Interaction Techniques Using The Wii Remote

(and other HCI projects)

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Nintendo Wii

Nintendo's 5th Video game console
Release Date: 11/19/06
30 million units worldwide (Jun, 2008)

>30 million Wii remotes

1-4 remotes per console

6-9 million Tablet PCs

Nintendo Wii Remote

Bluetooth HID compatible joystick
MSRP $40 USD

Inputs:
IR camera tracker
Accelerometer
12 digital buttons

Outputs:
Tactile – vibration motor
Auditory – small speaker
Visual –blue status LEDs

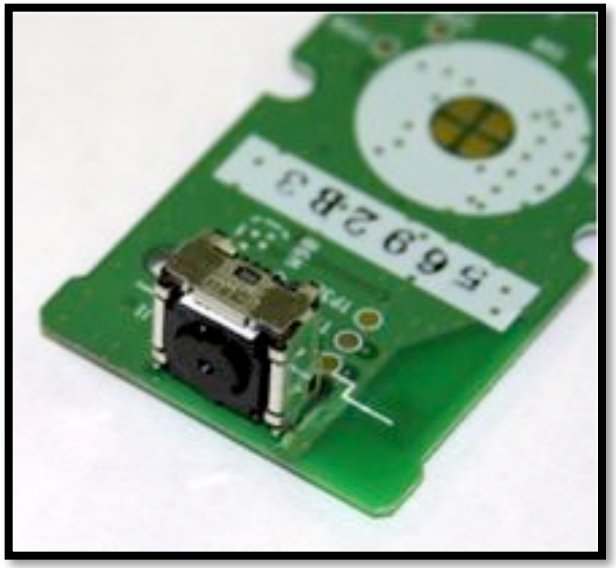
Other:
Expansion port
On-board memory
Batteries

IR Camera Tracker

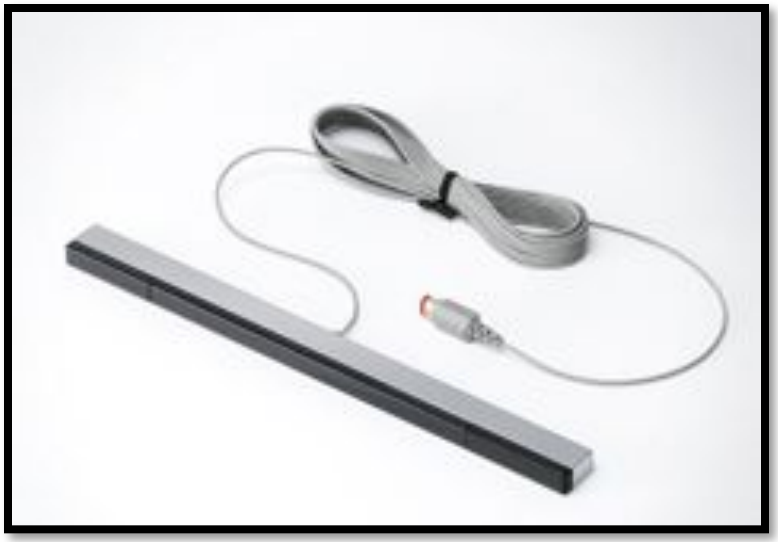
Manufactured by PixArt Imaging
Multi-Object Tracking™ engine (MOT sensor™)

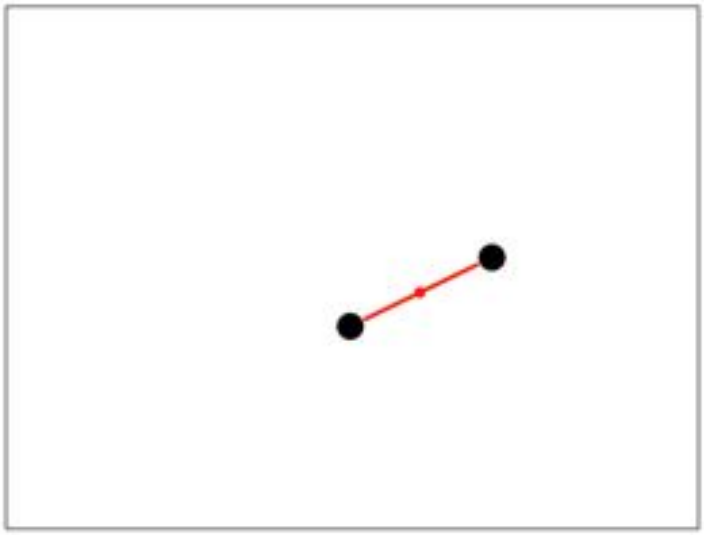
Official specifications are confidential, but….

Hardware IR blob tracking up to 4 points
Resolution: 1024x768 (true: 128x96?)
Refresh Rate; 100Hz
Dot size: 4-bits
Intensity: 8-bits (Full mode)
Bounding Box: 7-bits x-y (Full mode)
Horizontal Field of view: 45 degrees (calc. rad/pixel)



Nintendo Wii “Sensor Bar”





Contains two IR emitter groups

Two dots = 4 values: (*x1*, *y1*), (*x2*, *y2*)

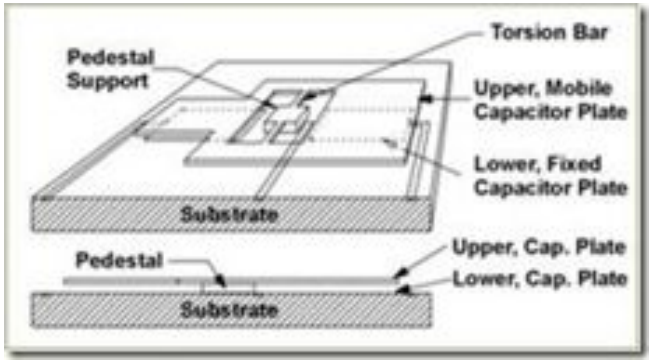
4 values → ***x***, ***y***, ***rotation***, and ***distance***

correspond primarily to: *tilt*, *yaw*, *roll*, and *distance*

Accelerometer

Analog Devices (ADXL330)

3-axis linear accelerometer
Range: +/-3g sensitivity
Resolution: 8 bits/axis
Sample Rate: 100Hz



Buttons

Total of 12 digital buttons
11 are accessible to an application

Power button - initiates and terminates
Bluetooth connection

Ambidextrous design
4 buttons arranged in a D-pad

Index finger trigger button (B)
Primary thumb button (A)

Output

Tactile – Vibration motor, up to100Hz update rate

Auditory – Small speaker, 4Khz*, 4-bit audio streamed from host, approx telephone quality.

Visual – Four blue LEDs, player ID, individually addressable, up to100Hz update rate

Other Features

Bluetooth – Broadcom 2042 for Human Interface Devices (HIDs). Not 100% compliant, but compatible with PCs.

Expansion Port – Proprietary 6-pin connector. Provides power and Fast I2C communication. Acts as a Bluetooth to I2C bridge.

Onboard Memory – device configuration and ~ 5KB of general memory. Physical association of data and identity with a remote.

Batteries – two AA batteries provide 20-30 of operation. 8-bit battery level sensor.

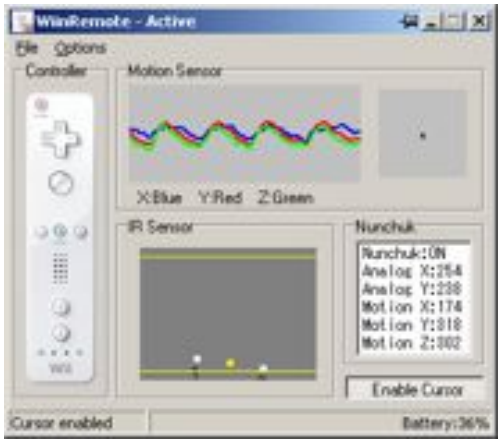
Developing Custom Applications

Bluetooth HID joystick compatible with HID driver libraries.

Libraries available for nearly every major development platforms on Windows, MacOS, and Linux.

Visit http://wiili.org or http://wiibrew.org

I use Brain Peeks C# managed WiimoteLib
Read values from data structure to access data
Most libraries include a sample program



Eventual support:

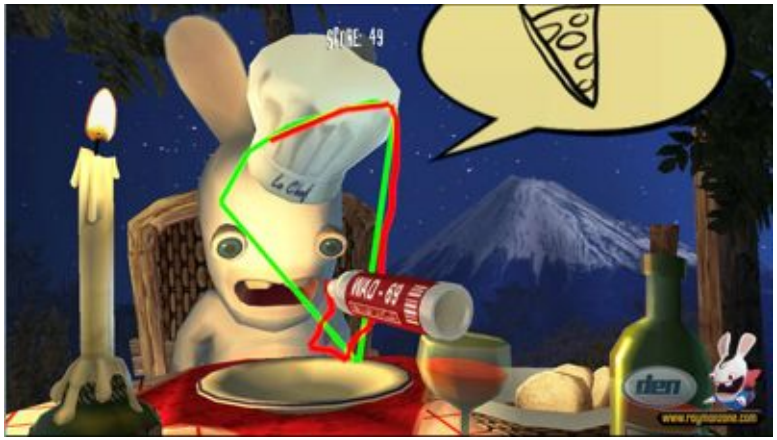
- Better Event-handling
- Related geometric transformations
- Gesture Recognition

Interaction Techniques

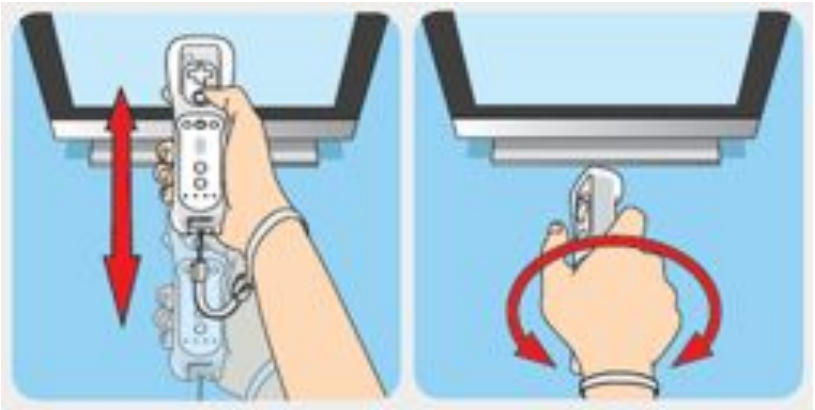
Game Interaction – Pointing

Selection/Navigation

Aiming a weapon/tool



Drawing



Push/Pull or Rotate

Note: All pointing is relative

Game Interaction – Motion

Directional Shake Trigger

Analog Shaking

Tilt Control

Swing Simulation

Games provide context on how to hold remote.

