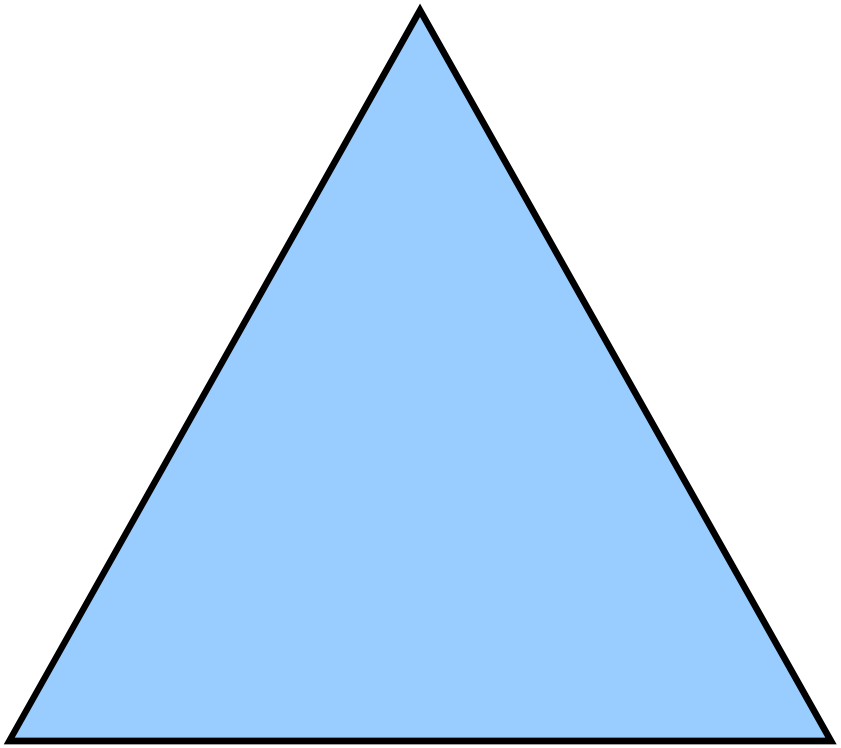
Interaction Techniques Using The Wii Remote

Johnny Chung Lee
Carnegie Mellon University
May 2008

What is HCI?

Psychology

Understanding People



CS/EE

Understanding Technology

Design

Understanding Needs

Interaction Techniques Using The Wii Remote

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Nintendo Wii

Nintendo's 5th Video game console
Release Date: 11/19/06
24 million units worldwide (3/31/08)

>24 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

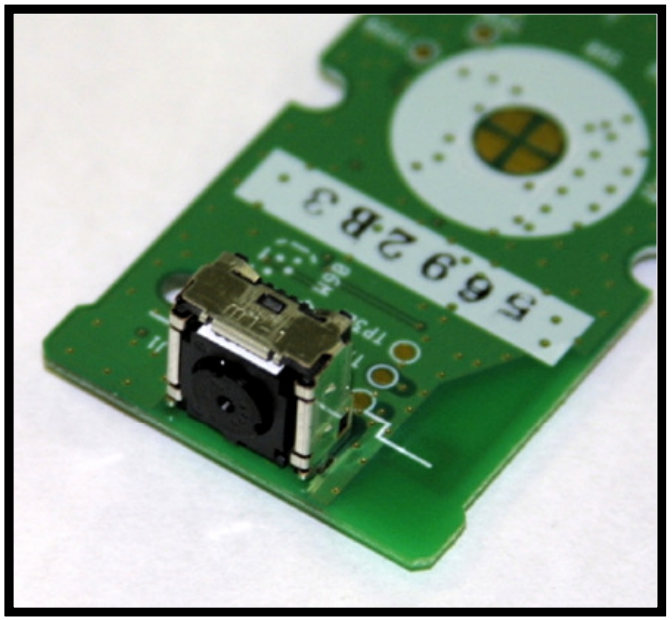
Other:
Expansion port
On-board memory
Batteries

IR Camera Tracker

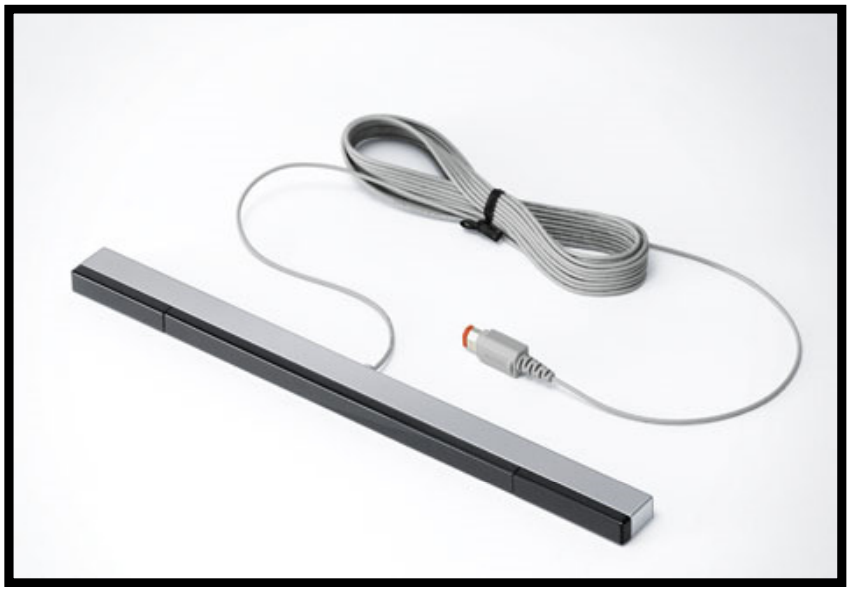
Manufactured by PixArt Imaging
Multi-Object Tracking™ engine (MOT sensor™)

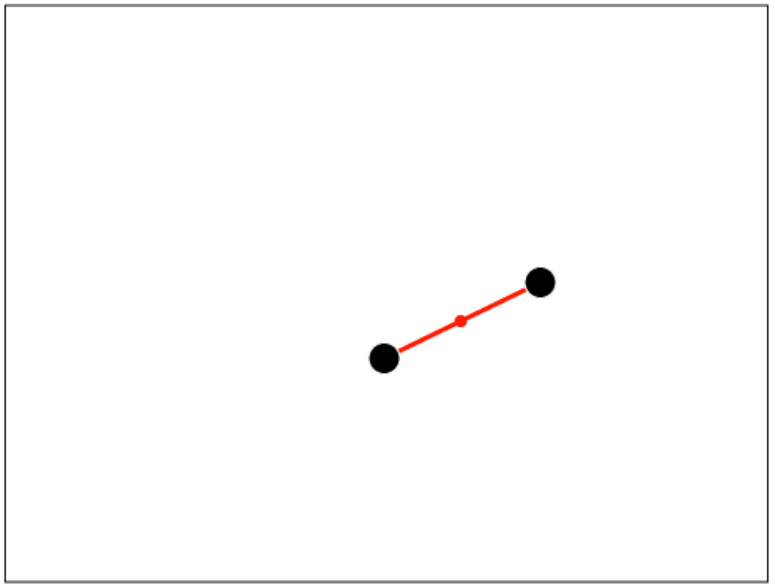
Official specifications are confidential, but….

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*)

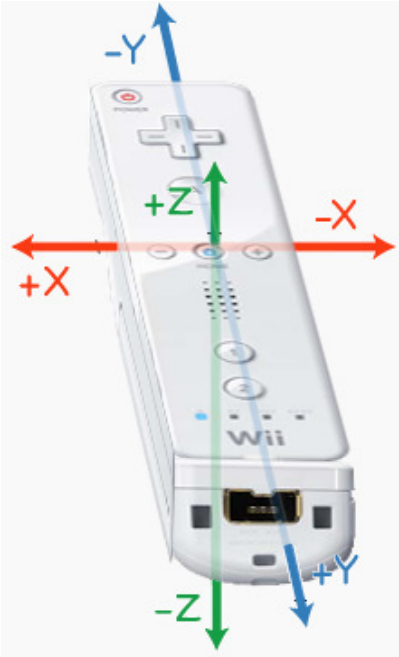
4 values → ***x***, ***y***, ***rotation***, and ***distance***

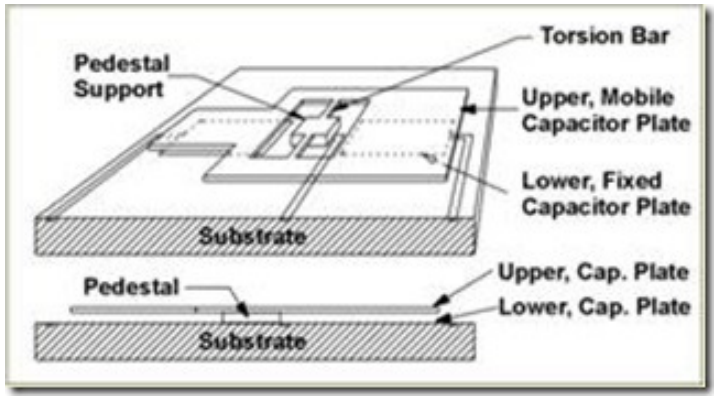
correspond primarily to: *tilt*, *yaw*, *roll*, and *distance*

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.

