# Emergent User Interfaces
# CS-E4200

Introduction to Multimodal Interaction 2

–

Movement / Gestures / Embodied interaction

# Gestural interaction

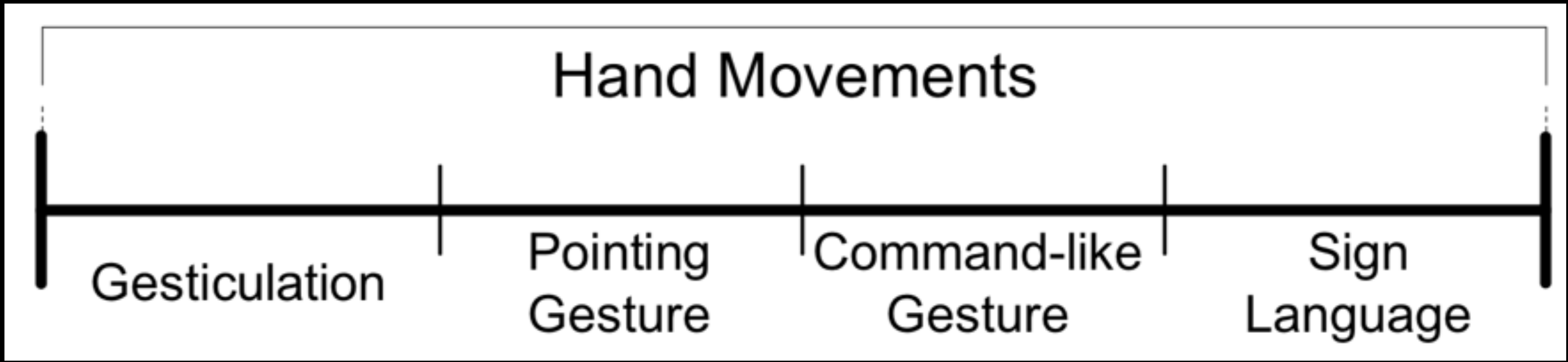
Minority Report 2002

# Gesture

- Kinaesthetics is bi-directional
- Can exploit our ability to use and memorise patterns and fine motor control to control things
- Use the body as an input device
  - E.g. Skinput
- Can detect and sense via different sensors
  - Accelerometer
  - Camera Tracking
  - Physical devices

# What is a Gesture?

- Motion with meaningful content




- simple gestures in WIMP interface
  - point & click = selection
  - click-drag-release = move an object / select a range

# Gestures on Touchpad

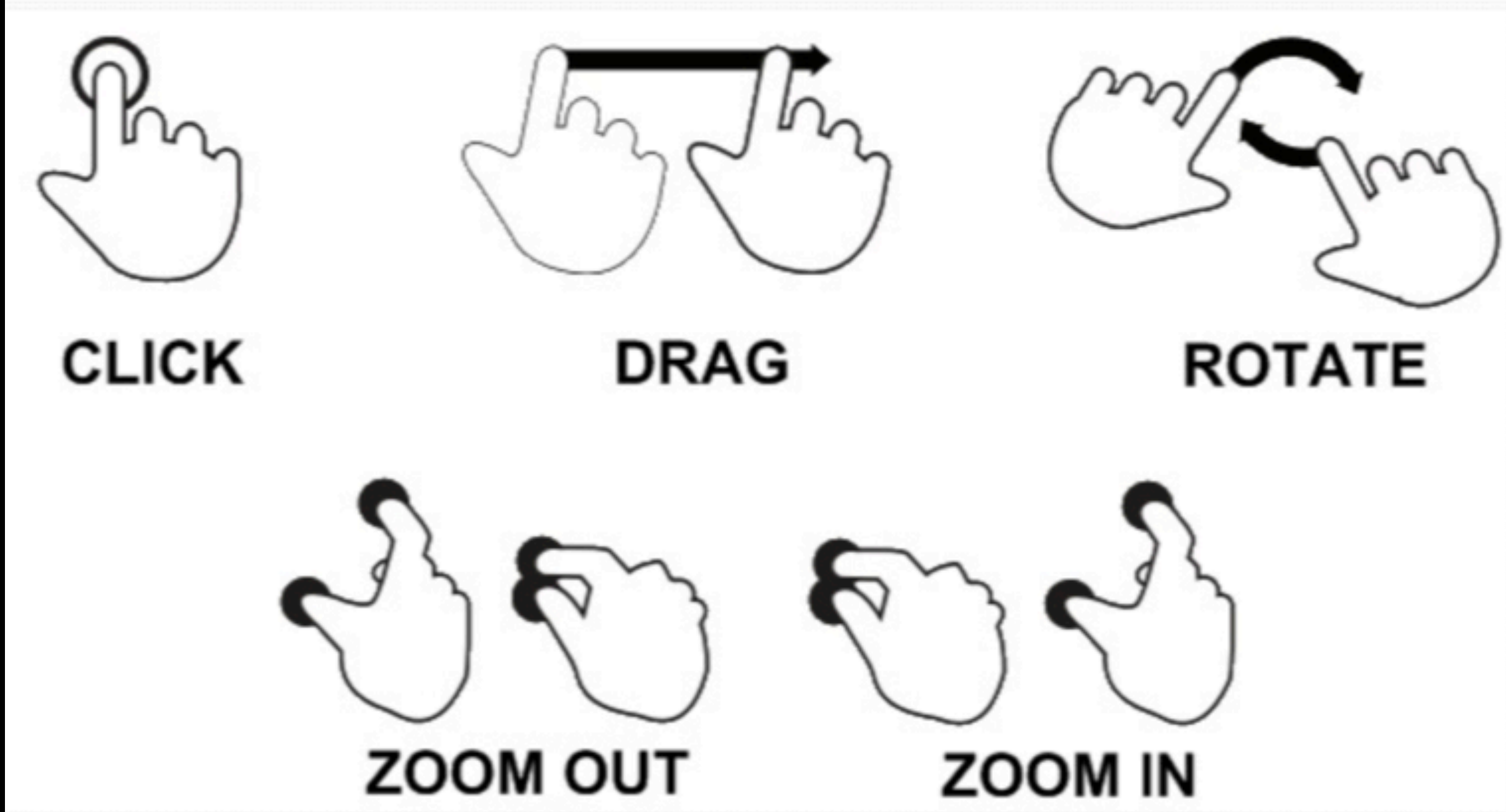



Figure 1. Typical gestures of gestural enabled interfaces with multi-touch capability.