Game Interaction – Buttons and Joysticks

Nunchuk attachment
for non-dominant hand

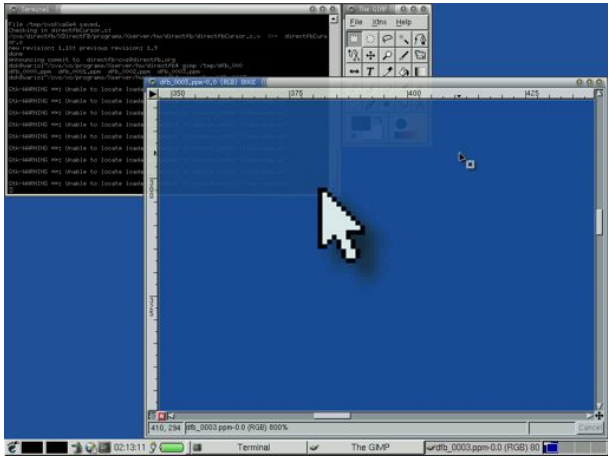
Joystick
2 buttons
3-axis accelerometer

Input Device	Digital	Analog
Wii Remote + Nunchuk	13	12
Xbox 360 Controller	14	6
Scroll Mouse	3	3

By the Developer Community

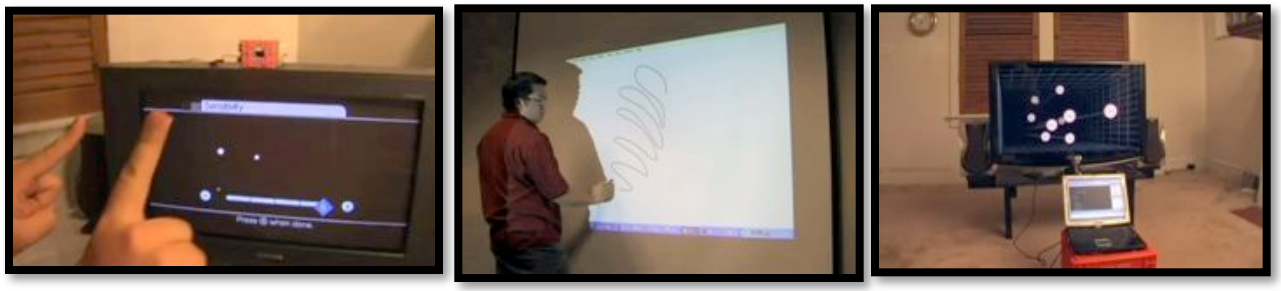
Robot Control

Synth Music Performance



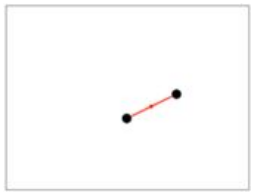
Cursor Control

Flash-Based Mouse Games



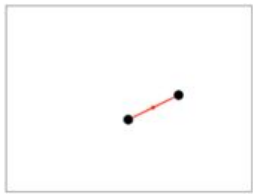
Online Videos Tutorials

Moving + **Stationary** = **Orientation**



tilt, ***yaw***, ***roll***, and ***z***

Moving + **Stationary** = **Translation**

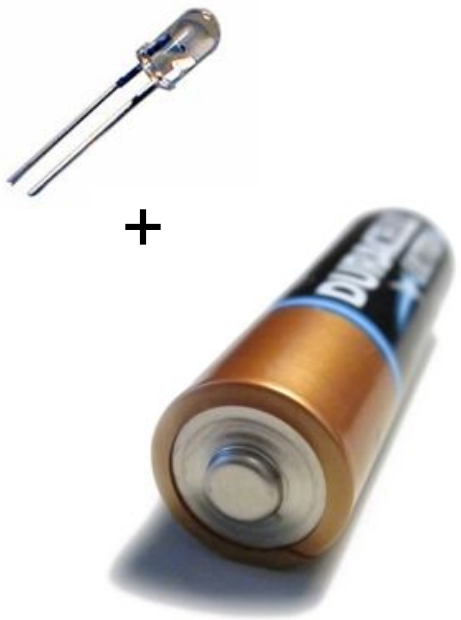


x, ***y***, ***z***, and ***roll***

project 1

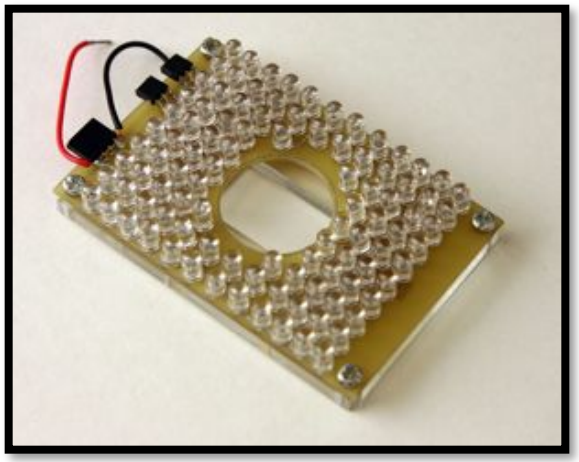
Finger and Object Tracking

Finger and Object Tracking



Wii remote can track any IR emitter
Active emitters can be cumbersome

Finger and Object Tracking



Vicon Motion Capture System

Video – Finger Tracking

Object Tracking - Limitations

Only 4 points – limitation of Wii remote, but good for the price. Temporal multiplexing, multiple remotes

No inactive cursor feedback → 4 point index finger and thumb tracking with pinch detection.

Arm Fatigue → Table top or transparent surfaces. Reflective tags may need repositioning.

Unintentional Reflections → Active IR emitters when possible. Can be installed in handheld or wearable devices (e.g. sports equipment, animal tracking).

project 2

Interactive Whiteboards

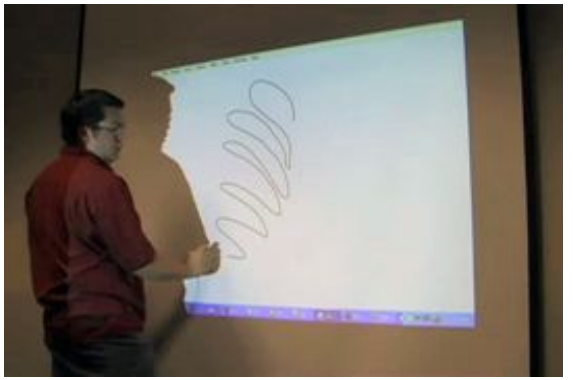
Multi-Touch Interactive Whiteboards

Point Wii remote at display
Map camera coordinates to display coordinates
4-point touch calibration (homography)
Simulate mouse cursor

Effective electronic whiteboard system for **$50**

>600,000 software downloads

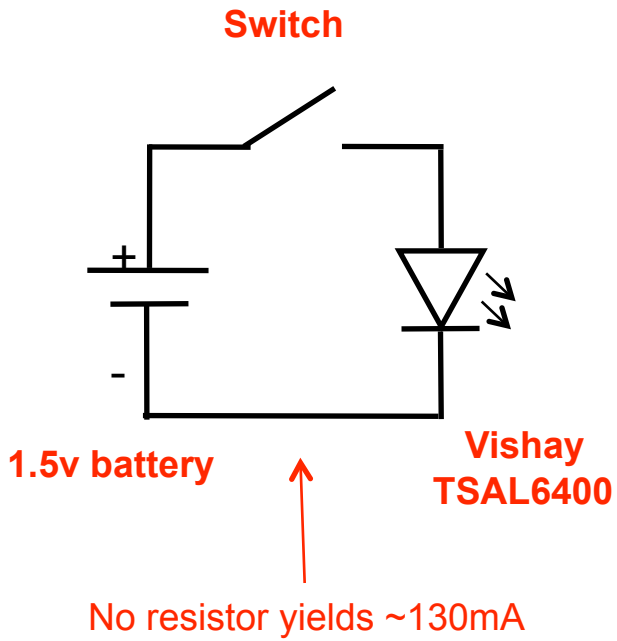
Already in use by educators around the world
Number of schools interested in large installations



Video – Whiteboard

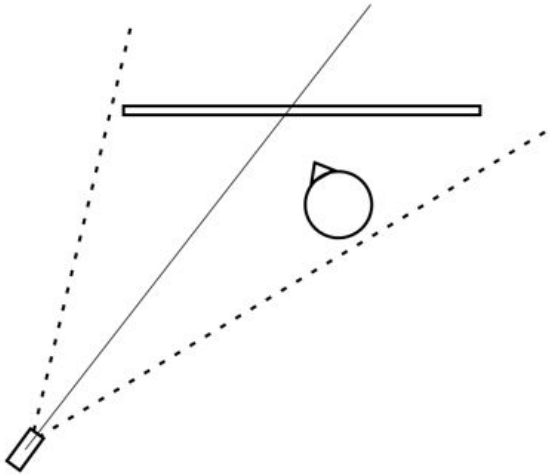
IR Pens


Expo
low odor

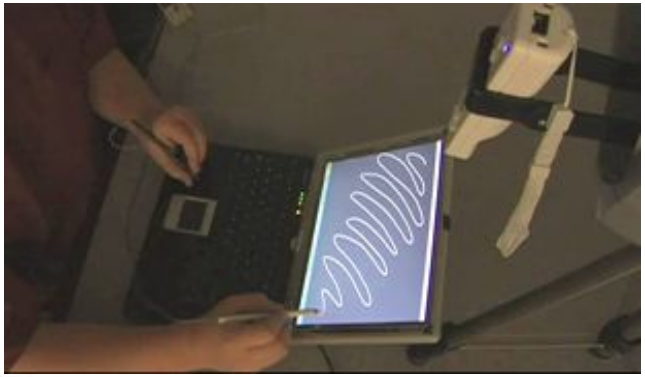

Switch
+
-
1.5v battery
Vishay
TSAL6400
No resistor yields ~130mA

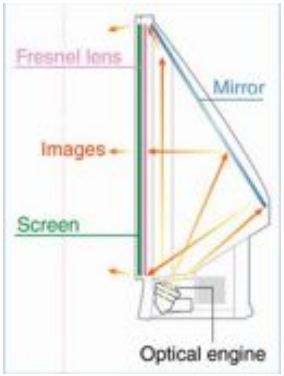
Interactive Whiteboards - Limitations

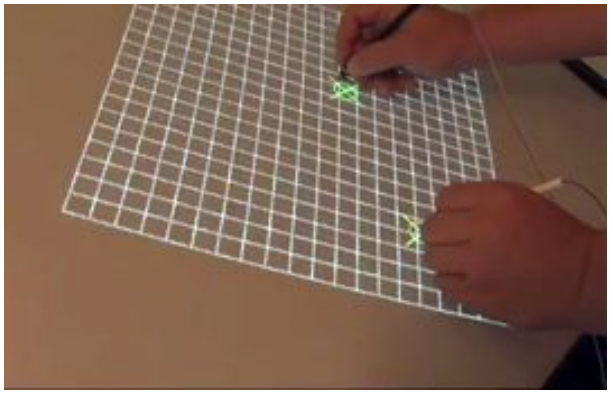
Maximum 1024x768 resolution.
Dependent on good camera positioning.
Sensitive to occlusion.



Solutions
Adjust camera position (over-head)
Use multiple Wii remotes
Use rear projected displays.