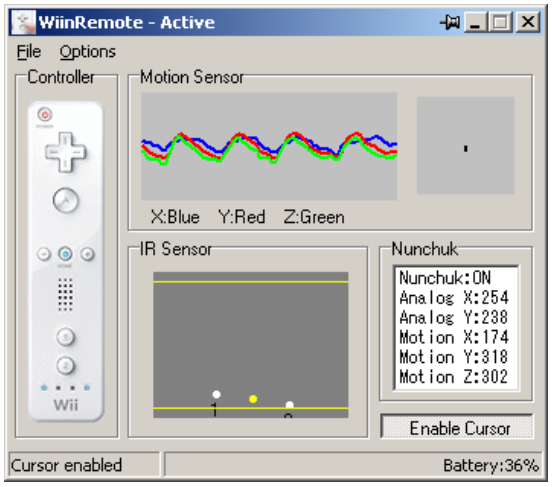
Developing Custom Applications

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



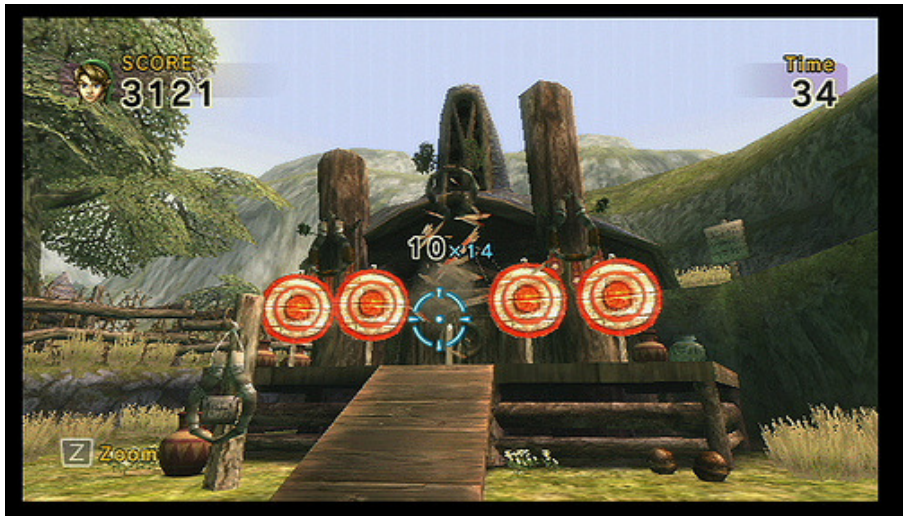
Eventual support:

