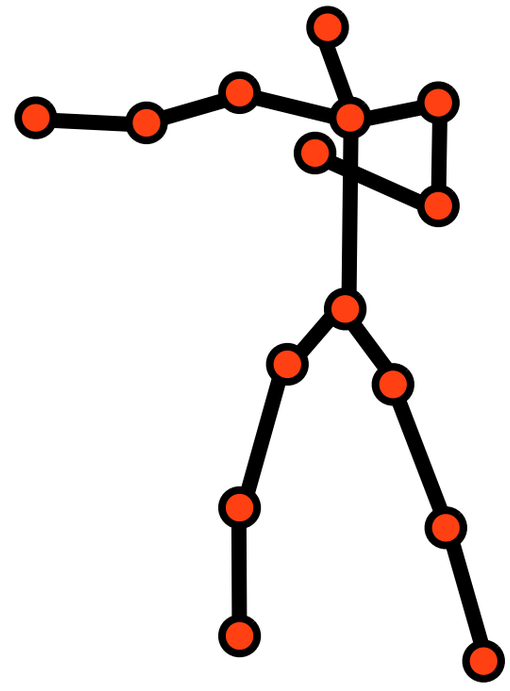
3. Application Design

Cool application

Course Project

Example 1: Touch-screen Joystick





Map 2D space onto Pose space

Course Project

Evaluation Rubric

1. Have you produced interesting results?

- Have you developed a good evaluation methodology?
- Have you done something creative or unexpected?

2. Have you built a good project blog post?

- Has your blog post generated discussion?
- Is the blog post a good summary of your work?

3. Have you met at least twice with your project mentor?

Reading Assignments

Summarize and Editorialize

- **10% of course grade**
- Post write-ups on course blog
  http://15-869-f12.blogspot.com/
- Some general guidelines for your write-ups
  1. **Summarize** the gist of the paper in a sentence or two.
  2. Mention **insights** in the paper that you liked.
  3. Mention the **limitations** of the paper.
- Contribute to the discussion of the paper
- Due before the class

Encourage critical reading.

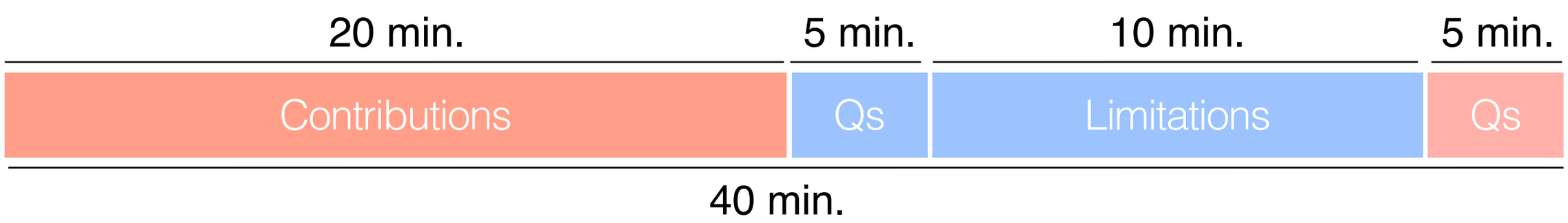
Paper Presentations

Debate-style Presentations

- **20% of course grade**
- **Red** and **Blue** team for each paper
- **Blue team (affirmative)**: Explain the **contributions** of the paper.
- **Red team (improvement)**: Explore the **limitations** of the paper.

Paper Presentations

Rules



1. Two people per team (pick a team, a paper, and email me)
2. Only clarification questions during statements
3. Continue discussion on blog