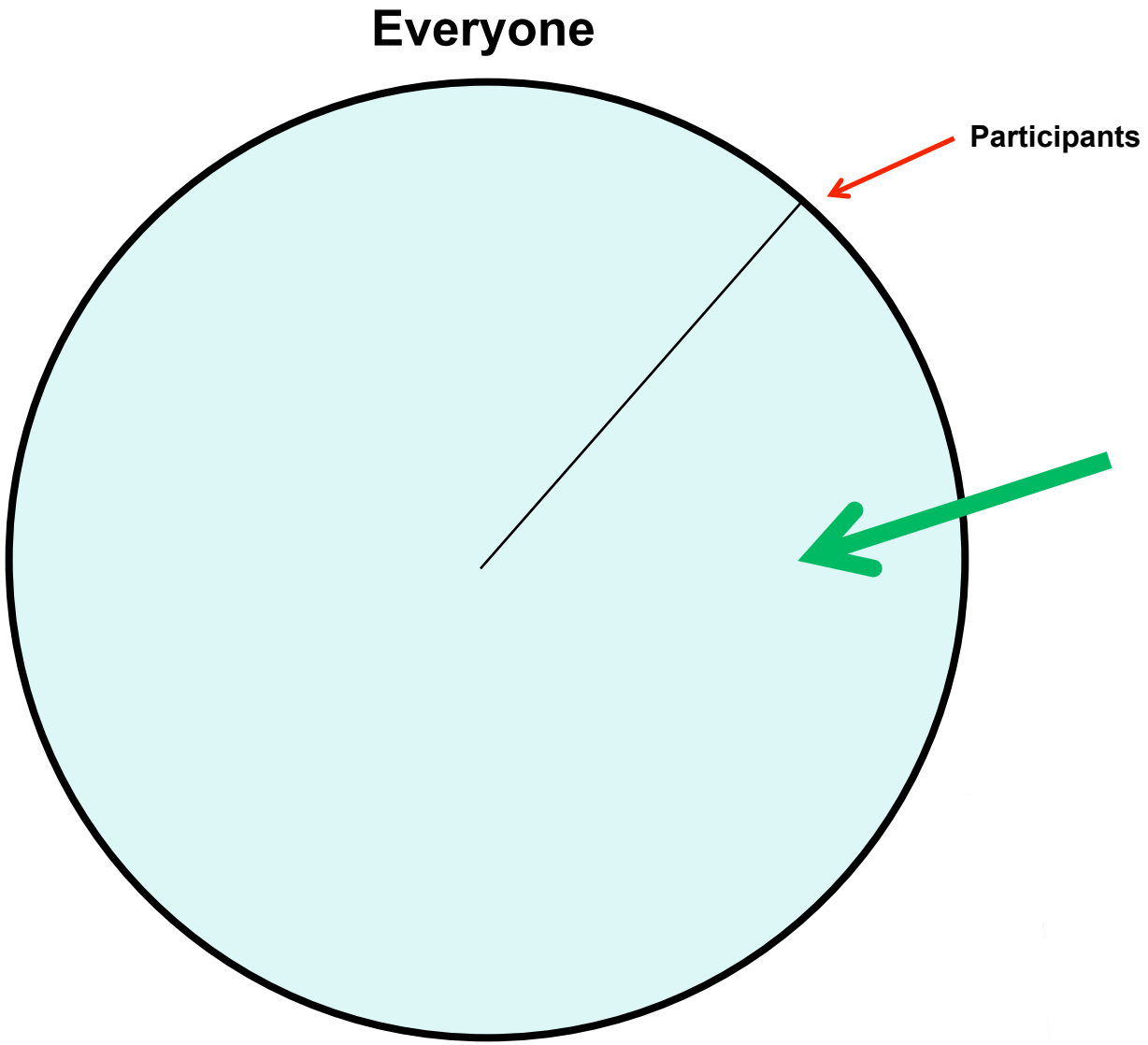






80% of the way there

1% of the cost


Everyone
Participants

Two Effects:

1. Increased participation:
   Advances the state of research

2. Increased practicality:
   Advances the state of technology


HCII

project 3

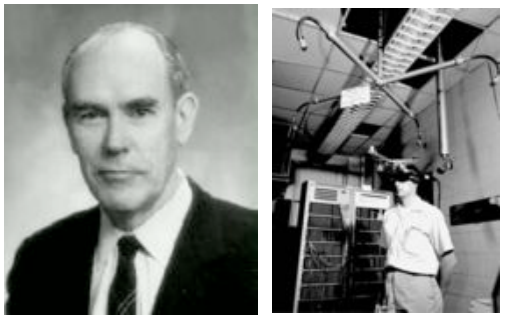
Head Tracking for Desktop VR

Head Tracking for Desktop VR

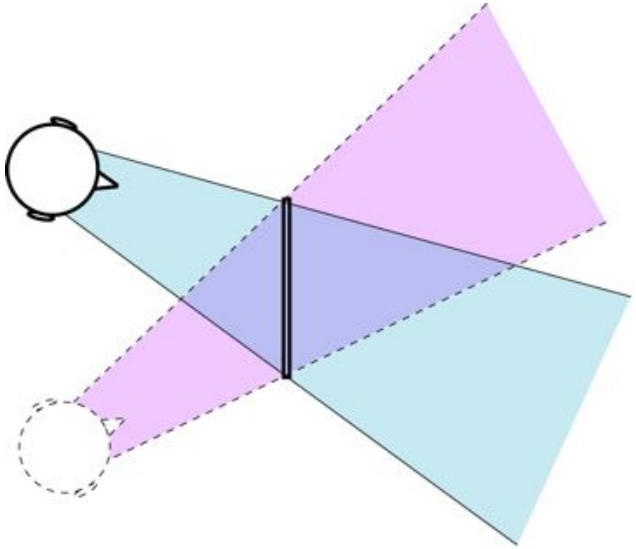
Rigid pair of head-mounted IR emitters
yields ***x,y,z*** position relative to display

Create motion parallax displays

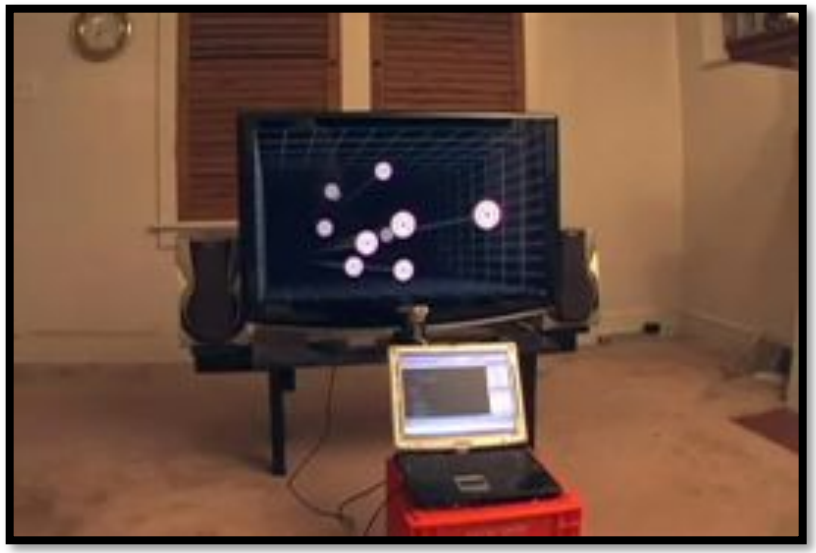
Sufficient hardware now in millions of homes
6+ major game studios



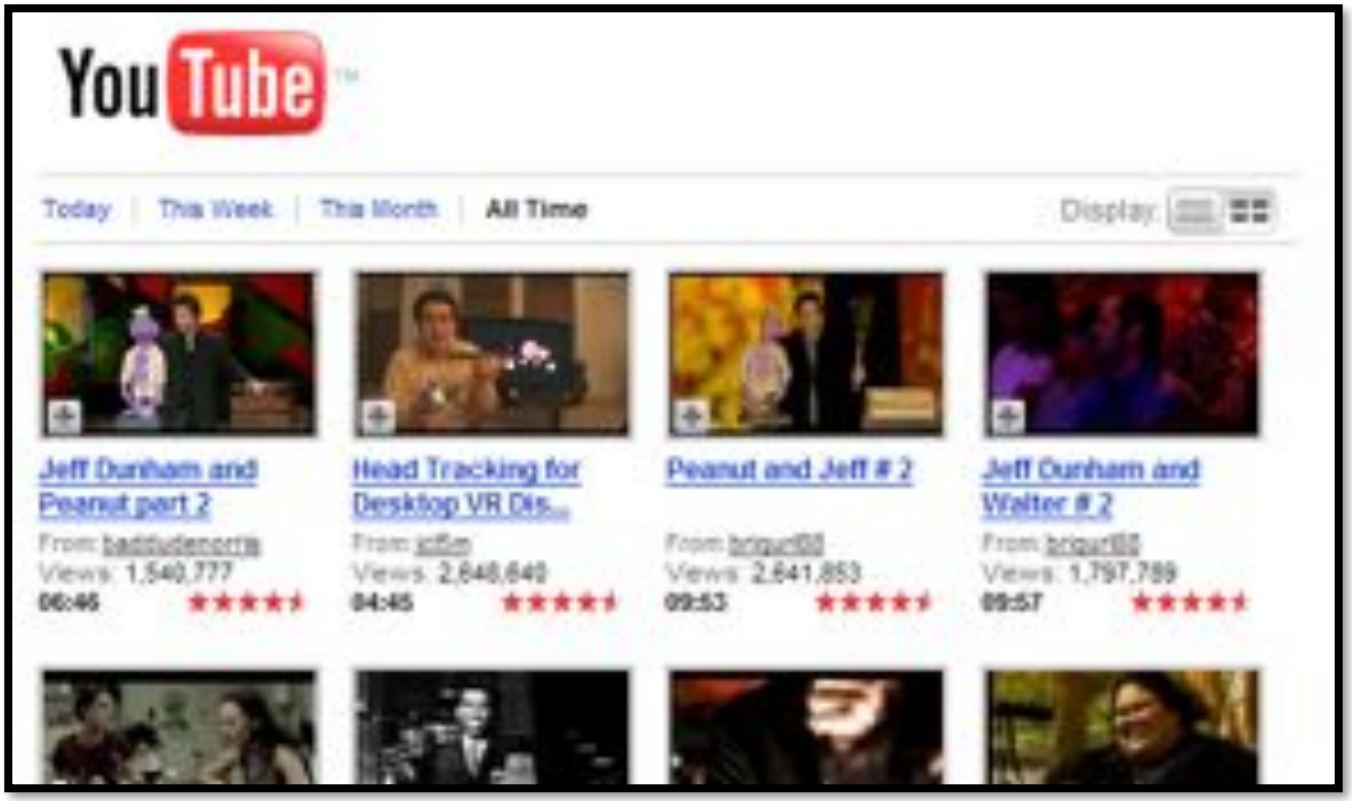
Ivan Sutherland, Harvard University, *c.* 1967.



Head Tracking for Desktop VR



Video – Head tracking


YouTube
Today
This Week
This Month
All Time
Display:
Jeff Dunham and Peanut part 2
From: baditudenorris
Views: 1,540,777
06:46
Head Tracking for Desktop VR Dis...
From: jdfm
Views: 2,648,640
04:45
Peanut and Jeff # 2
From: brigur88
Views: 2,641,853
09:53
Jeff Dunham and Walter # 2
From: brigur88
Views: 1,797,789
09:57

Motion Parallax

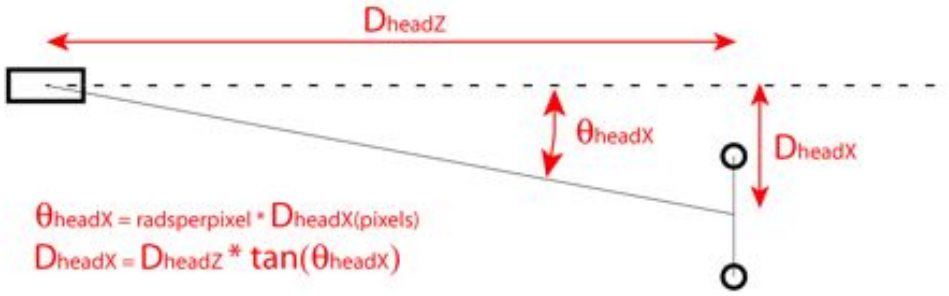
www.flickr.com/photos/kap_cris/472159801/

- Very important depth cue
- Velocity of objects when moving
- Occlusion behavior