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

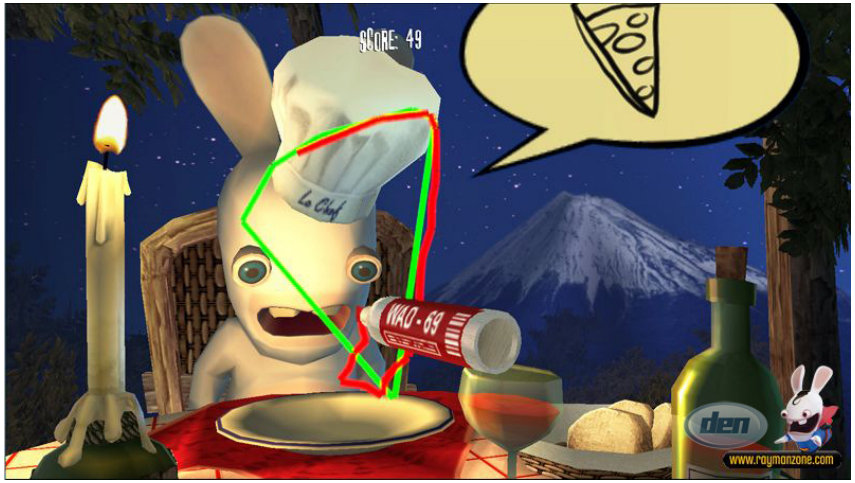
Interaction Techniques

Game Interaction – Pointing

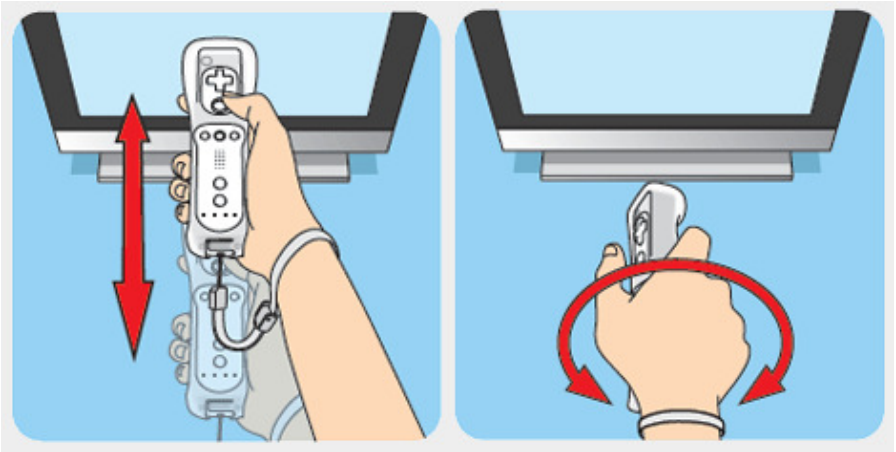
Selection/Navigation



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

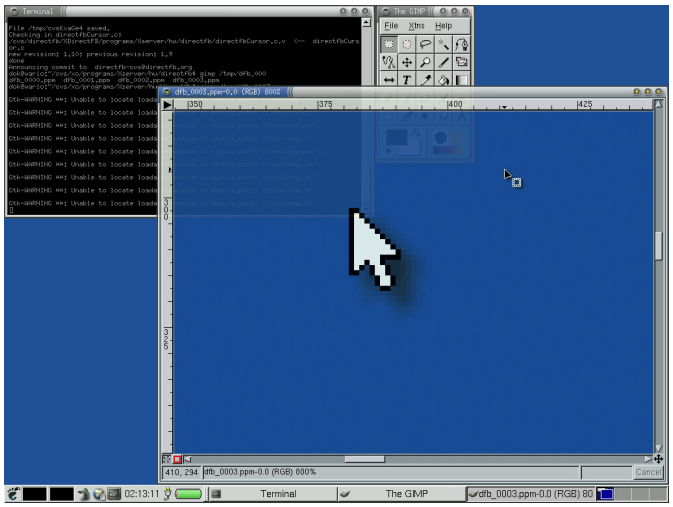
Joystick
2 buttons
3-axis accelerometer

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

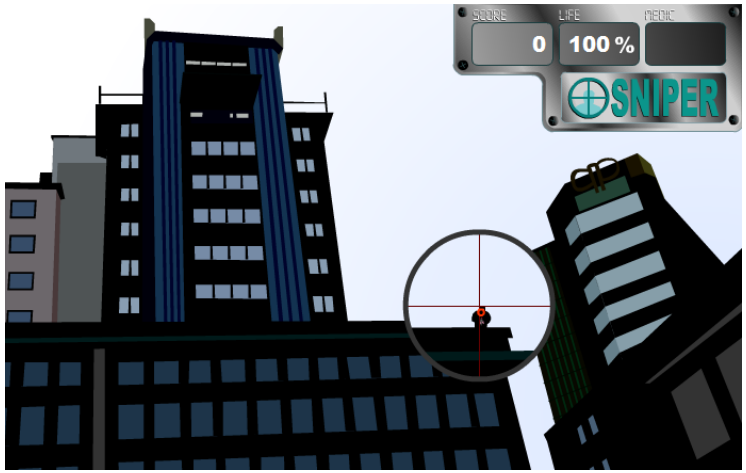
By the Developer Community

Robot Control

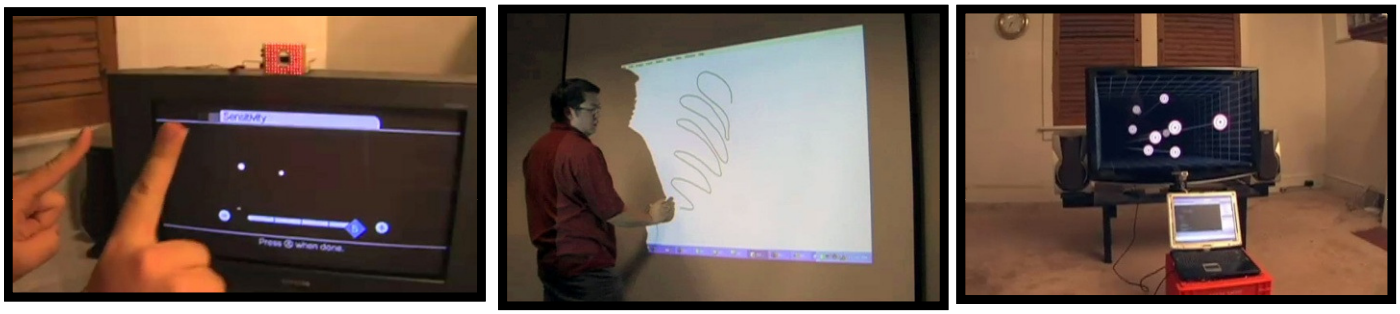
Synth Music Performance



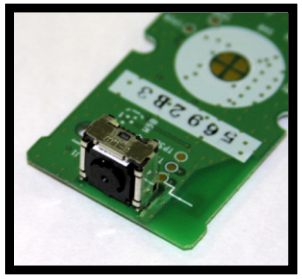
Cursor Control



Flash-Based Mouse Games



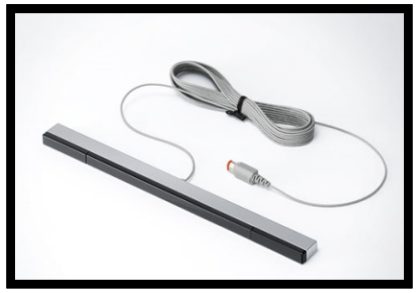
Online Videos Tutorials



Moving

+

Stationary



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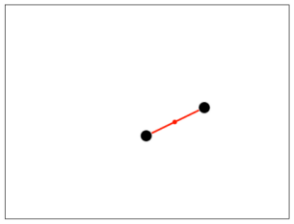


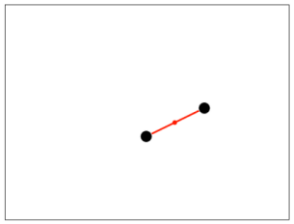
Two dots = 4 values: (*x1*, *y1*), (*x2*, *y2*)
4 values → ***tilt***, ***yaw***, ***roll***, and ***z***

Moving

+

Stationary

=

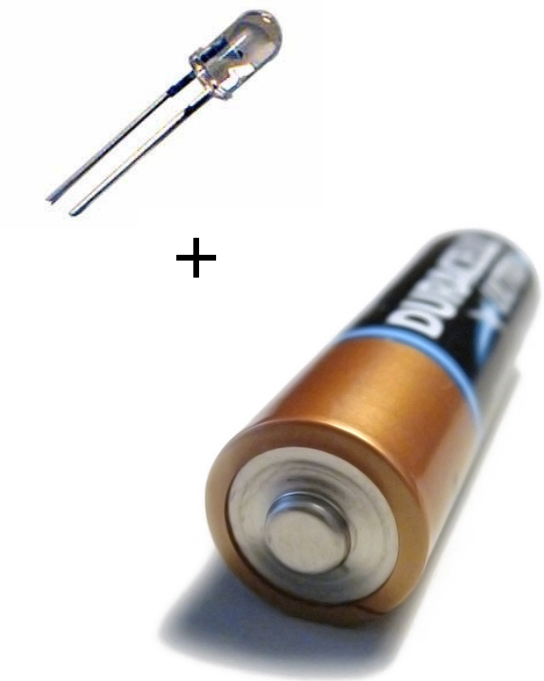


Two dots = 4 values: (*x1*, *y1*), (*x2*, *y2*)
4 values → ***x***, ***y***, ***z***, and ***roll***

project 1

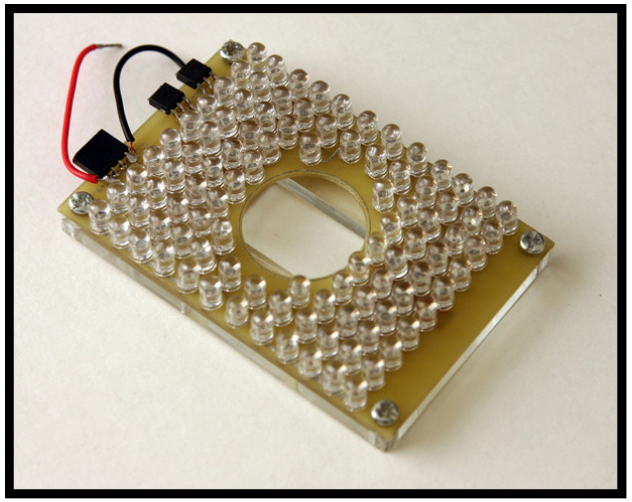
Finger and Object Tracking

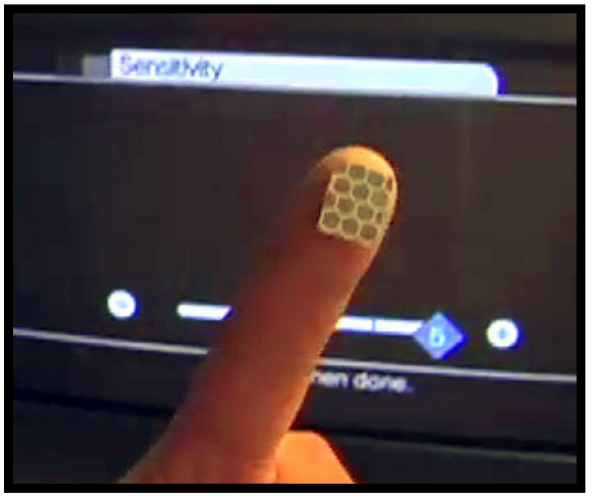
Finger and Object Tracking



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

Finger and Object Tracking

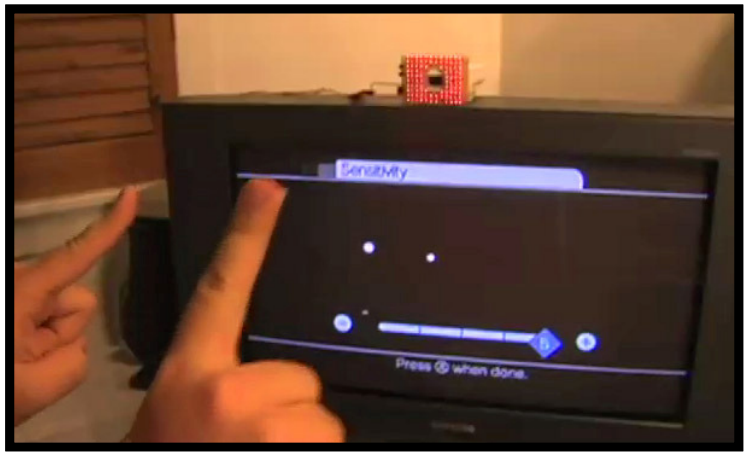




Vicon Motion Capture System

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

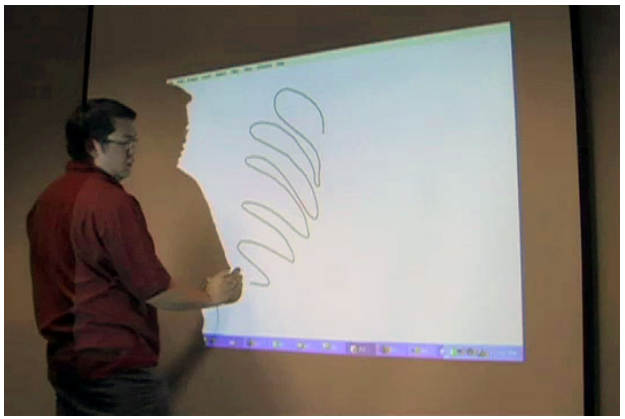
Effective electronic whiteboard system for **$50**