# More options…

| Outcome | Gesture |
|---|---|
| selection | one finger tap |
| | one finger drag |
| pan/move camera | one finger drag |
| | two finger drag |
| | five finger drag |
| move objects | one finger drag |
| | vertical hand position drag |
| | rearrange objects |
| throw/catch objects | one finger flick |
| rotate camera | one finger drag |
| | two finger rotational drag |
| | three finger drag |
| | multiple finger rotational drag |
| | one finger hold, one drag |
| | flat hand position rotates |

- variable, not standardized

| | |
|---|---|
| tilt camera | two finger hold, one drag |
| rotate objects | one finger hold, one drags around |
| zoom | two finger drag apart/together |
| resize objects | multiple finger drag apart/together |
| resize by powers of ten | two finger hold, one drag |
| toggle mode | one finger tap |
| show menu or details | one finger hold |
| | horizontal hand |
| | tilted horizontal hand |
| define region | four finger touch |
| | two "L" shaped hands |

Ingram, A., Wang, X., & Ribarsky, W. (2012, May). Towards the establishment of a framework for intuitive multi-touch interaction design. In Proceedings of the International Working Conference on Advanced Visual Interfaces (pp. 66-73). ACM.

# Multitouch in large scale

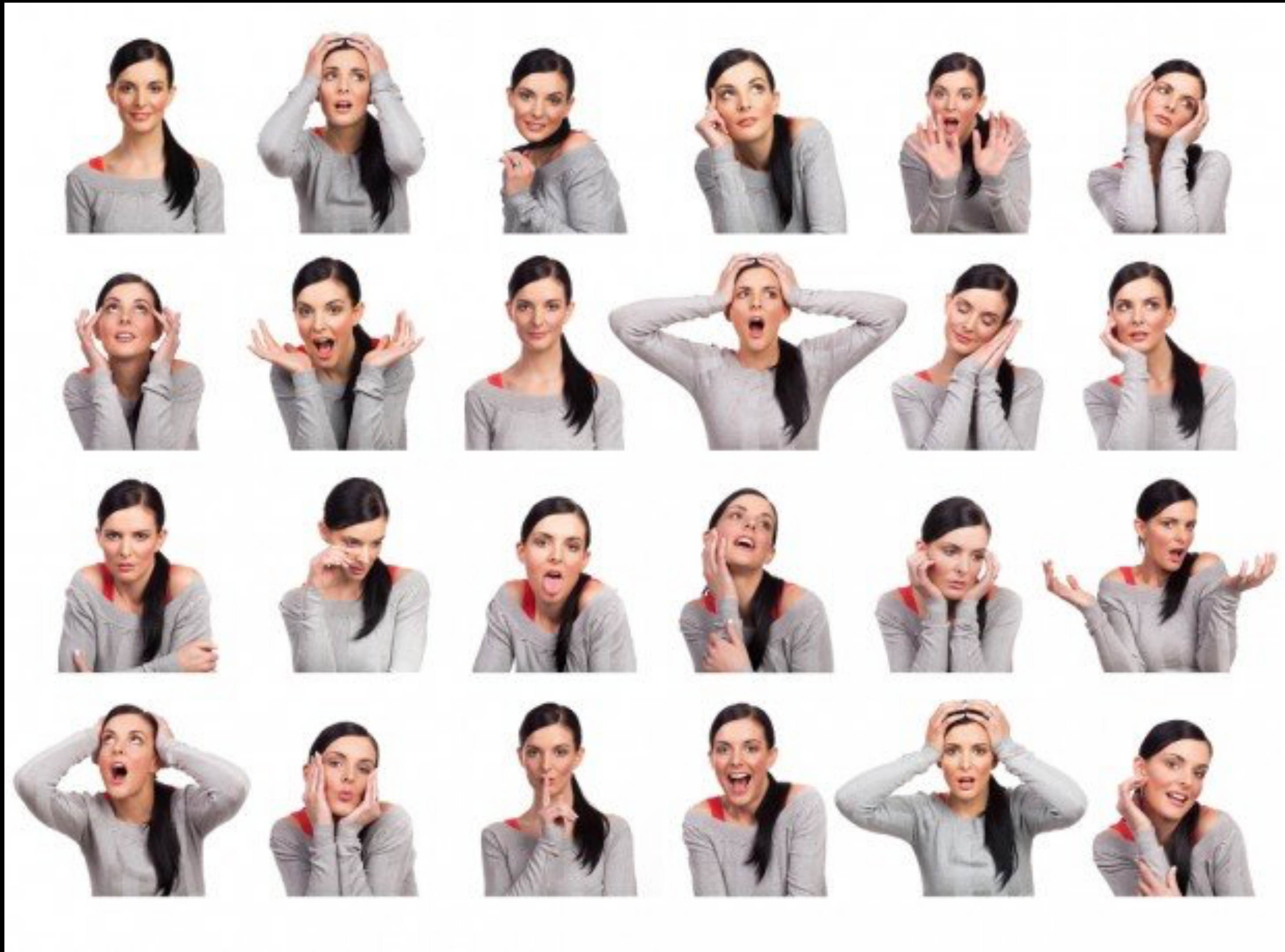
https://www.multitaction.com/product/mt-showcase/

# Gestures in 3D

- No physical reference surface
  ➔ less accurate positioning
  ➔ hand fatigue, "gorilla arms"

- More degrees of freedom
  – 3D movement
  – not only finger tips ➔ hand orientation and shape
  – more than hands and fingers ➔ arms / legs / body

# Body Language

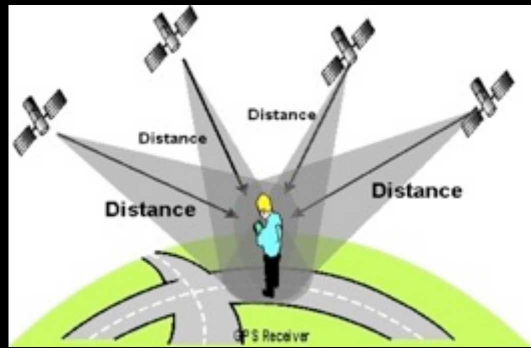


Corneanu, Ciprian, et al. "Survey on Emotional Body Gesture Recognition."
IEEE Transactions on Affective Computing (2018).

# Motion Tracking

- Physical
  - mouse (2D), joined arms, PHANTOM
- Sensors
  - vibration/touch
  - accelerometer
  - biosensors: EMG
- Camera
  - with/without markers on body
  - conventional videocam (RGB)
  - depth camera (RGBD)

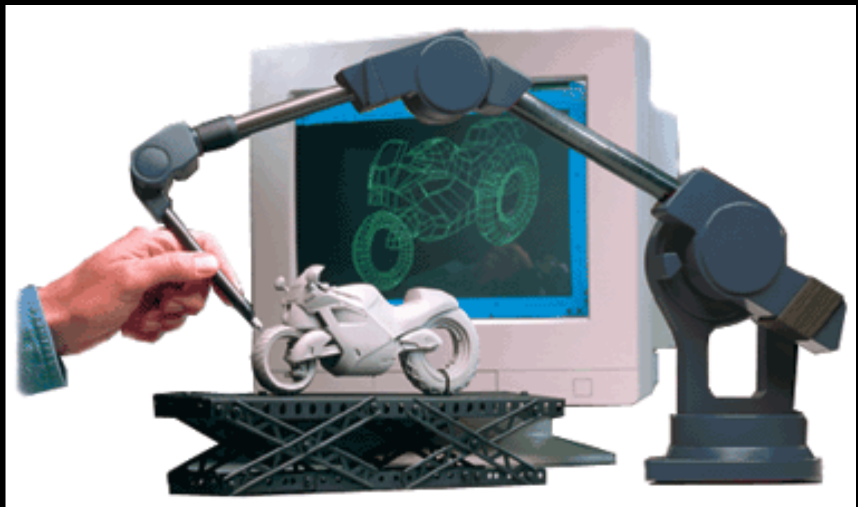
# Tracking Technologies




- Active
  - Mechanical, Magnetic, Ultrasonic
  - GPS, Wifi, cell location
- Passive
  - Inertial sensors (compass, accelerometer, gyro)
  - Computer Vision
    - Marker based, Natural feature tracking
- Hybrid Tracking
  - Combined sensors (eg Vision + Inertial)