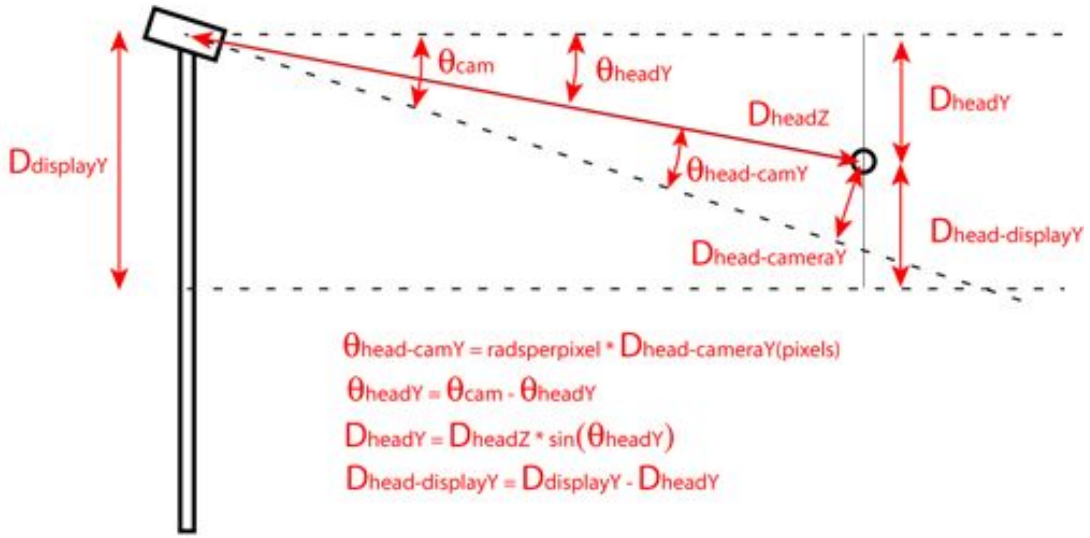
[Ware, Arthur, and Booth CHI'93]
Motion parallax is more important than stereo

Calculating Head Position

Horizontal Position



Vertical Position



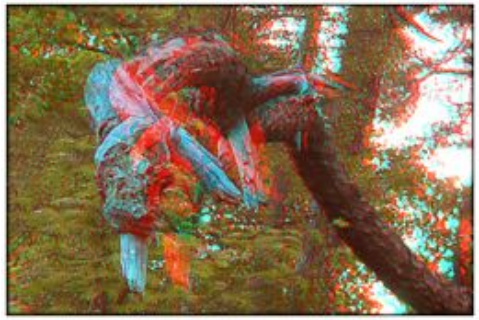
Head Tracking - Limitations

Perspective is correct for only 1 person – split screen or shutter glasses

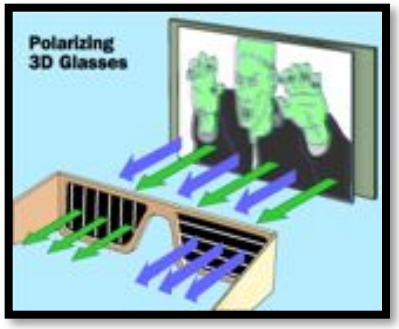
Limited Tracking Volume – increase field of view with wide angle lens or use multiple remotes.

Can't touch objects – Sorry. Keep objects behind the display surface and blame the display.

Conflicting Stereo Depth Cues – weakens the effect, use stereoscopic display technology (polarized/shutter glasses, etc)

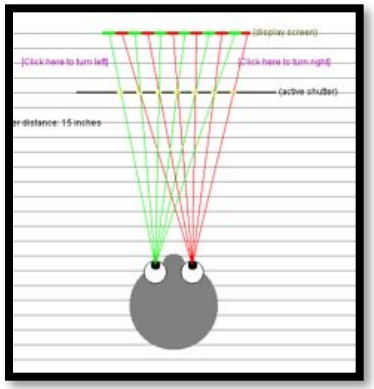


Anaglyph (red/blue): bad color fidelity, but would work, cheap



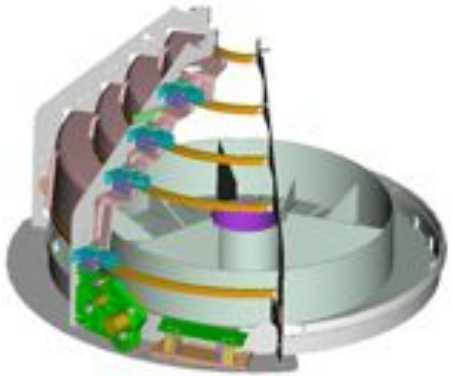
Polarized glasses: does not work with most existing consumer televisions, cheap

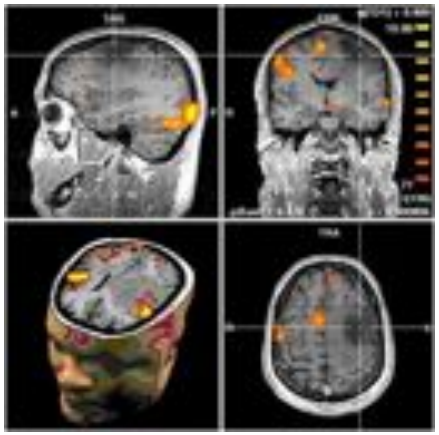
Shutter glasses: active device, frame sync, higher frame rates (120Hz okay)



Auto-stereoscopic:
not consumer technology yet

If you can’t provide stereo, removing the conflicting stereo depth cues **will improve** the head tracking illusion.

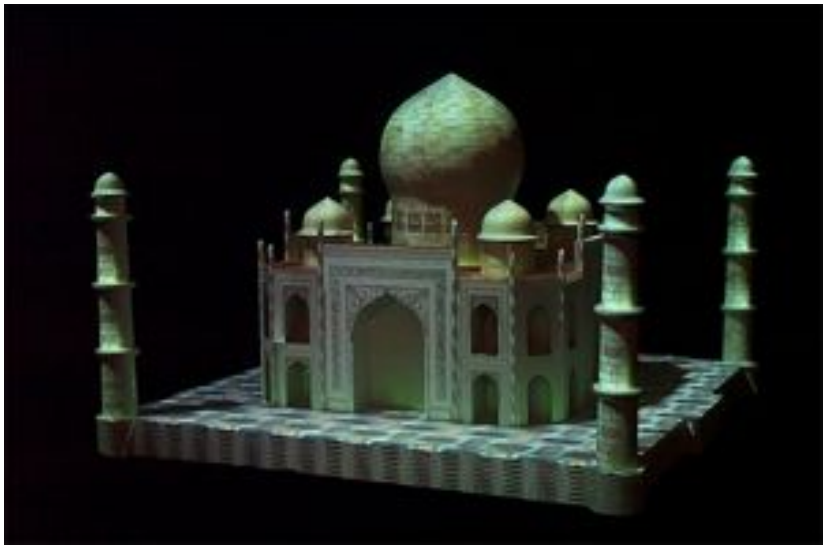




project 4

Spatial Augmented Reality

Spatial Augmented Reality



Shader Lamps, Raskar et al UNC/MERL

Everywhere Displays, Pinhanez et. al, IBM

Projected light can be used to augment the appearance of physical objects.

Aligning to static objects can be done manually.
Moving objects requires low-latency, high-resolution tracking.

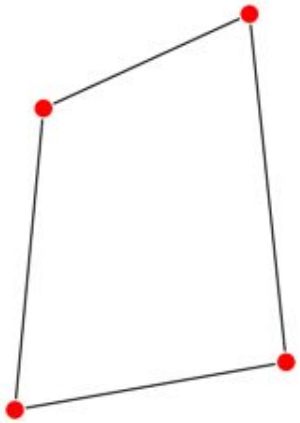
1024x768 @ 100Hz tracking of the Wii remote is quite good.

Video – Foldable Displays

Spatial Augmented Reality

Wii remote only tracks 4 points.

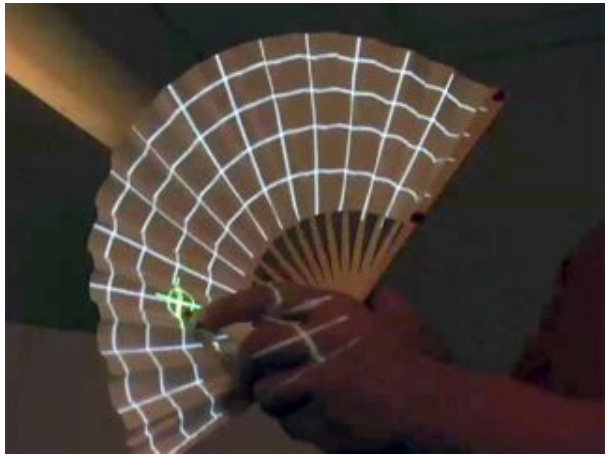
- Limits the number of objects
- Limits the geometric complexity



4 points can track arbitrary quadrilateral

Assumptions reduces necessary points

- square surface
- constrained to a plane



Other Wiimote projects …

3D Motion Tracking - extension of finger tracking, using 2 or more remotes allow tracking of individual points in 3D space.

Tracking with ID – currently no point ID. Use high-speed IR receiver in conjunction with camera should allow location with ID.

IR Glyphs – use varying spatial and temporal behavior of 4 IR emitters to create unique IDs. Allows Wii remote to know what object it is pointing at.

Laser Tag – instrument each Wii remote with IR emitters so they can see each other. ID can be temporally verified.

Summary

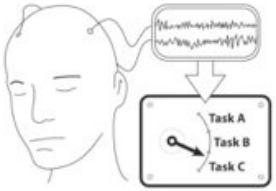
>30 million Wiimotes
Sophisticated I/O capabilities
- IR camera, Accelerometer, Buttons
Vibration, Speaker, LEDs,I2C port
Only $40 USD

Vast number of applications
limited only by creativity

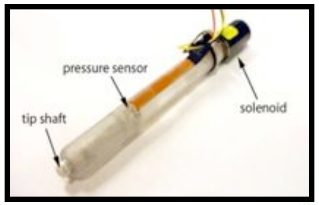
Document & Share
~10 million views (Youtube)
> 600,000 downloads
1000s of students and teachers
8 patent licensees (in progress)
> 6 major game studios
Exploring large educational initiatives