>600,000 software downloads (>1.6m views)

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

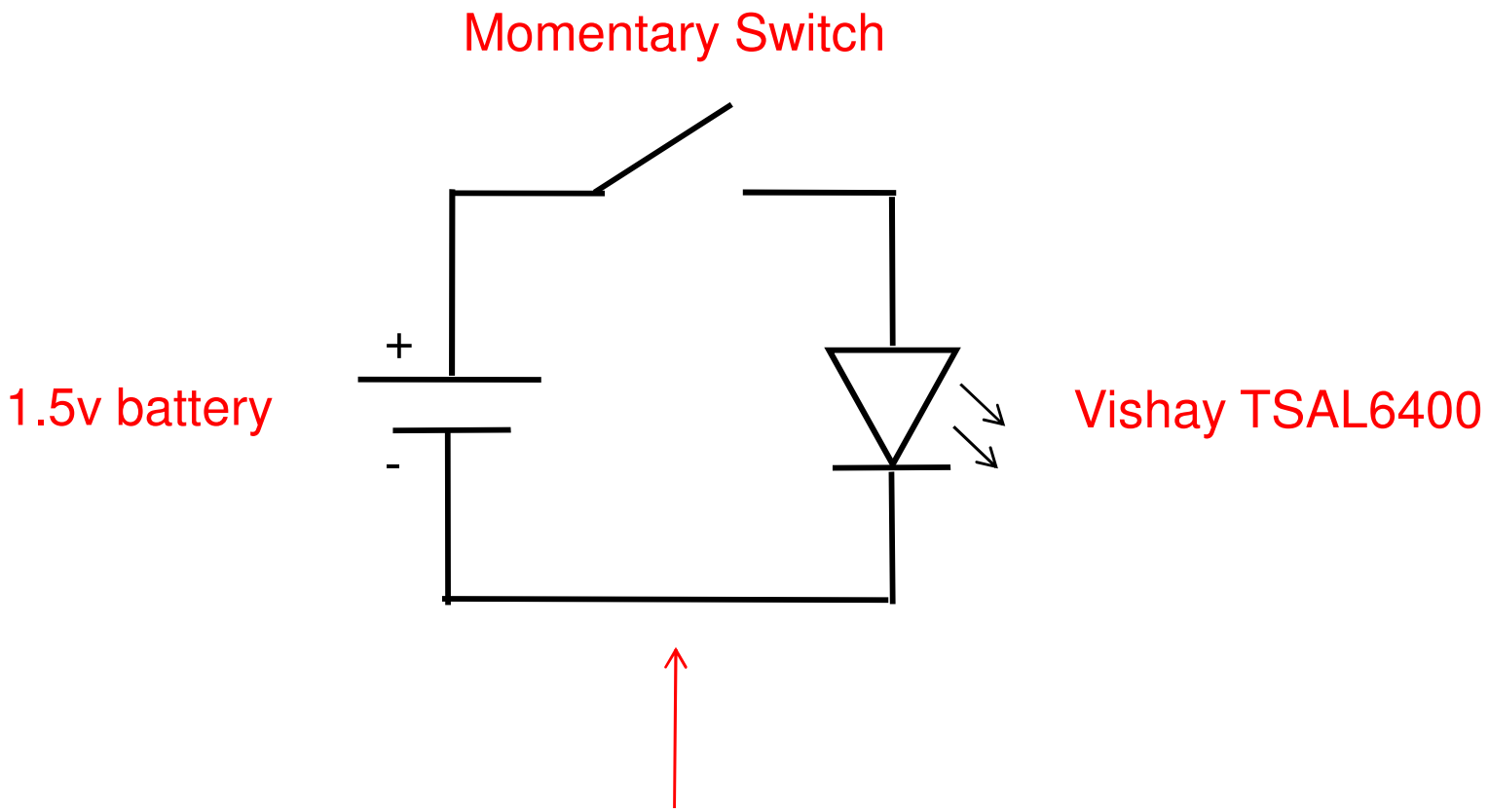
Tracks up to 4 pens simultaneously.

Most planar surfaces/display technologies



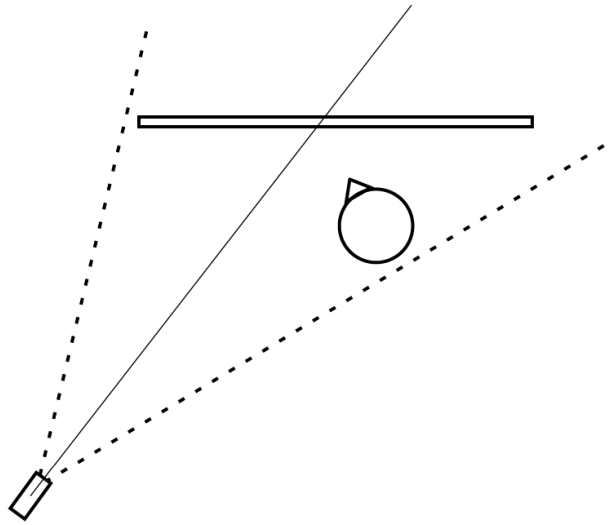
Video – Whiteboard

IR Pens

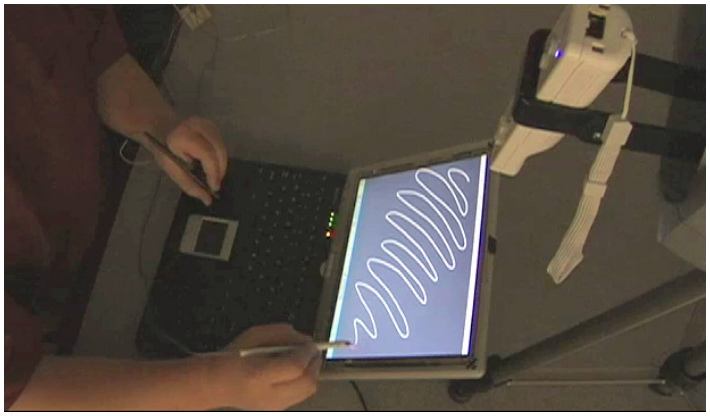

Momentary Switch
1.5v battery
+
-
Vishay TSAL6400
No resistor will yield about ~130mA
Better to use resistor to run at 100mA

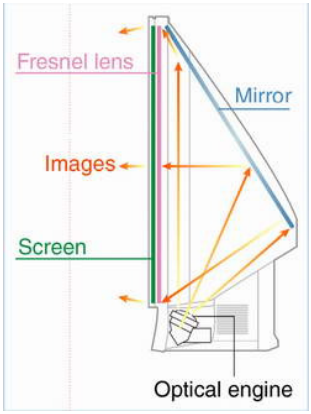
Interactive Whiteboards - Limitations

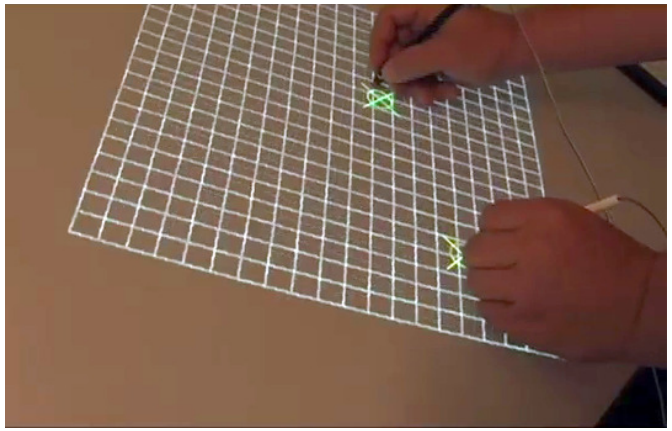
Maximum 1024x768 resolution.
Dependent on good camera positioning.
Sensitive to occlusion.