http://www.howell.k12.nj.us/twroot/mms/jlangenberger/914/downloads/newdebate.pdf

Paper Presentations

Guidelines

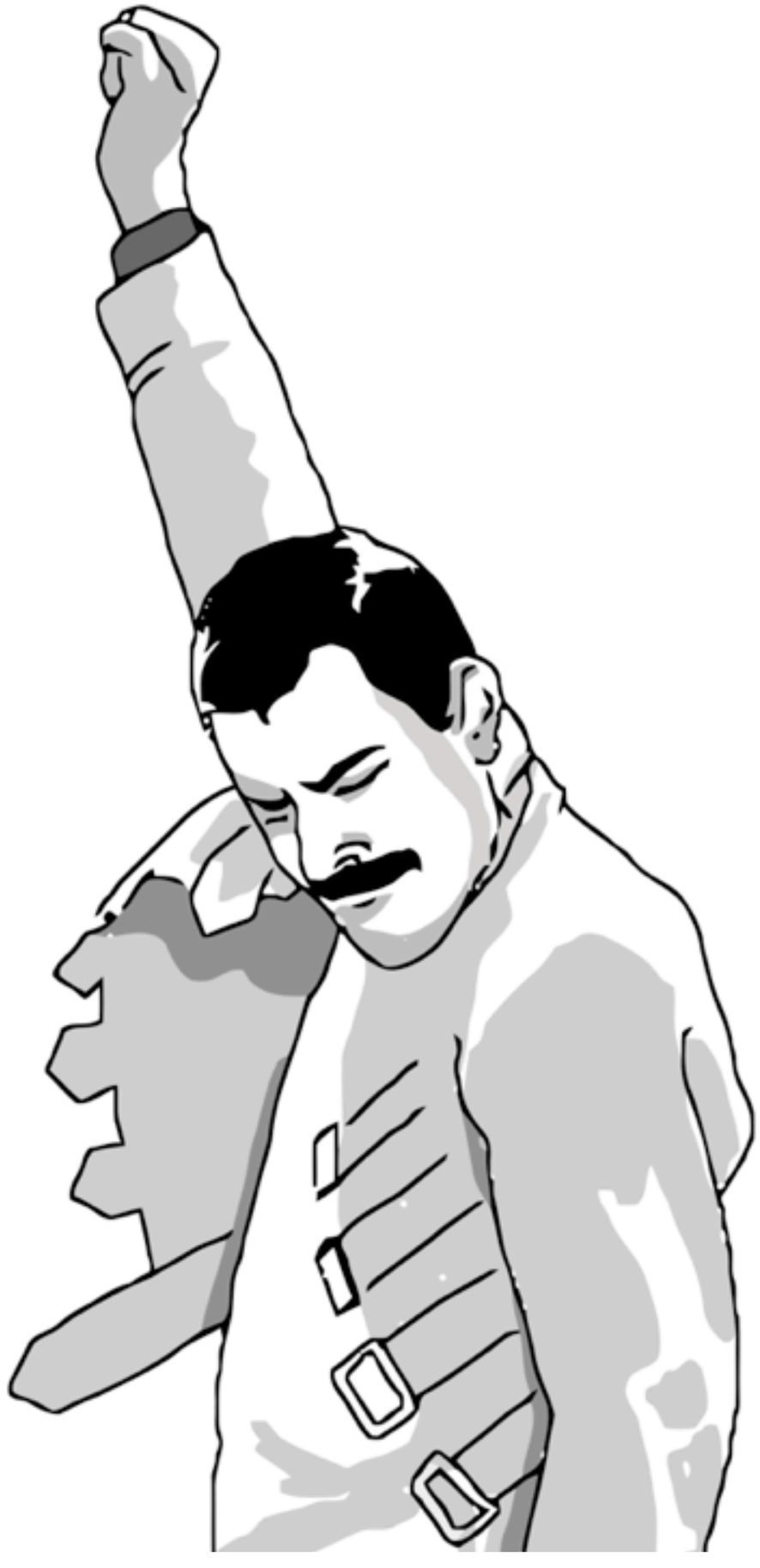
1. Understand the contributions and limitations of the proposed approaches
2. Build a scientific argument
3. Develop an eye for evaluating techniques for human motion
4. Use code to show examples (or counter-examples)

http://www.howell.k12.nj.us/twroot/mms/jlangenberger/914/downloads/newdebate.pdf

Awards!

Vote for:

- Best Project Award
- Best Blogger Award
- Best Presentation Award



Reading List

References

(1) Wolpert et al., Principles of Sensorimotor Learning, Nature, 2011.

(2) Blake and Shiffrar, Perception of Human Motion, Annual Review Psychology, 2007.

(3) Klette and Tee, Understanding Human Motion: A Historic Review, 2008.

(4) Pentland, To Signal is Human, American Scientist, 2010.

(5) Place et al., The ability to judge the romantic interest of others, Psychological Science, 2009.

(6) Iacoboni et al., Imitation, Empathy, and Mirror Neurons, Annual Review Psychology, 2009.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