# Mechanical Tracker

- Idea: mechanical arms with joint sensors



Microscribe

Sutherland (1968)

- ++: high accuracy, haptic feedback
- – – : cumbersome, expensive

# Magnetic Tracker

- Idea: measure difference between a magnetic transmitter and a receiver

Polhemus Fastrack

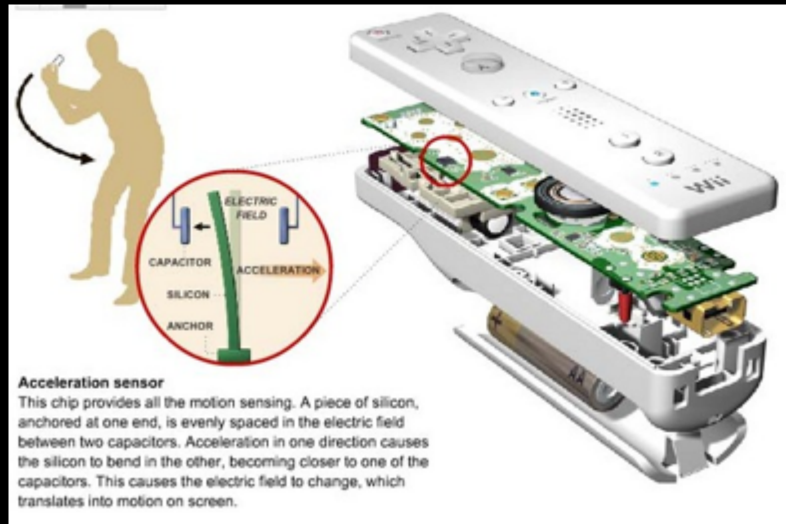
Flock of Birds (Ascension)

- ++: 6DOF, robust
- -- : wired, sensible to metal, noisy, expensive
- -- : error increases with distance

# Inertial Tracker

- Idea: measuring linear and angular orientation rates (accelerometer/gyroscope)


IS300 (Intersense)

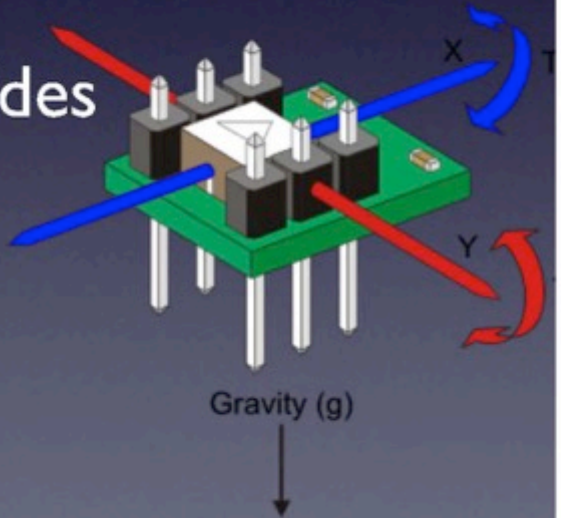



Wii Remote

- ++: no transmitter, cheap, small, high frequency, wireless
- -- : drift, hysteris, only 3DOF

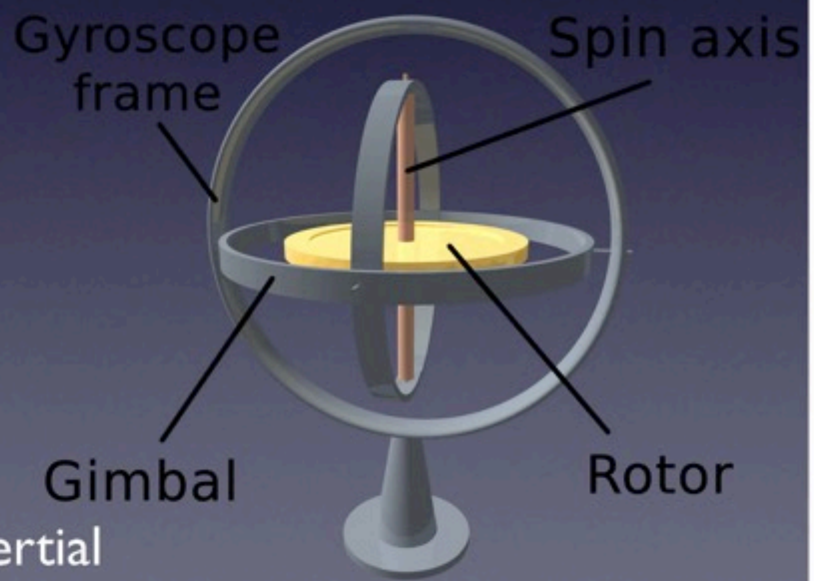
# Accelerometer

- Mass attached to a spring
- Calibrated to 1G in a vertical dimension at rest
    - 3 aligned on cardinal axes provides orientation
- Applying force increases reading
    - Until maximum force reached
- Can record and process force over time