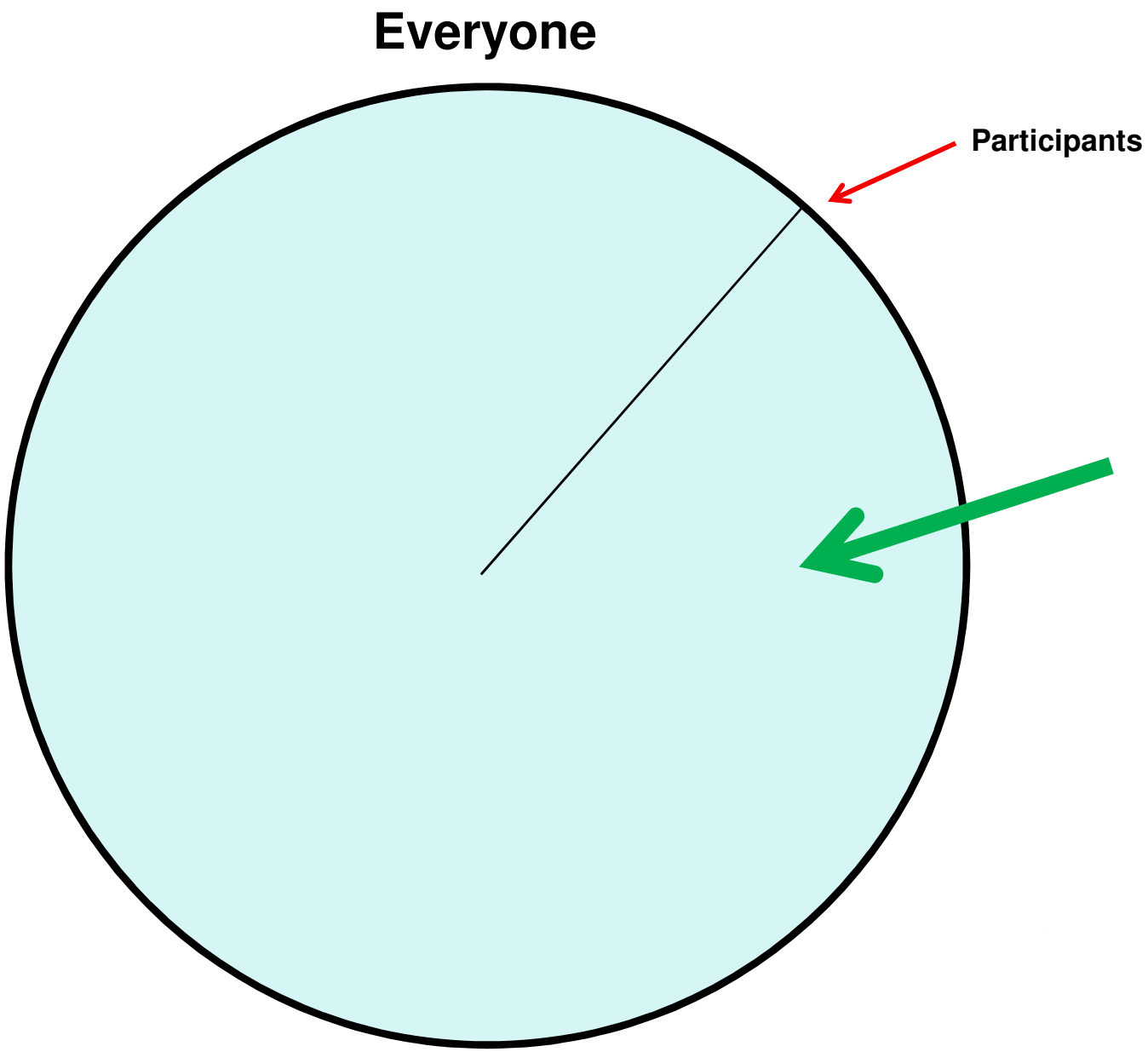
Solutions
Adjust camera position (over-head)
Use multiple Wii remotes
Use rear projected displays.







80% of the way there at
1% of the cost


Everyone
Participants


HCII

Two Effects:

1. **Increased participation:**
   Advances the state of research

2. **Increased practicality:**
   Advances the state of technology


HCII

project 3

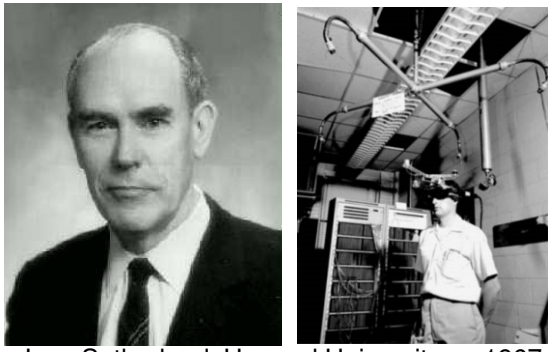
Head Tracking for Desktop VR

Head Tracking for Desktop VR

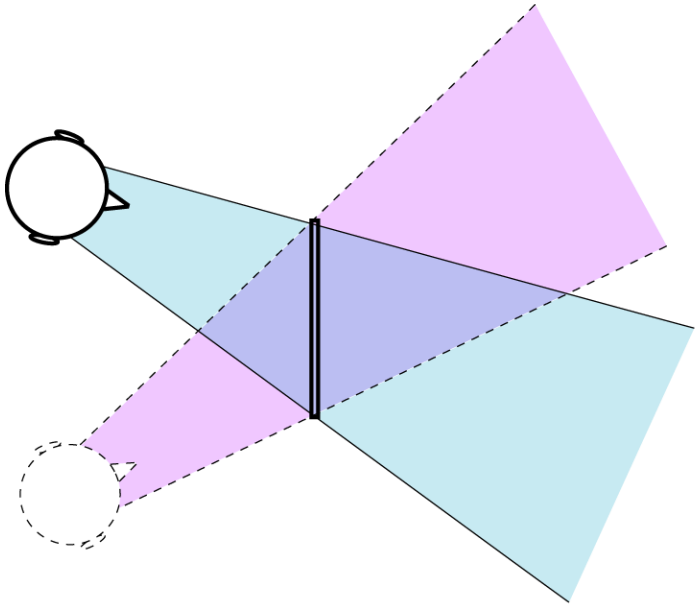
Rigid pair of head-mounted IR emitters
yields ***x,y,z*** position relative to display

Create motion parallax displays

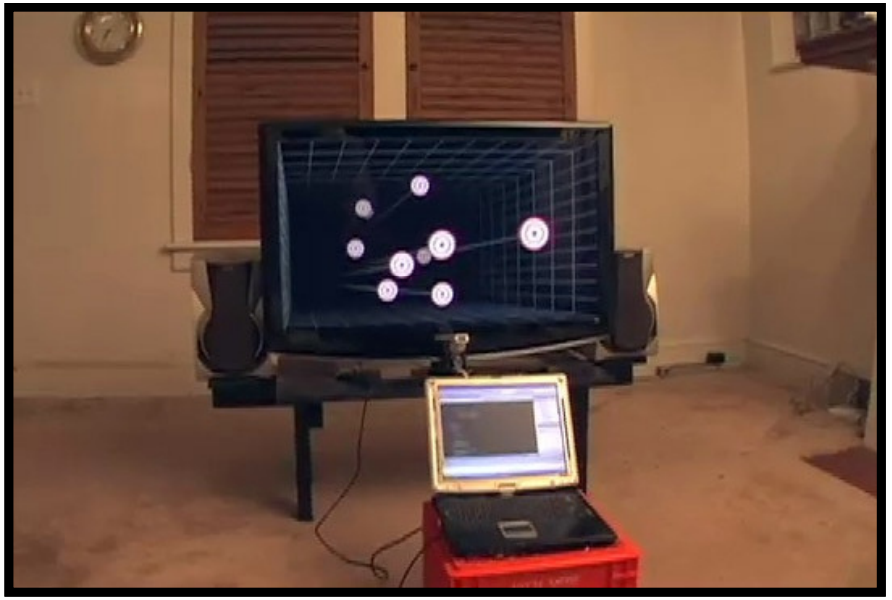
Sufficient hardware now in millions of homes
6+ major game studios