Other Projects

Projector-Based Location Discovery and Tracking



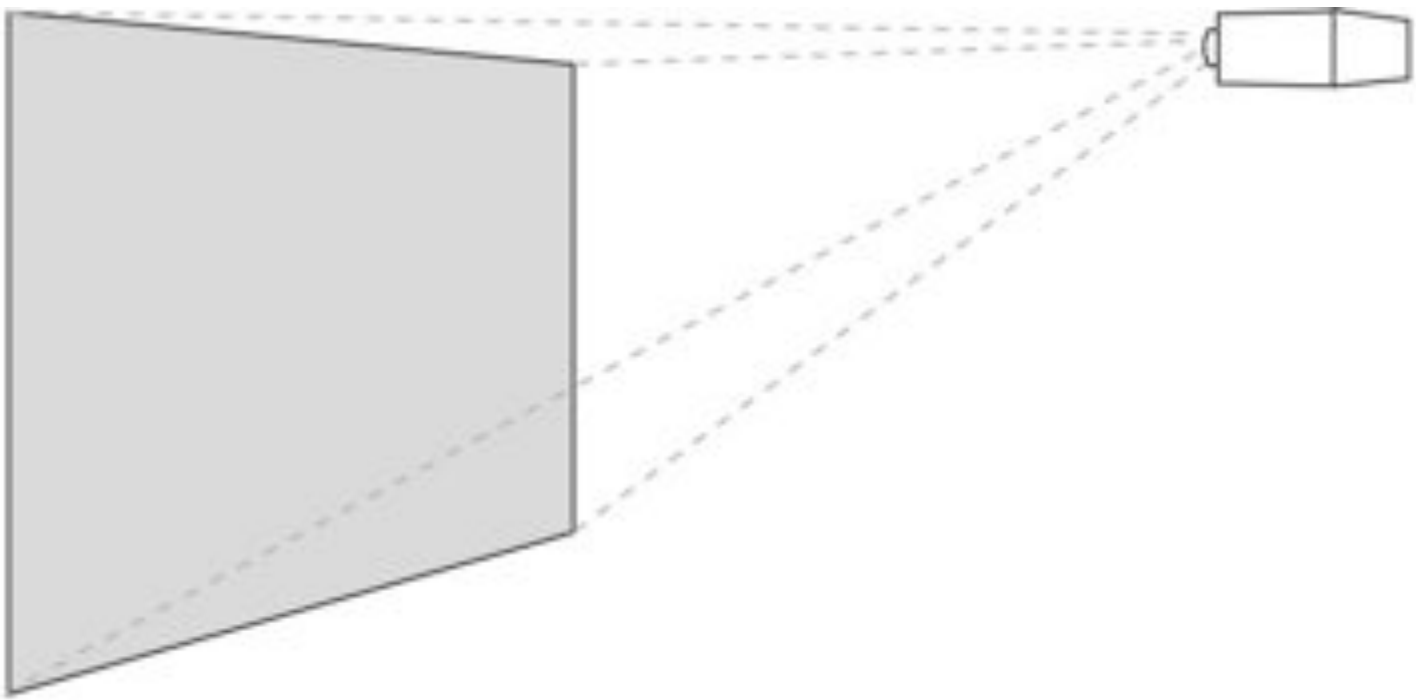
Low-Cost EEG for Task Classification

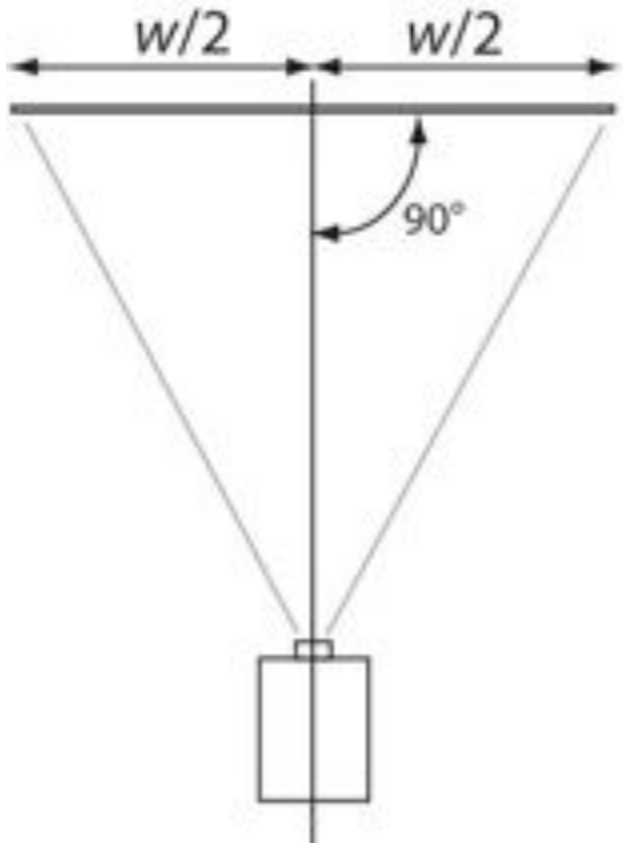


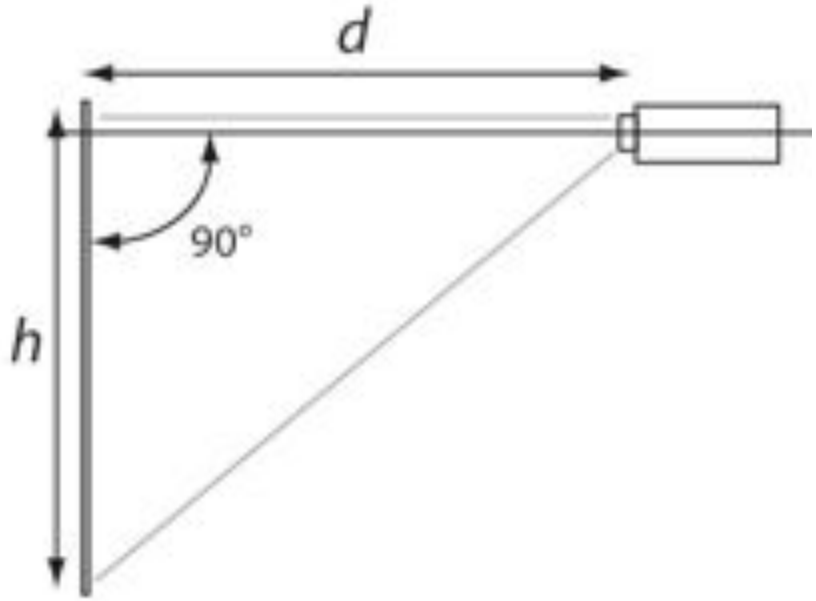
Haptic Pen

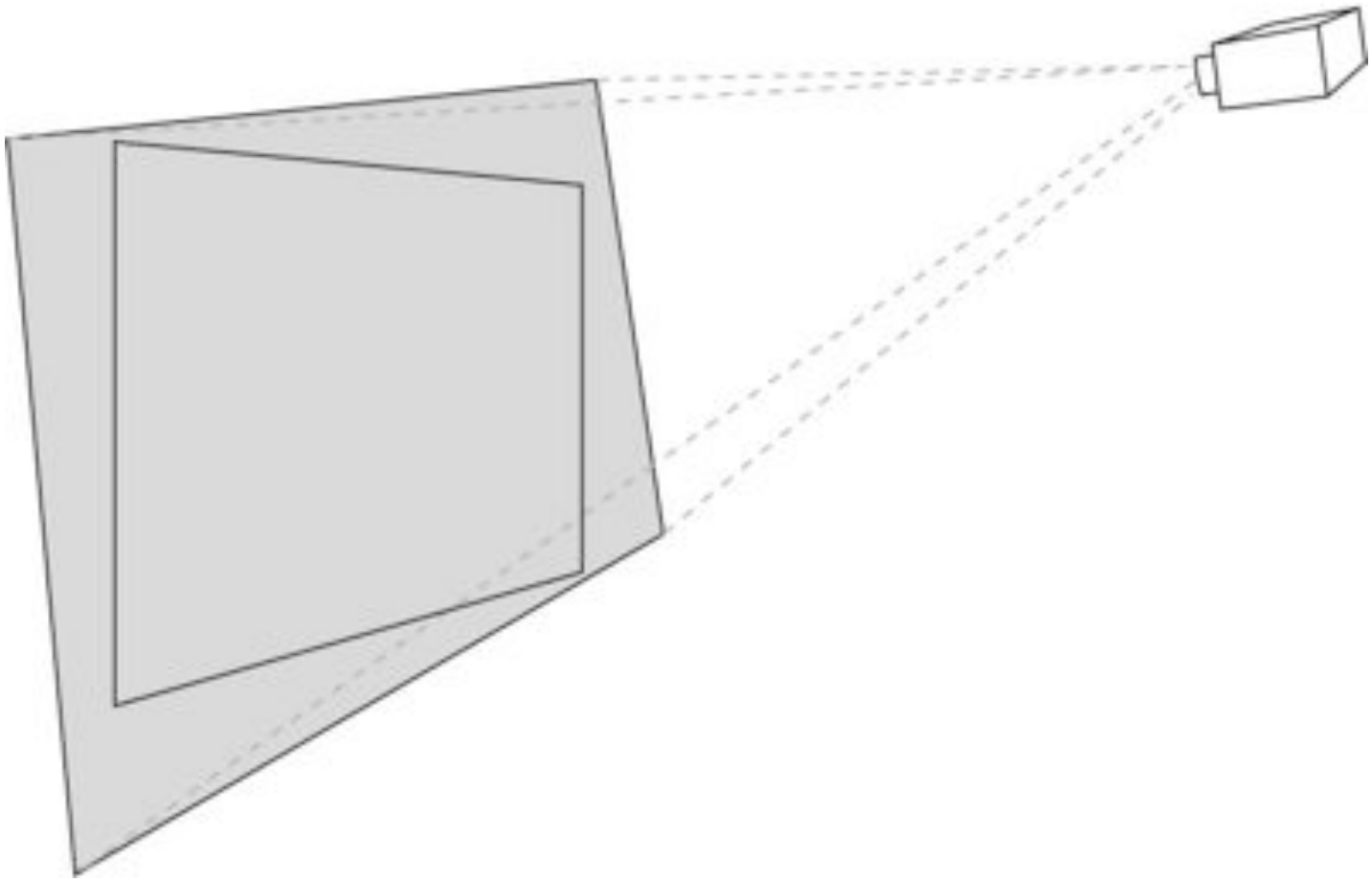
$14 steadycam

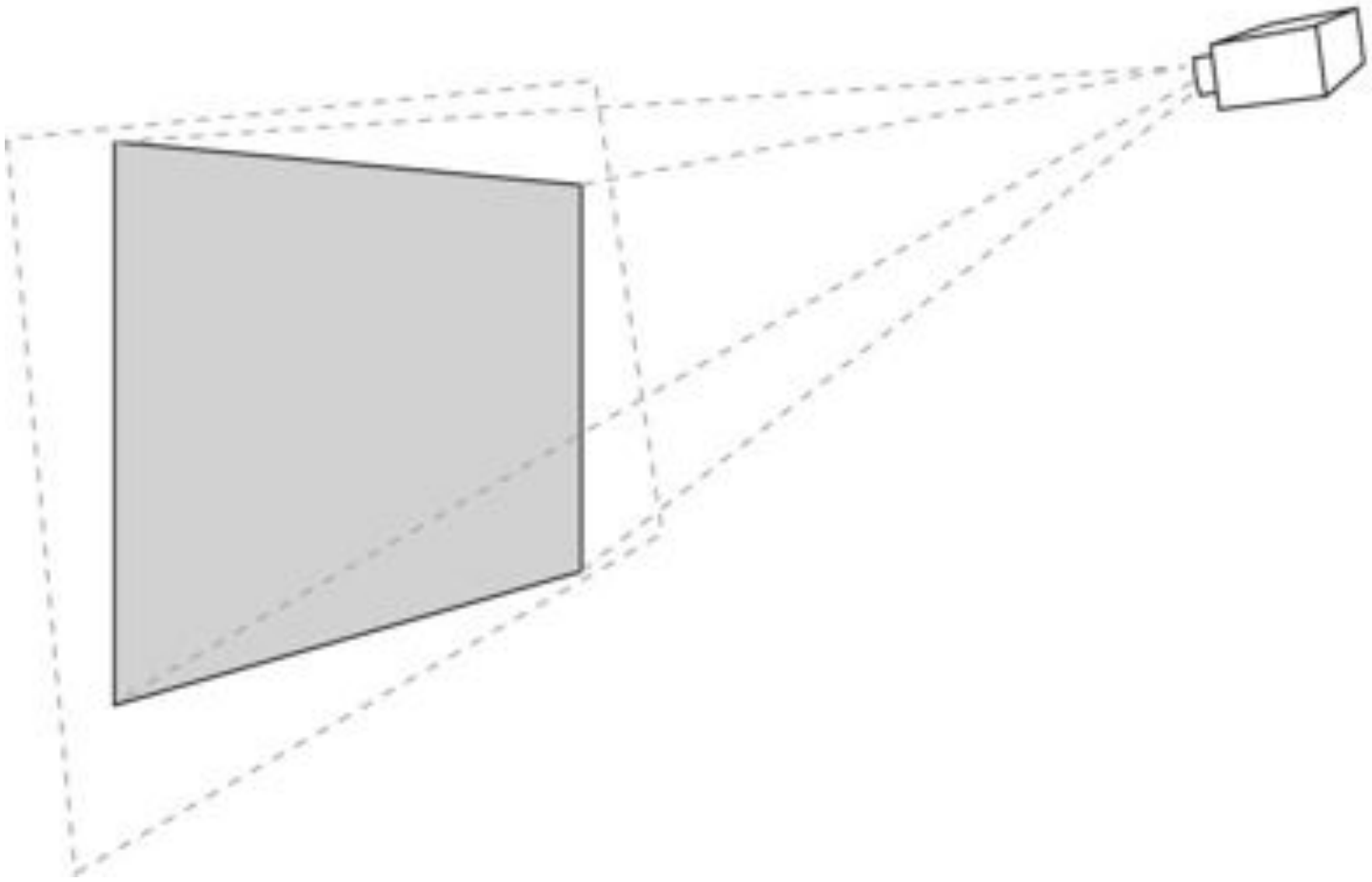
Projector-Based Location Discovery



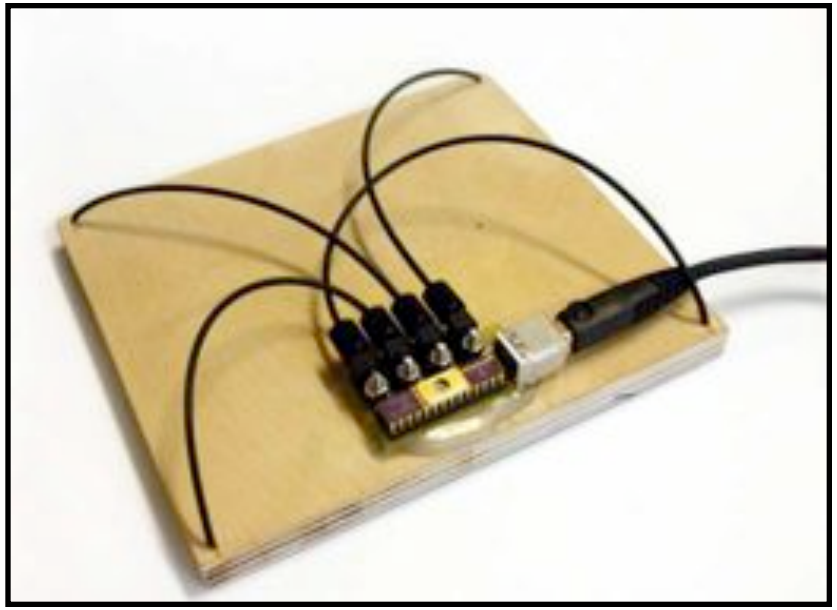

w/2
w/2
90°


d
90°
h





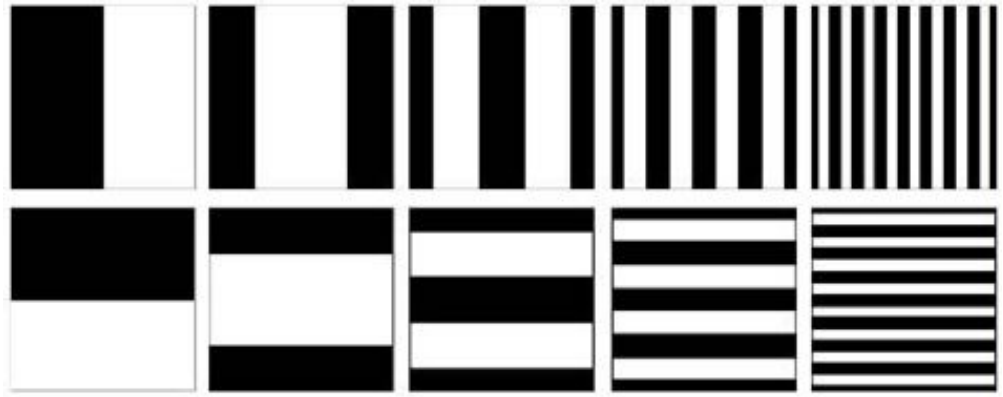
Step 1:
Embed light sensors

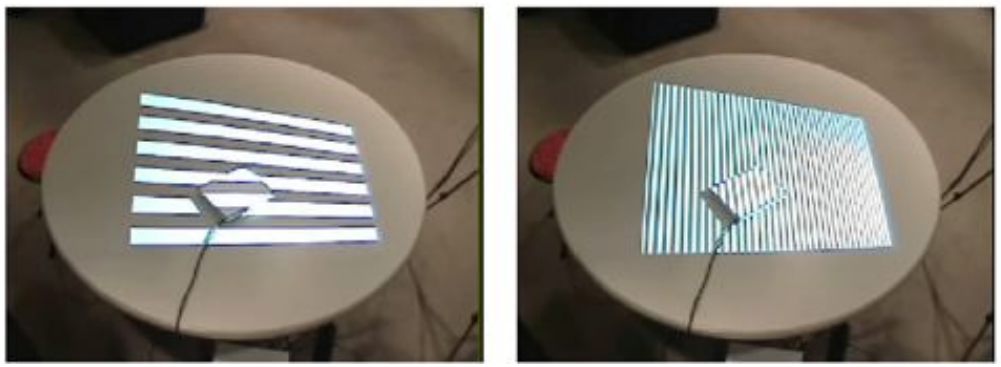


[UIST 2004]

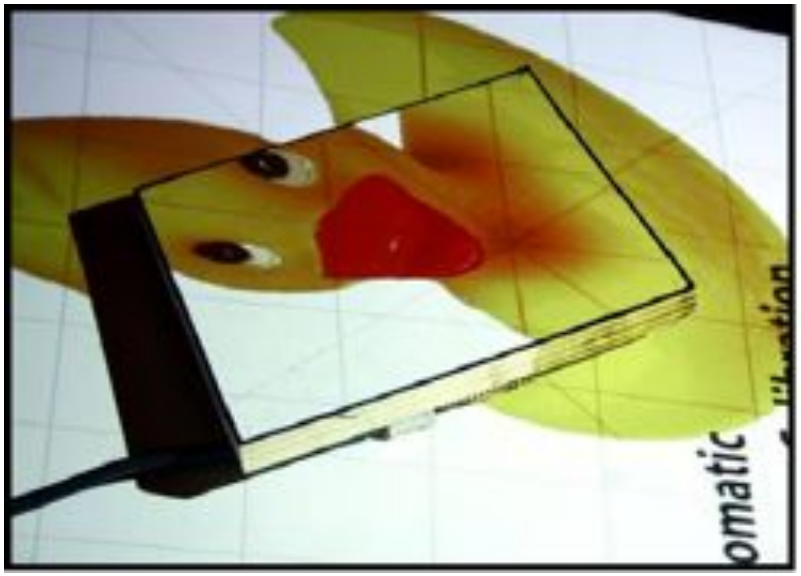
Step 2:

Project Gray-coded patterns