# Gyroscope

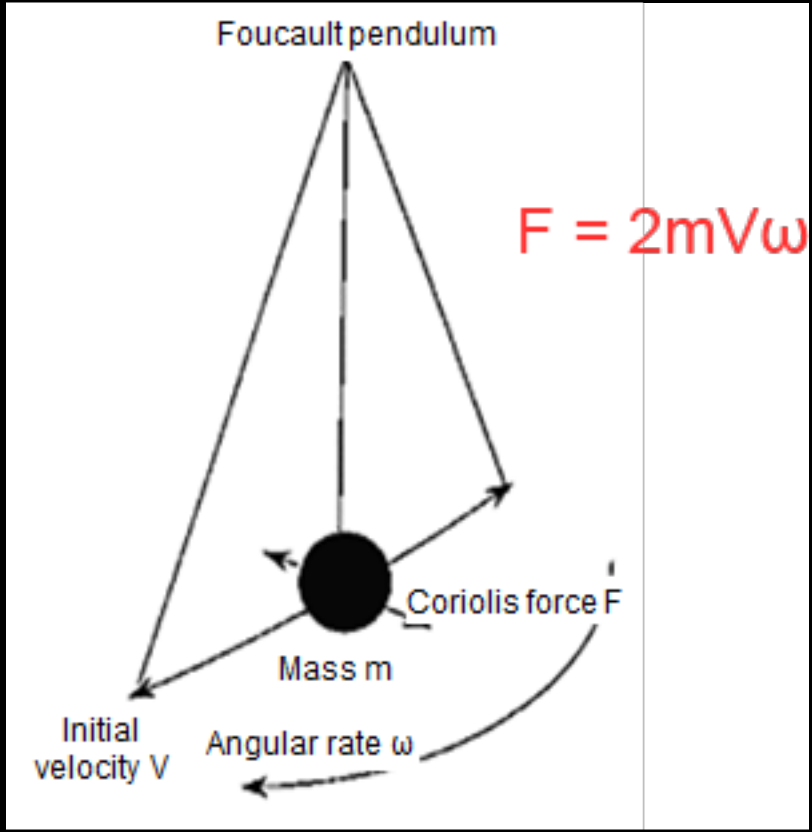
- When you spin a wheel it continues to spin on the same axis and resists movement to turn.
- Take 3 and you can determine orientation in space.
- Supports orientation around gravity
- Some issues
    - Requires ramp up time
    - Quality and Drift
    - No global frame of reference
- With an accelerometer often called inertial tracking



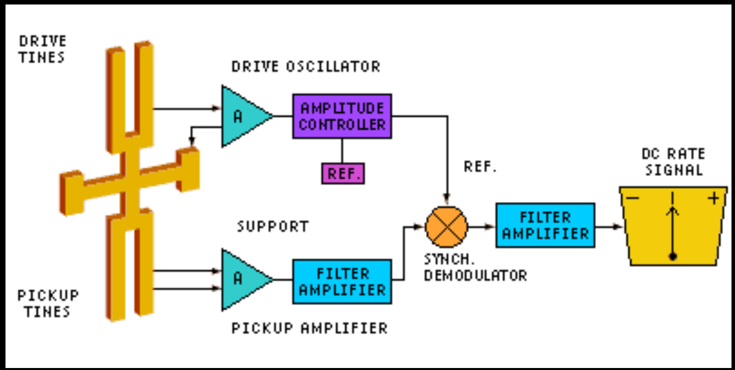

wikipedia.org

# Angular Rate Sensor, "gyro"

- Called "gyroscope" but works differently:
  - rather than indicating direction, indicates the rate of change of angle




- Implemented with MEMS technology
  - measures the Coriolis acceleration of a vibrating mass



# Optical Tracker

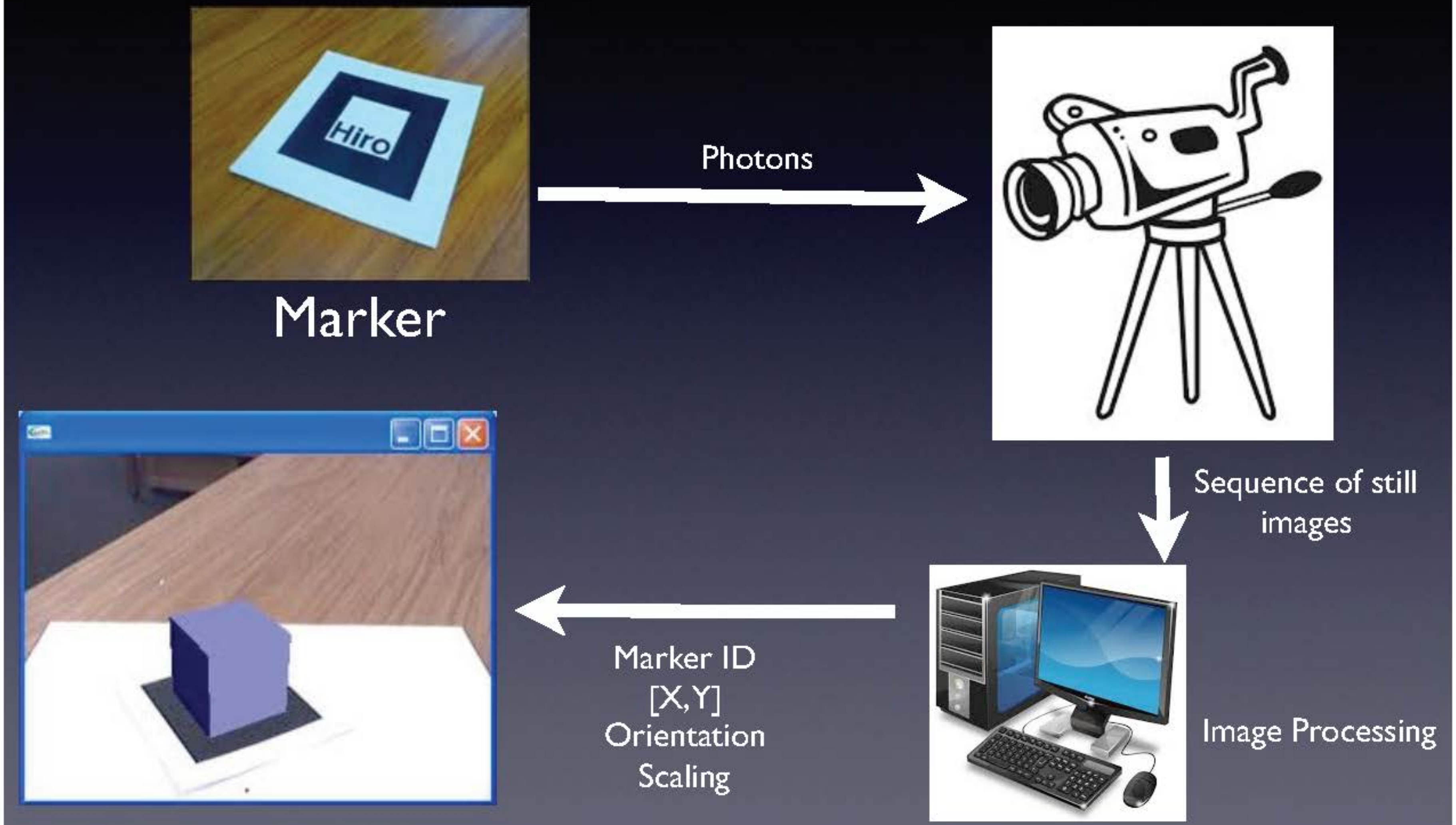
- Idea: Image Processing and Computer Vision
- Specialized
  - Infrared, Retro-Reflective, Stereoscopic