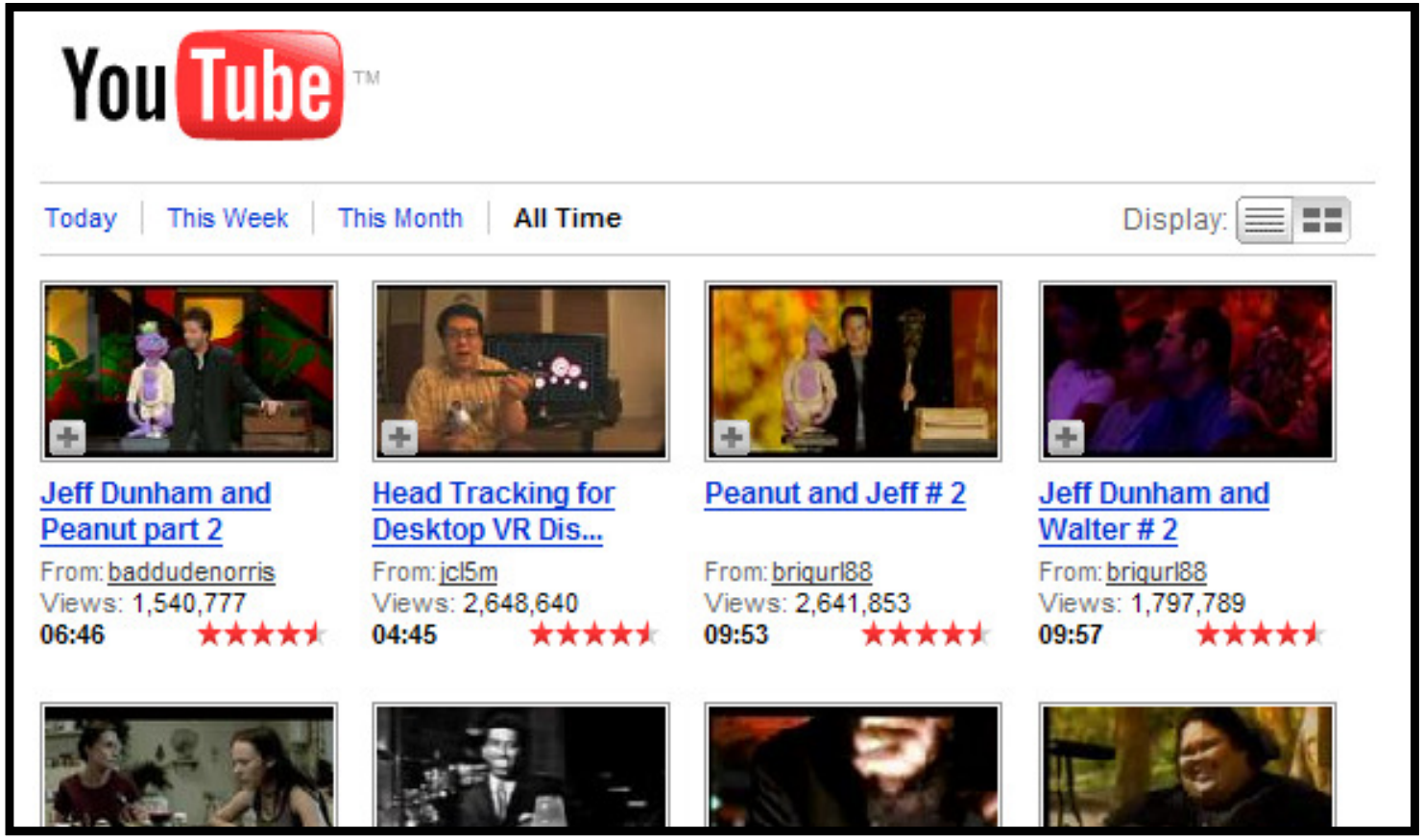
Ivan Sutherland, Harvard University, *c.* 1967.



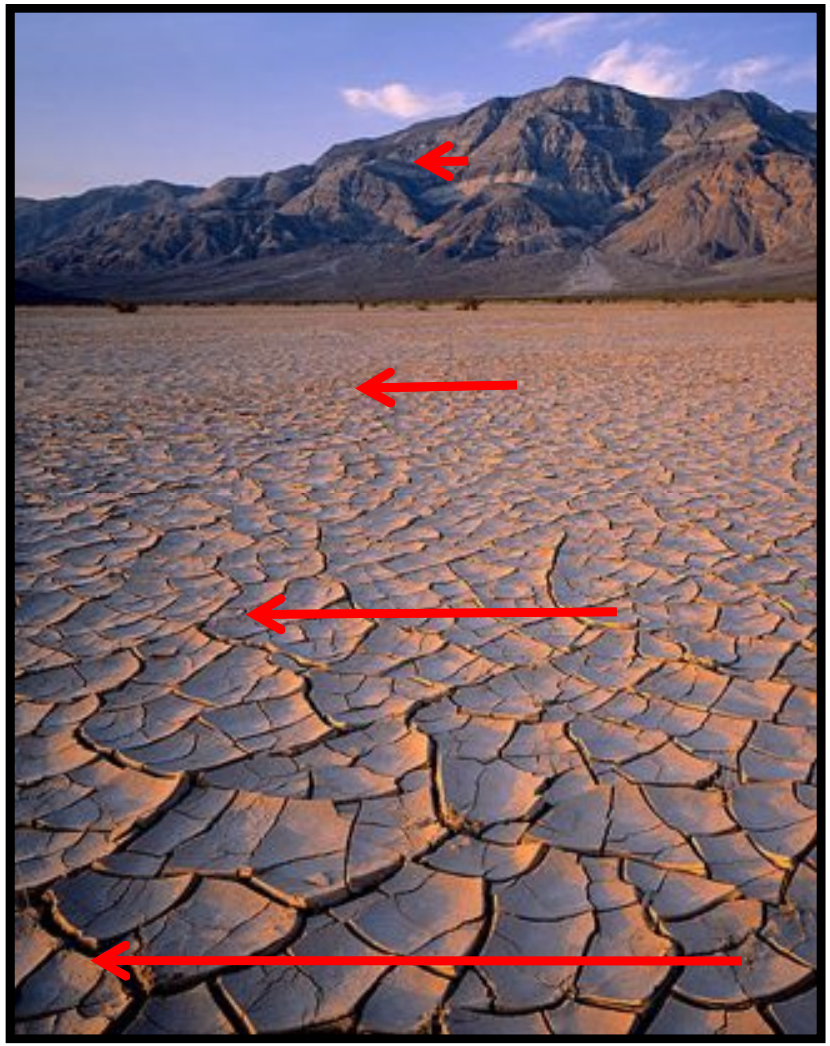
Head Tracking for Desktop VR

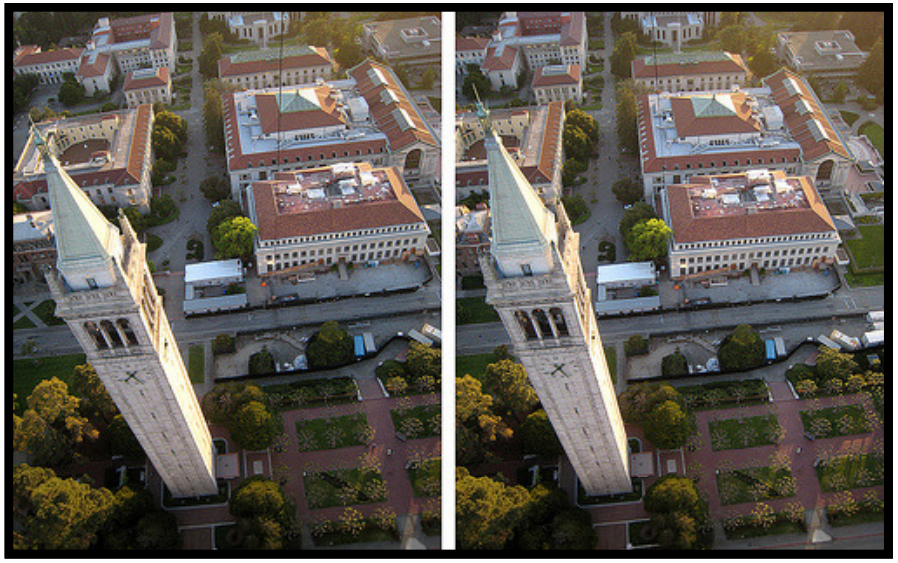


Video – Head tracking


YouTube
Today
This Week
This Month
All Time
Display:
Jeff Dunham and Peanut part 2
From: baddudenorris
Views: 1,540,777
06:46
Head Tracking for Desktop VR Dis...
From: jcl5m
Views: 2,648,640
04:45
Peanut and Jeff # 2
From: briqurl88
Views: 2,641,853
09:53
Jeff Dunham and Walter # 2
From: briqurl88
Views: 1,797,789
09:57