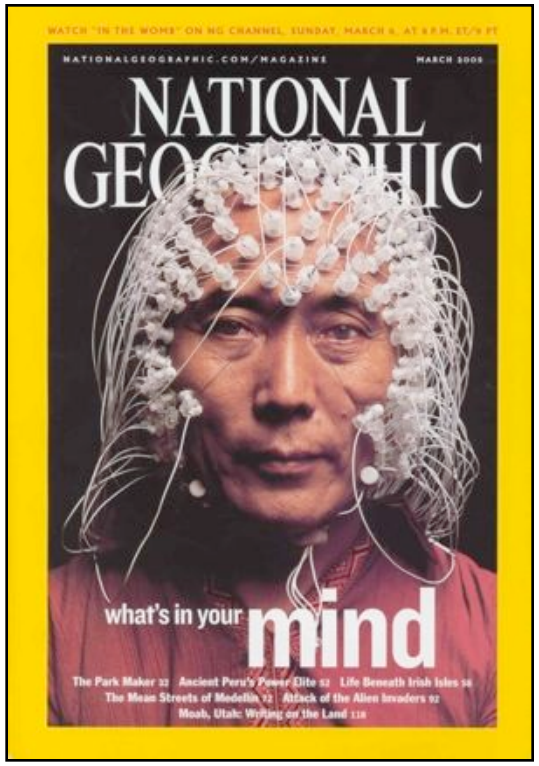




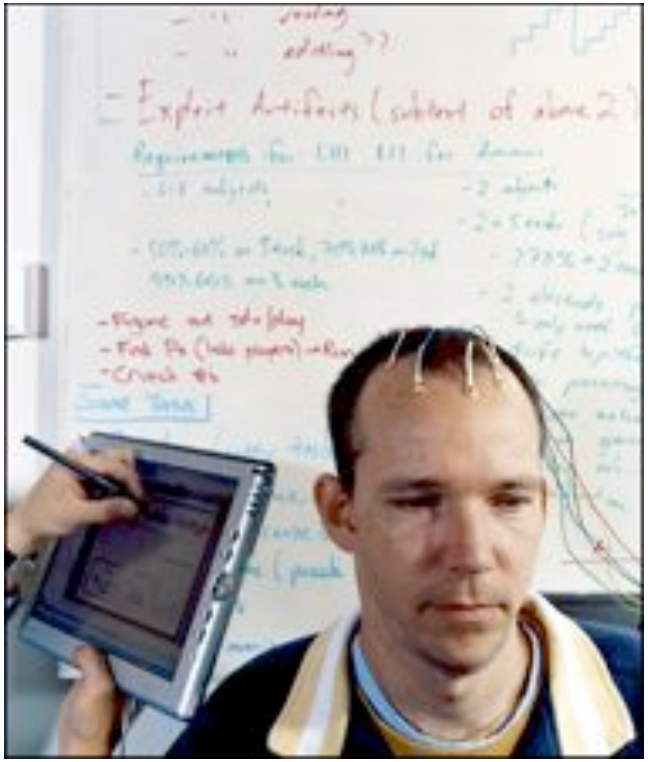
Step 3:
Decode location for application



Low-Cost EEG
for Task Classification in HCI Research



National Geographic, March 2005



NY Times Magazine, October 16, 2005

EEG Devices

Manufacturer: EGI Systems
Channels: 128-512
Cost: **$100K-$250K USD**

Manufacturer: BioSemi
Channels: 64-128
Cost: **~$30K USD**

The Brainmaster

Lowest cost FDA approved device

Designed for home and small clinical use.

Only $1500 USD

Specs:

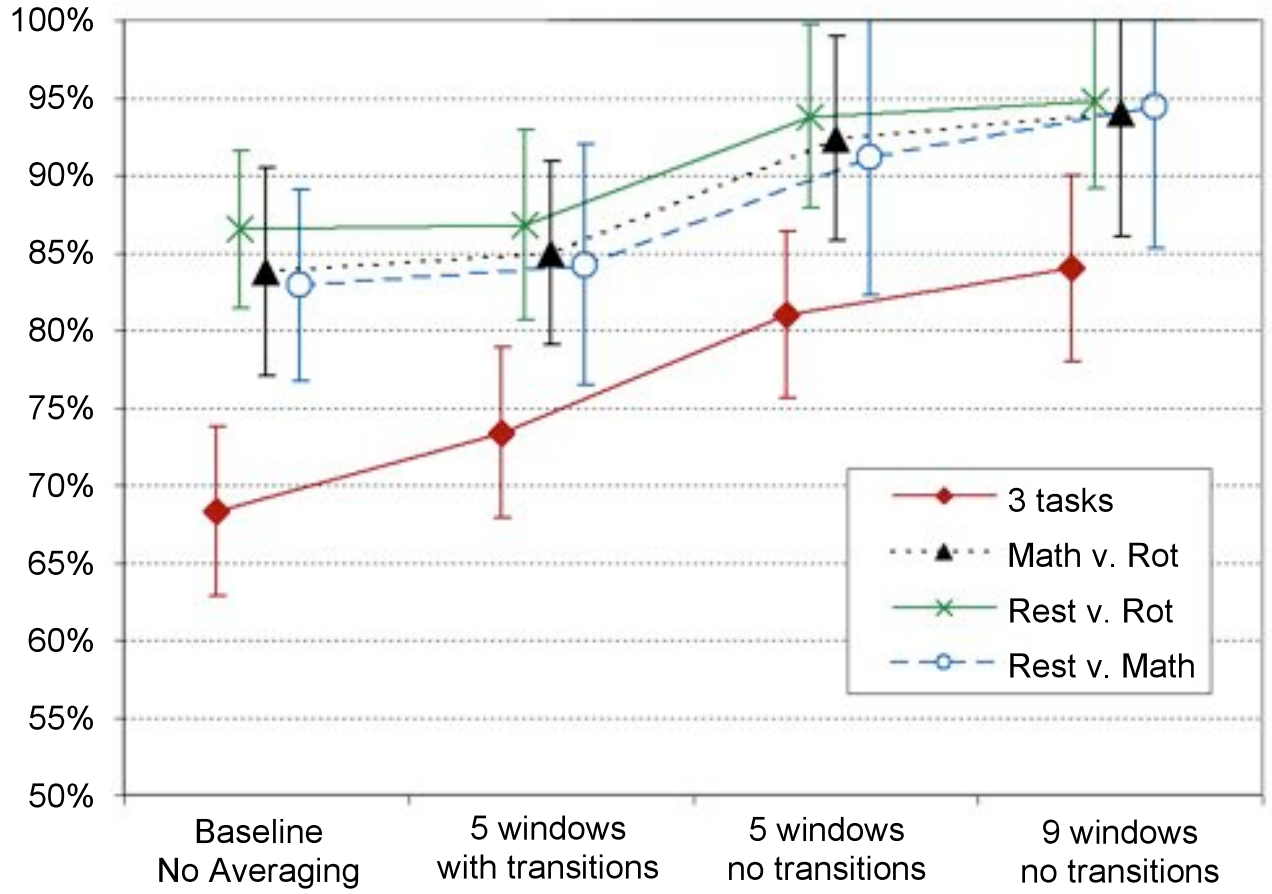
- 2-channels
- 8-bit at 4μV resolution
- 256 samples/sec

Needs to be validated for BCI research work.