ART

Hi-Ball

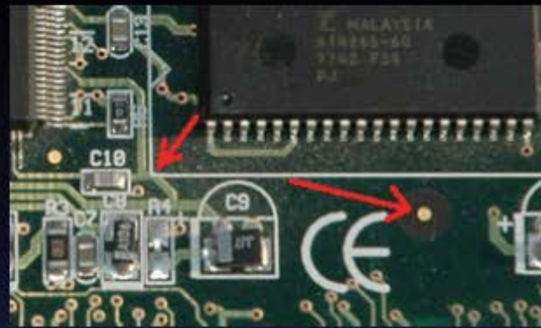
- Monocular Based Vision Tracking

# Camera Tracking

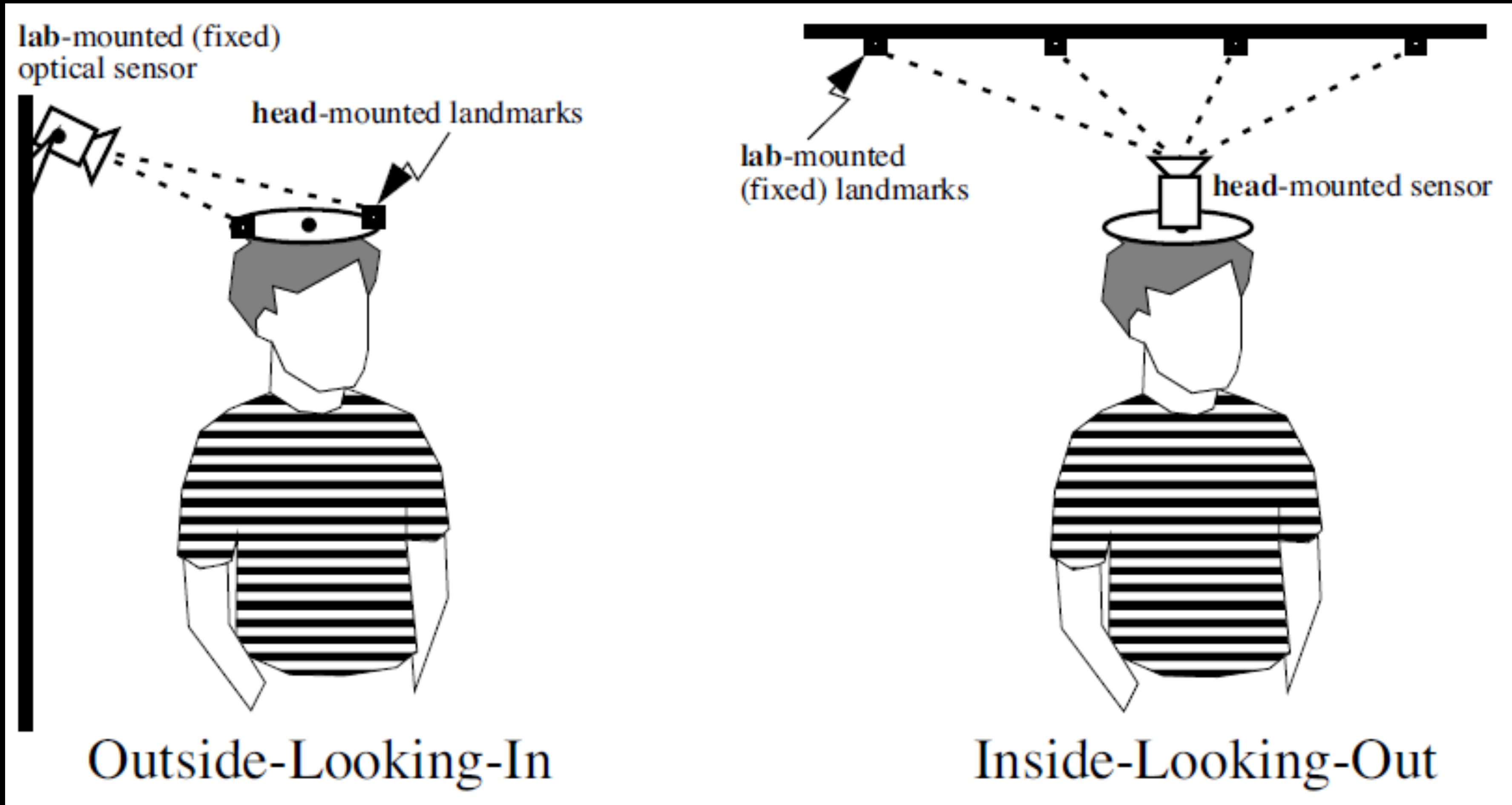


# Basics of Camera Tracking

- Markers can be of different types, often anything but must be unique
  - Fiducials, Fingers, Colours, Faces
- Markers must be known to the the computer beforehand
- The camera must also be calibrated to the environment
- All tracking is affected by image processing limitations
  - Light & Contrast, Orientation



# Outside-In vs. Inside-Out Tracking



# Bare Hands



- Using computer vision to track bare hand input
- Creates compelling sense of Presence, natural interaction
- Challenges need to be solved
  – Not having sense of touch
  – Line of sight required to sensor
  – Fatigue from holding hands in front of sensor

# Leap Motion

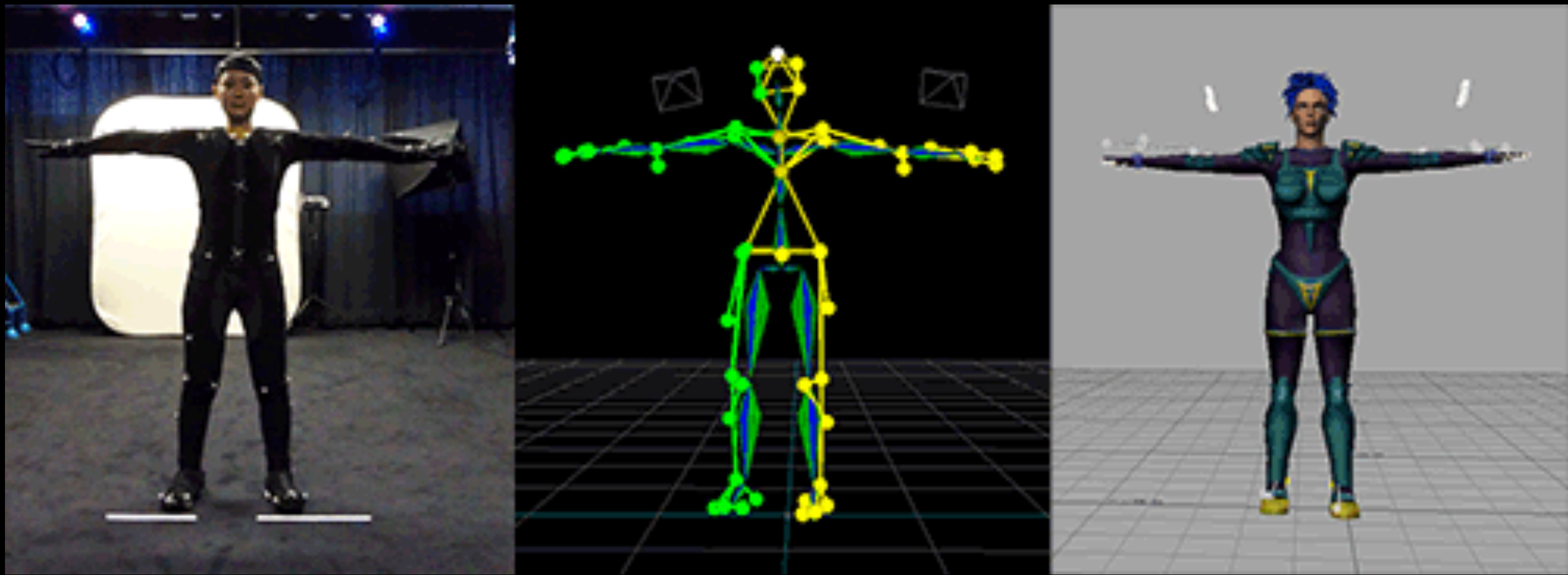
- IR based sensor for hand tracking ($50 USD)
  - HMD + Leap Motion = Hand input in VR
- Technology
  - 3 IR LEDS and 2 wide angle cameras
  - The LEDS generate patternless IR light
  - IR reflections picked up by cameras
  - Software performs hand tracking
- Performance
  - 1m range, 0.7 mm accuracy, 200Hz