Motion Parallax





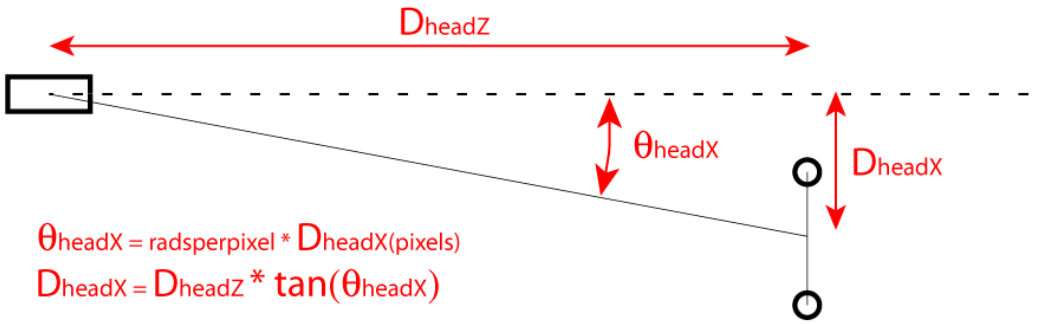
www.flickr.com/photos/kap_cris/472159801/

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

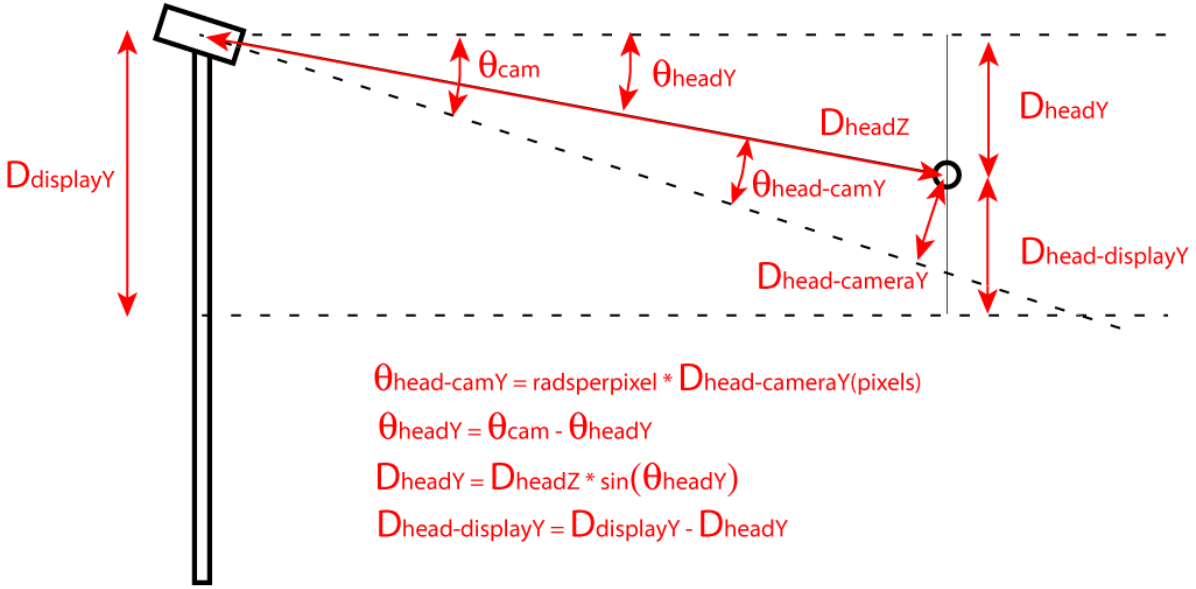
[Ware, Arthur, and Booth CHI'93]
Motion parallax is more important than stereo