If it works, it **lowers the entry bar** for BCI research.

Classification Accuracy with Averaging

Mean Classification Accuracy vs. Averaging Scenarios (Mental Tasks)

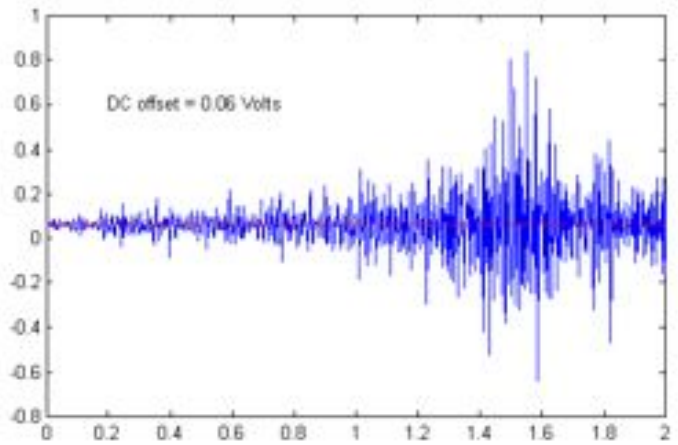


Error bars represent standard deviation

Human as a Sensor


HCII

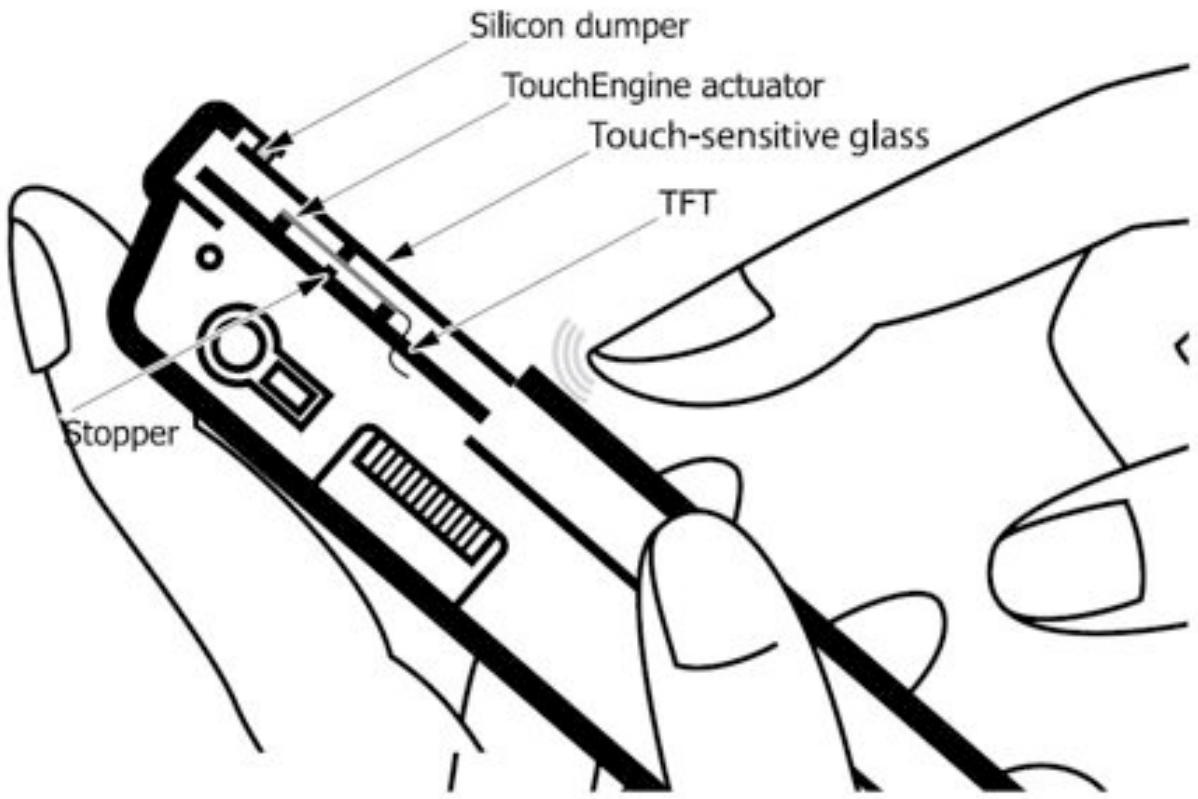
Muscle-Computer Interfaces



Pressure, Position, Tap, Lift

Haptic Pen (MERL - 2004)

> $2000 USD



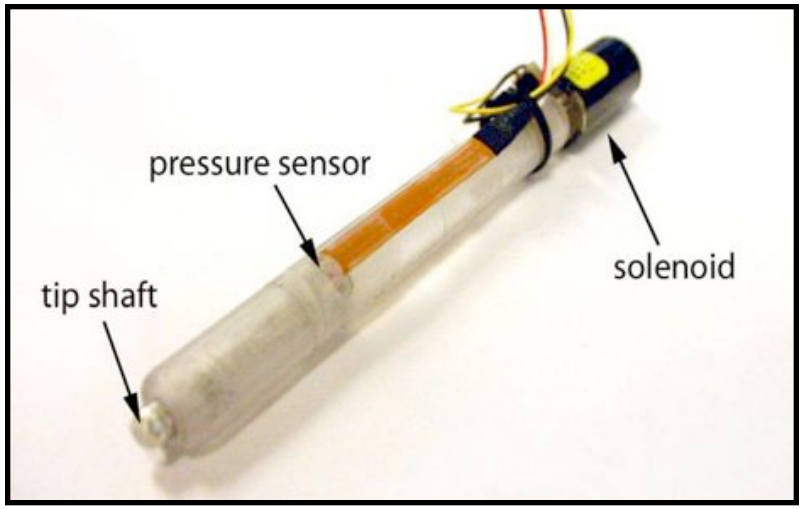
[Poupyrev and Maruyama, UIST 2003]

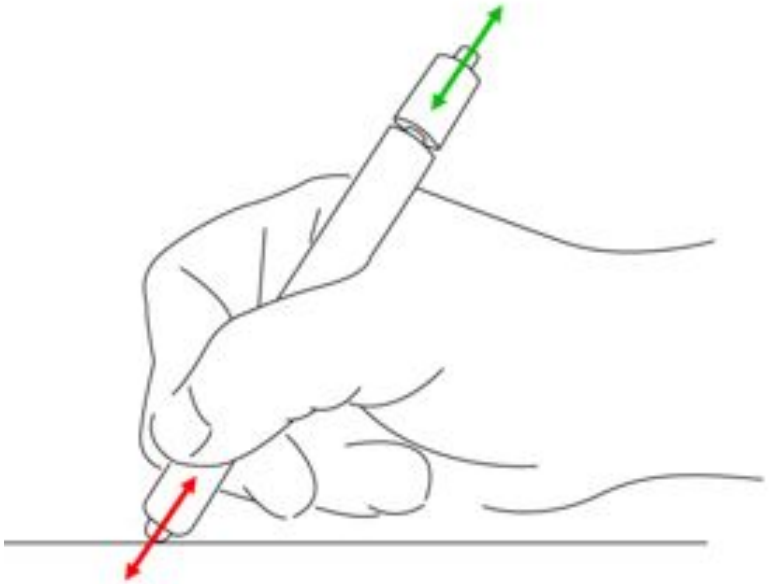
One touch, one person, small screens

Goals: Support large touch-sensitive displays.
Support multiple simultaneous users.

Solution: Haptic Pen

- Individualized feedback
- Pressure Sensitivity
- Hover tracking data
- Feedback not bound to display
- Aftermarket device
- Low-cost (~$10)



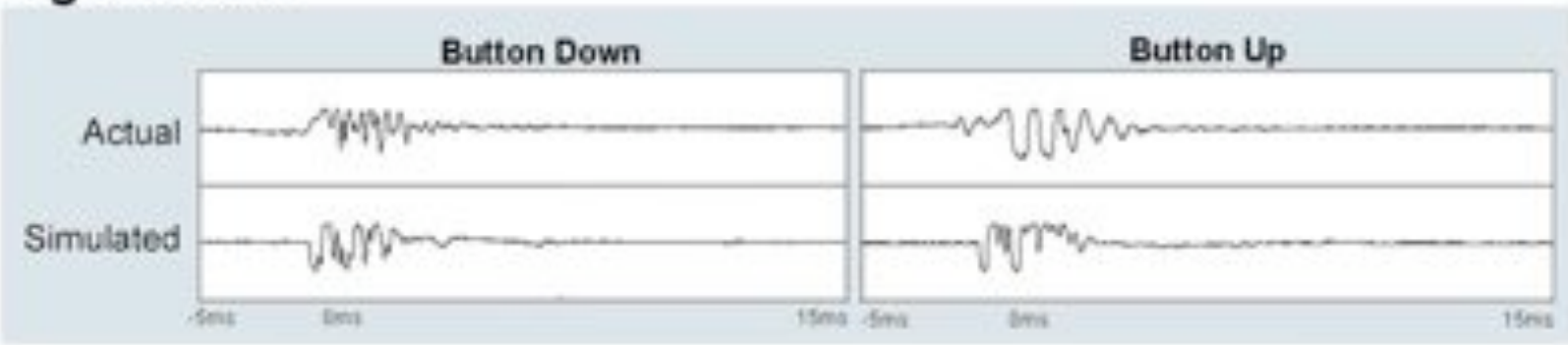


Pressure sensitivity allows variable feedback/activation

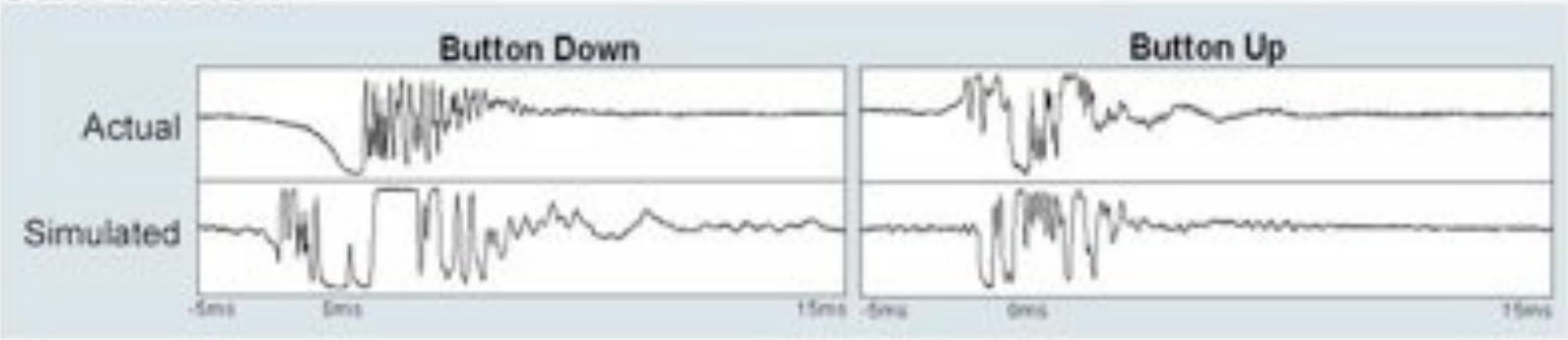
Multi-level buttons also possible (camera shutter)