- https://www.leapmotion.com/

# Example: Leap Motion

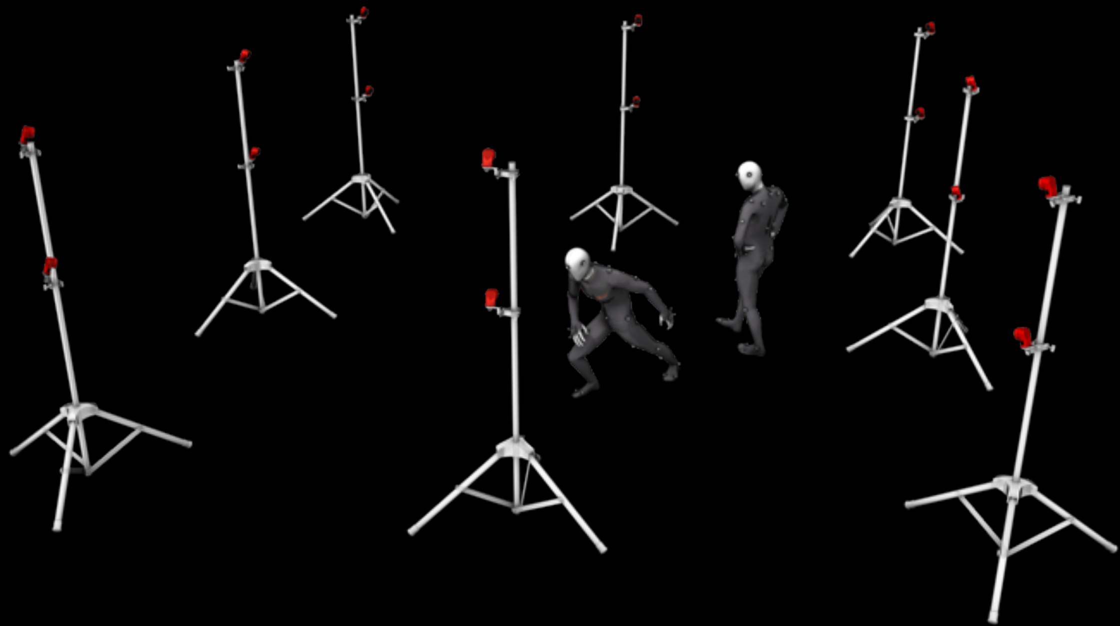
- https://www.youtube.com/watch?v=QD4qQBL0X80

# Full Body Tracking



- Adding full-body input into VR
  - Creates illusion of self-embodiment
  - Significantly enhances sense of Presence
- Technologies
  - Motion capture suit, camera based systems
  - Can track large number of significant feature points

# Camera Based Motion Capture

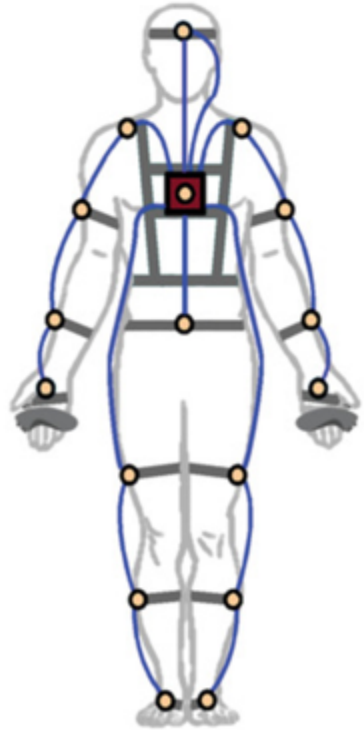



- Use multiple cameras
- Reflective markers on body
- Eg – Optitrack (www.optitrack.com)
  - 120 – 360 fps, < 10ms latency, < 1mm accuracy

# Optitrack Demo

- https://www.youtube.com/watch?v=tBAvjU0ScuI

# Wearable Motion Capture: PrioVR




- Wearable motion capture system
  - 8 – 17 inertial sensors + wireless data transmission
  - 30 – 40m range, 7.5 ms latency, 0.09$^{o}$ precision
  - Supports full range of motion, no occlusion
- www.priovr.com

# PrioVR Demo

- https://www.youtube.com/watch?v=q72iErtvhNc

# Markerless body tracking

- Using "deep learning" (convolutional neural networks)
- Multiple skeletons tracked from single video feed

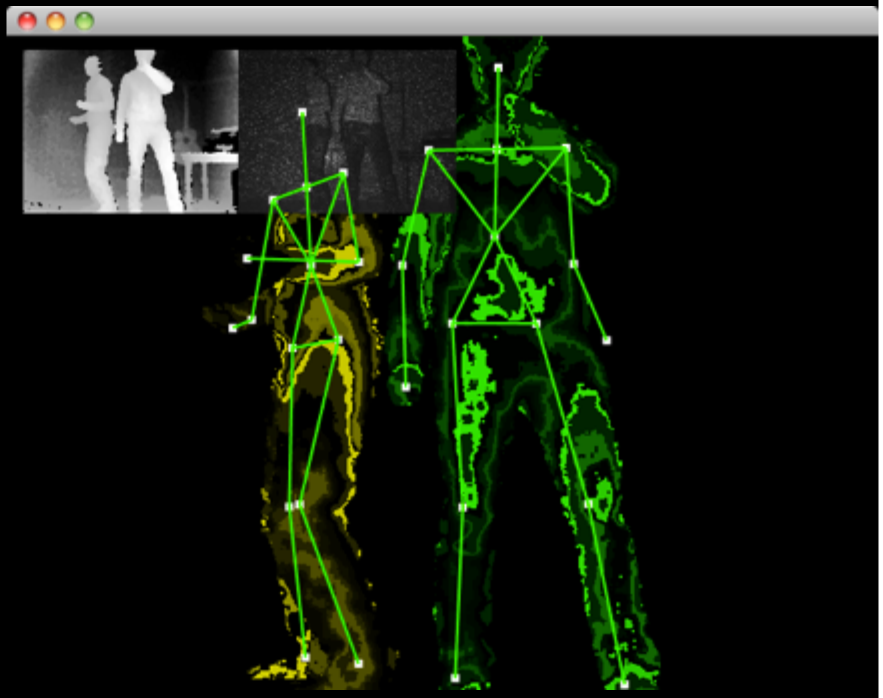

- VNect: Real-time 3D Human Pose Estimation with a Single RGB Camera (SIGGRAPH 2017) https://www.youtube.com/watch?v=W1ZNFfftx2E
- Realtime Multi-Person 2D Human Pose Estimation using Part Affinity Fields (CVPR 2017) https://www.youtube.com/watch?v=pW6nZXeWlGM

# Tracking with Depth Camera

Depth information helps to interpret images:

- separate foreground from background
- recognize body features

Kinect with OpenNI software



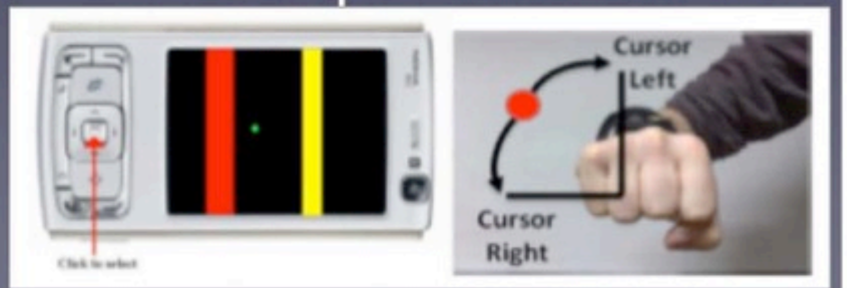
https://www.youtube.com/watch?v=FmXbS5DkSsw

# Gestural Interaction
# APPLICATIONS

Brewster, Stephen, et al. "The gaime project: Gestural and auditory interactions for mobile environments." British computer Society (2009).

# GAIME

- Compared Fitt's Law performance on Seated, Standing, Resting & Walking
- No significant difference other than Walking
- Accuracy was good for larger target and small separation ~90%
- But slower and less accurate for Walking
- Participants also not confident in their performance



# Shoogle

- Cellphone users can shake their phone to feel and hear how full their battery or message inbox is - as if it were a liquid fuel tank.

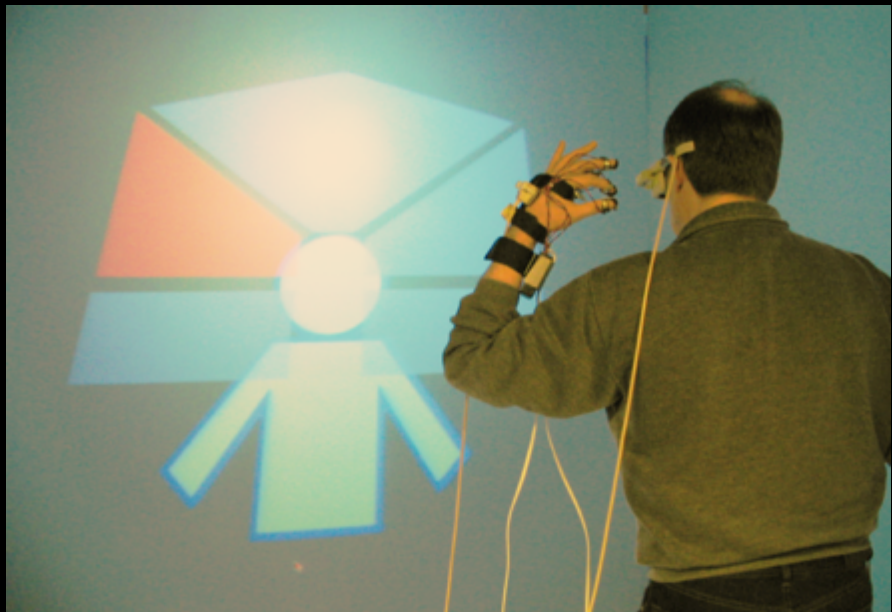

https://www.youtube.com/watch?v=AWc-j4Xs5_w

# Body Spaces

- Menus can be confusing
- Why not use body location to access functionality?
- Detect movements to body locations via a sensor (accelerometer) pack

# Virtual Pockets

- Drawing tools in an egocentric "tool jacket"



Ilmonen & Reunanen (2005)