On-axis feedback **more** accurate than vibration

Light Button



Stiff Button



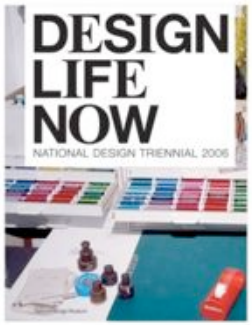
$14 Steadycam (2000)

$6000-$10,000

$14

Over **1.4M** views (not including syndication)
Over **$250K** in revenue

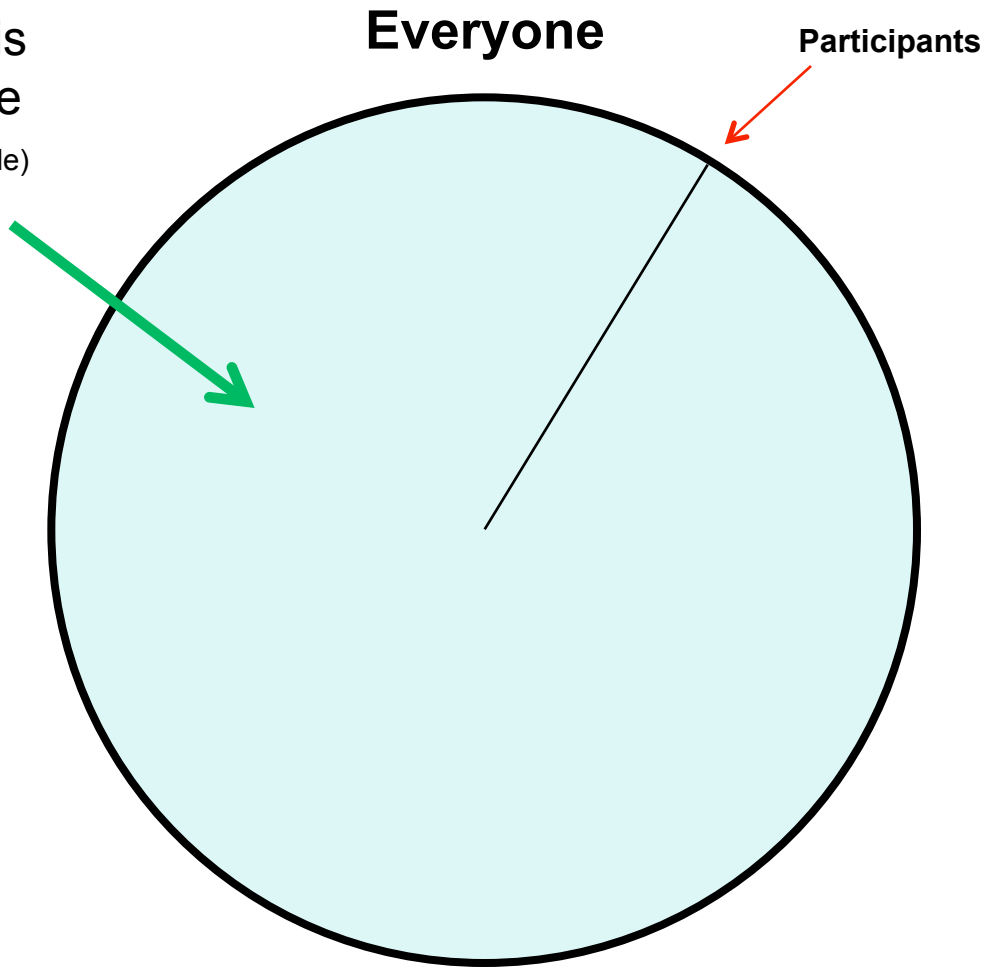
Staple of independent/student filmmaking community.
Used in many high-school and college programs.



If you create technology that is **accessible**, you can advance the state of humanity (if only a little)

2-3 orders of magnitude

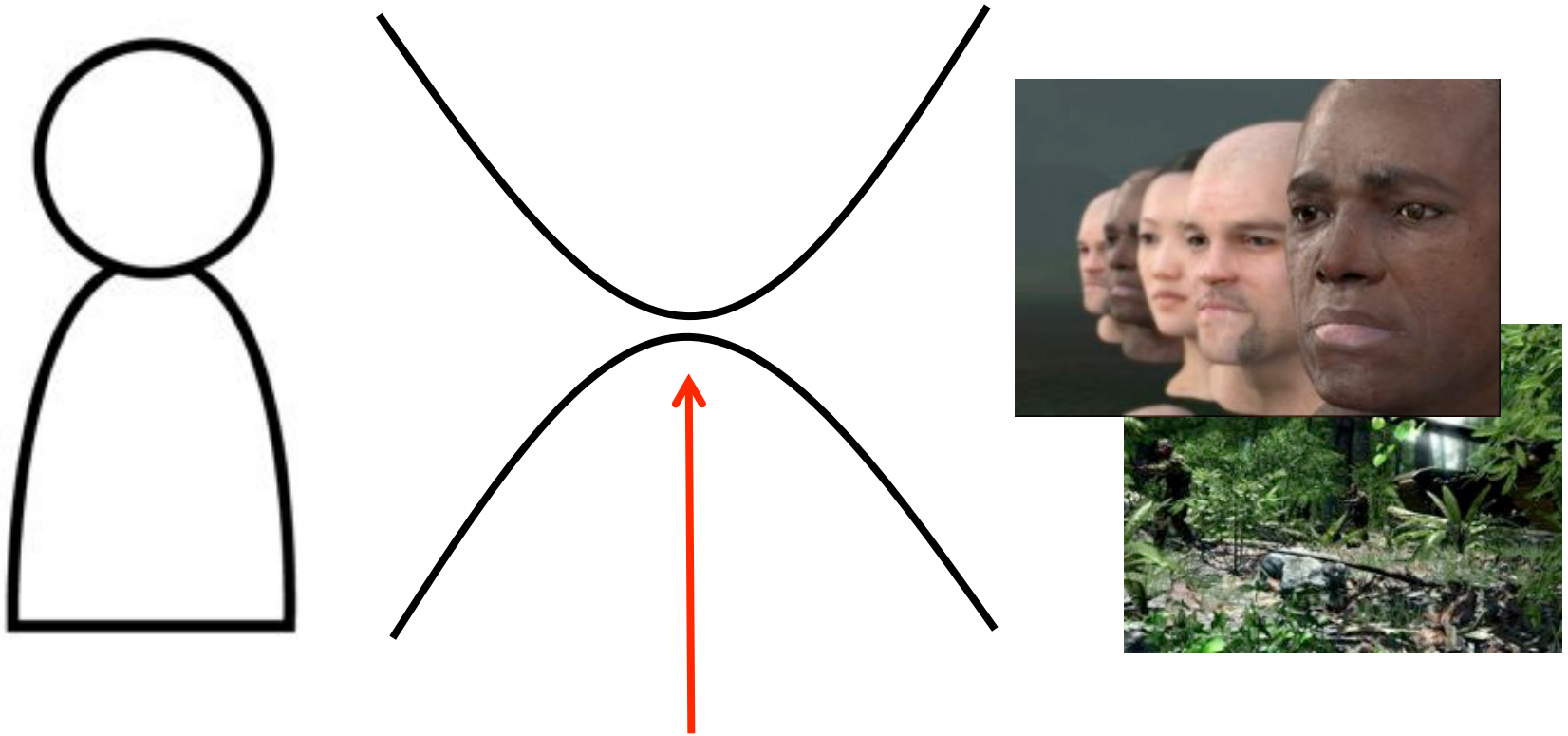
Augmented reality
Multi-touch surfaces
Immersive Displays
Brain-Computer Interfaces
Haptics
Filmmaking



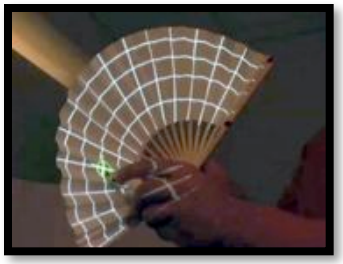
What next?

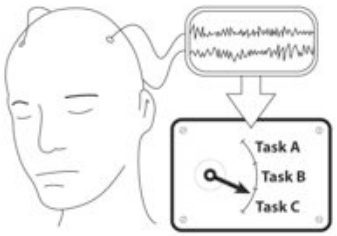
Star Trek – Next Generation, 24th century

Crysis, EA, 2007



Immersion
Interactivity




Task A
Task B
Task C


POLICE 911
逮 捕


GIZMODO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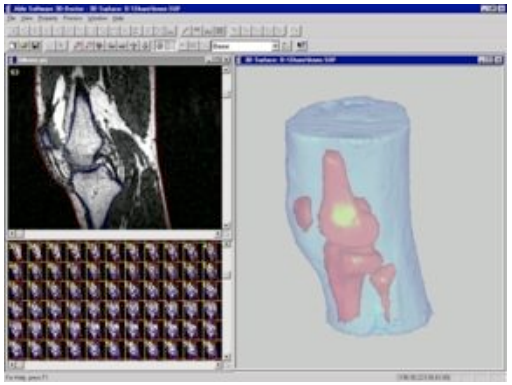
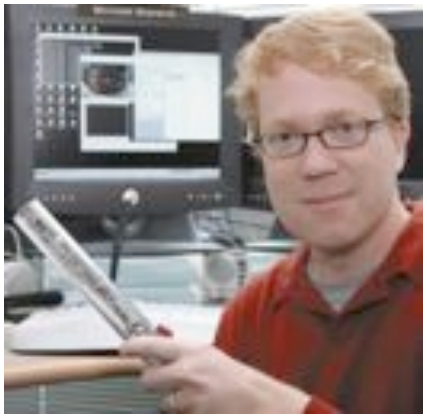


Jeff Han – FTIR/Perceptive Pixel

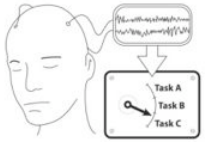


Andy Wilson – Surface/Xwand

Paul Dietz – Diamond Touch/iPhone parent

Bill Buxton –Multi-touch/Maya/Alias

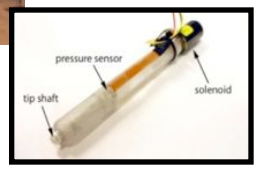
UIST – User Interface Software & Technology
Also consider: SIGGRAPH & SIGCHI & UBICOMP



Projector-Based Location Discovery and Tracking

Low-Cost EEG for Task Classification

Interaction Techniques using the Wii Remote



Haptic Pen

$14 steadycam

Collaborators: Desney Tan, Paul Dietz, Scott Hudson, Ramesh Raskar, Dan Maynes-Aminzade, Jay Summit, Chris Kyriakakis, Darren Leigh

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