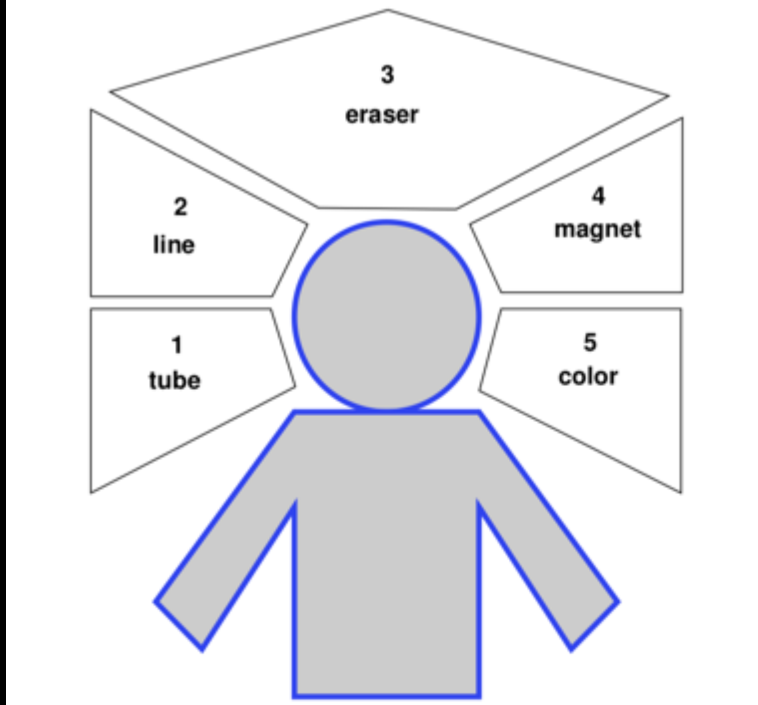
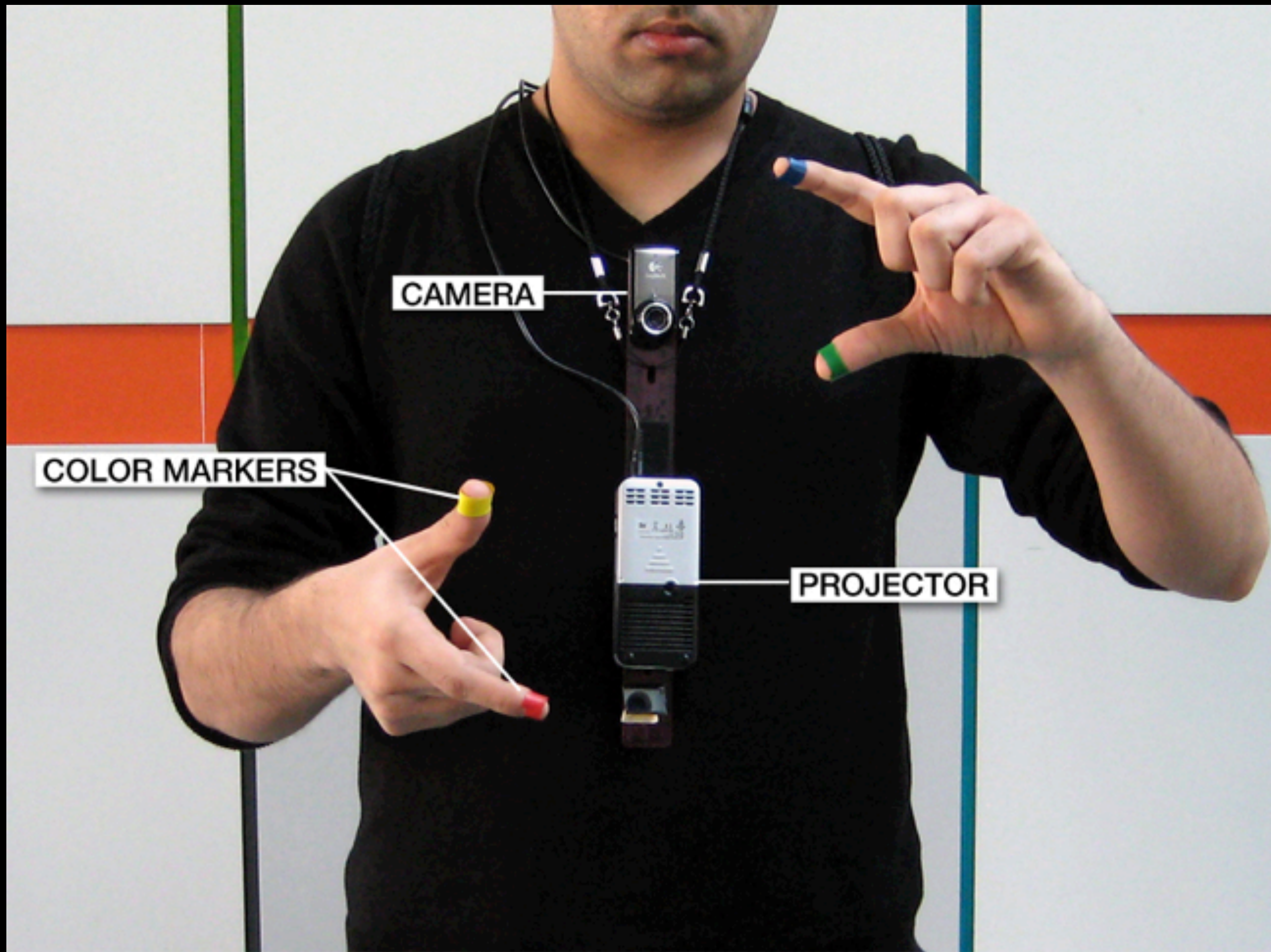



**Figure 5:** *The locations and contents of the pockets.*

# Sixth Sense




http://www.pranavmistry.com/projects/sixthsense/
https://www.youtube.com/watch?v=ZfV4R4x2SK0

# OmniTouch

- Depth Sensing and Projectors allow any surface to be a touch-surface
- Ultimately support ubiquitous interaction

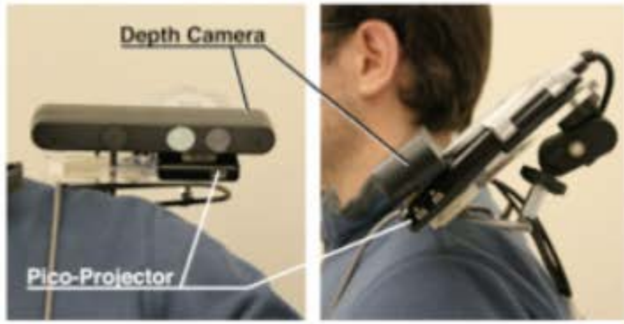



**Figure 2. Our prototype shoulder-worn *OmniTouch* System.**

Images: Chris Harrison, Hrvoje Benko, and Andrew D. Wilson. 2011. OmniTouch: wearable multitouch interaction everywhere. In *Proceedings of the 24th annual ACM symposium on User interface software and technology* (UIST '11). ACM, New York, NY, USA, 441-450.

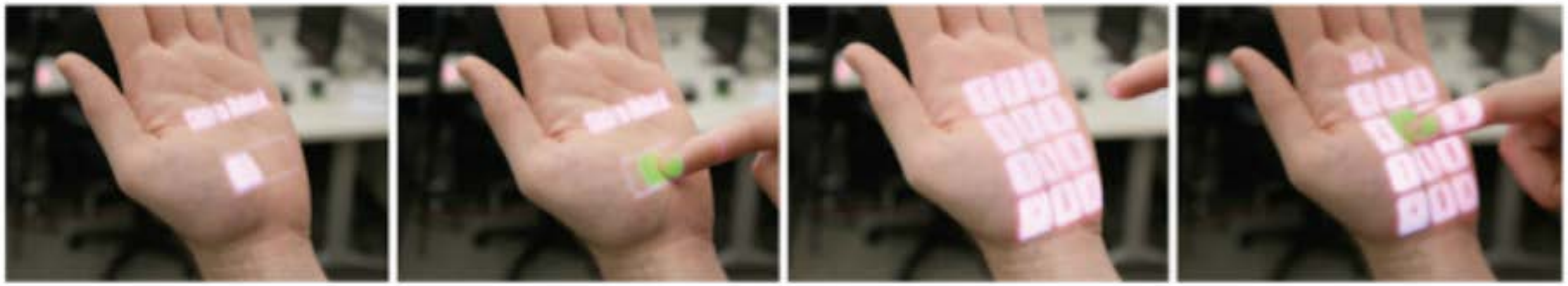


**Figure 10. We created a simple phone keypad application; in this sequence, time progresses left to right.**

# Art and Entertainment

- *Virtual Dancer*, 2006, a university course project. YouTube video available at http://youtu.be/gDfd1c4E6v8

- Drawing in the air, reserach project, 2005 http://www.tml.tkk.fi/Research/HELMA/

# Limitations of Sensors and Tradeoffs

- In general sensors are defined by a set of criteria
- Its important to understand the limitations of sensors
  - Error
  - Drift
  - Update Rate
  - Lag/Latency
  - Sample Rate
  - Failure Conditions
  - Ground Truth (particularly with AR)

# Design Guidelines

DESIGN

**Beyond touch: designing effective gestural interactions**

10 min read

https://www.invisionapp.com/inside-design/effective-gestural-interaction-design/