Calculating Head Position

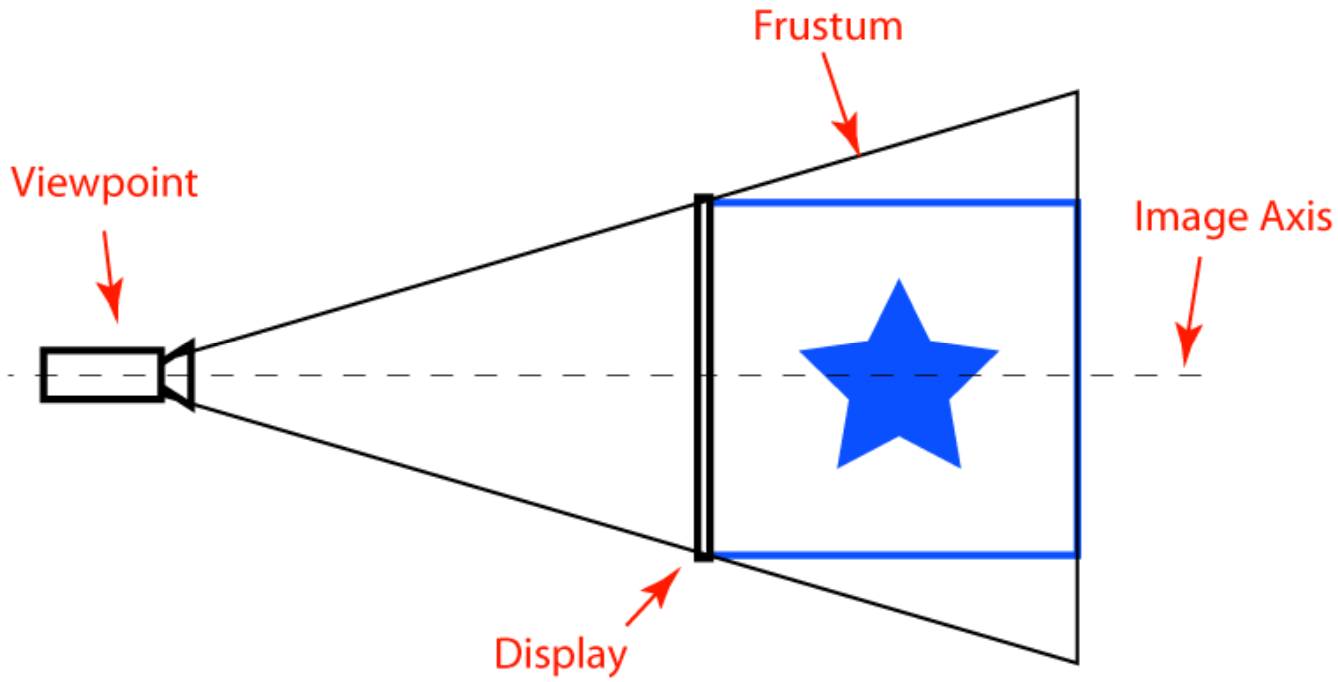
Horizontal Position



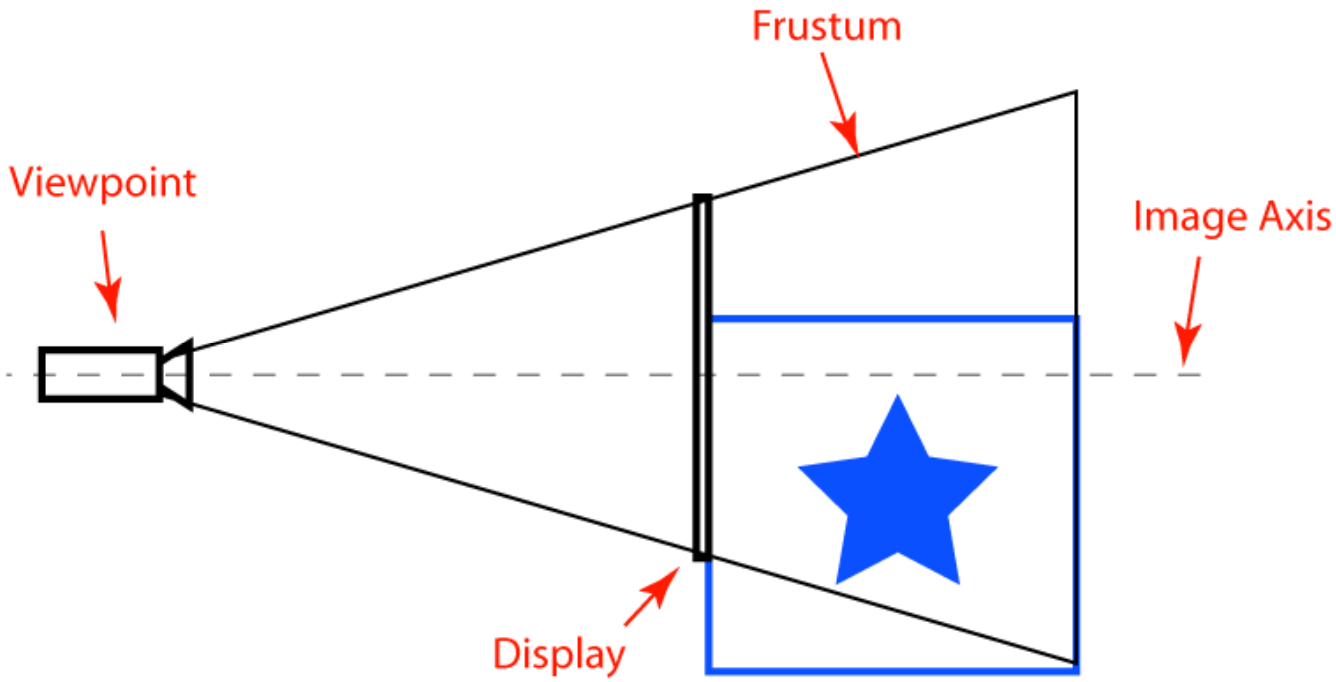
Vertical Position



Now we have head X, Y, Z…

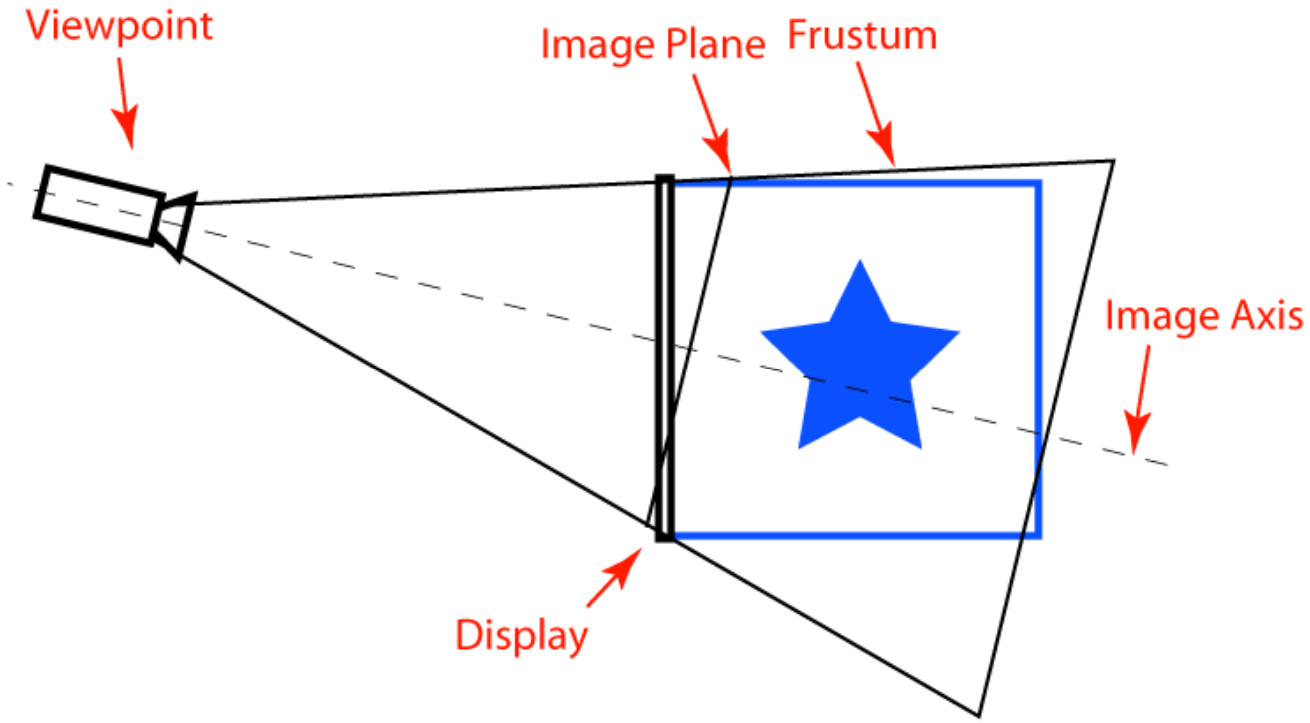


Translating the camera



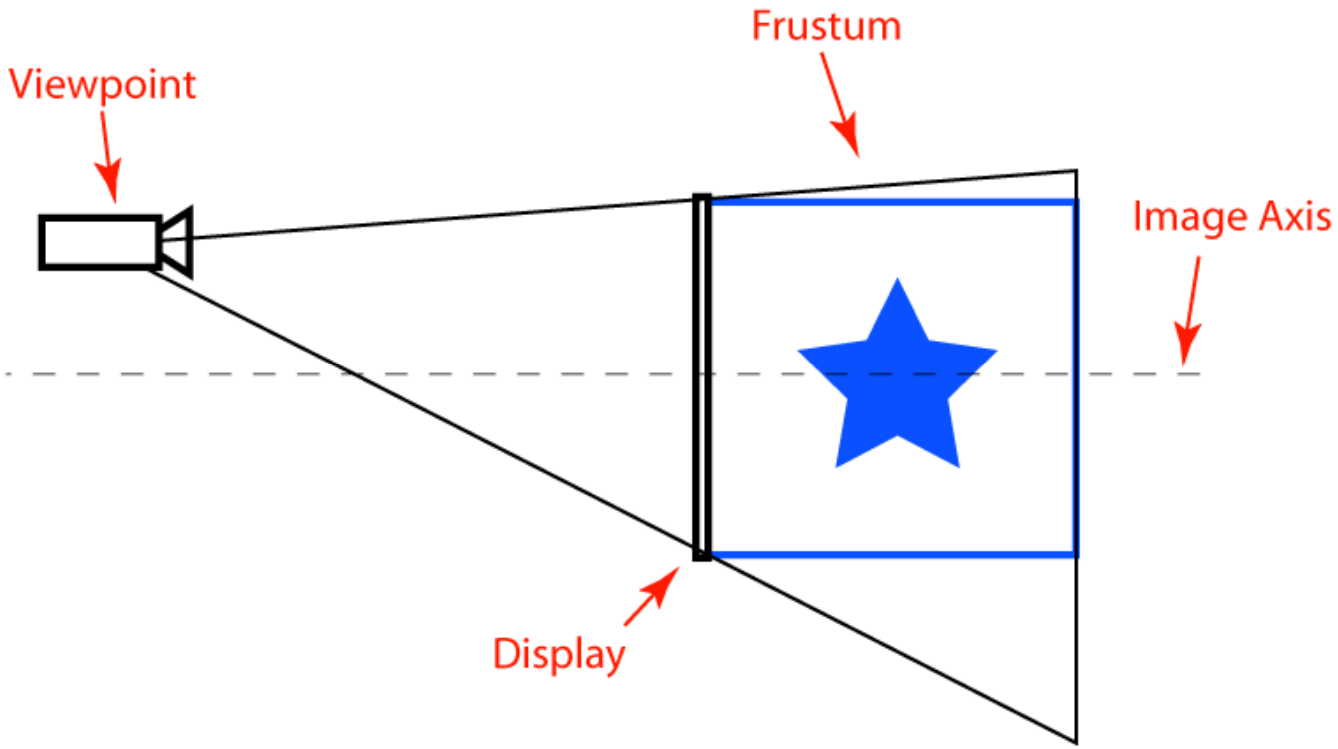
Provides motion parallax, but **inaccurate** for portal simulation.

Rotating the camera



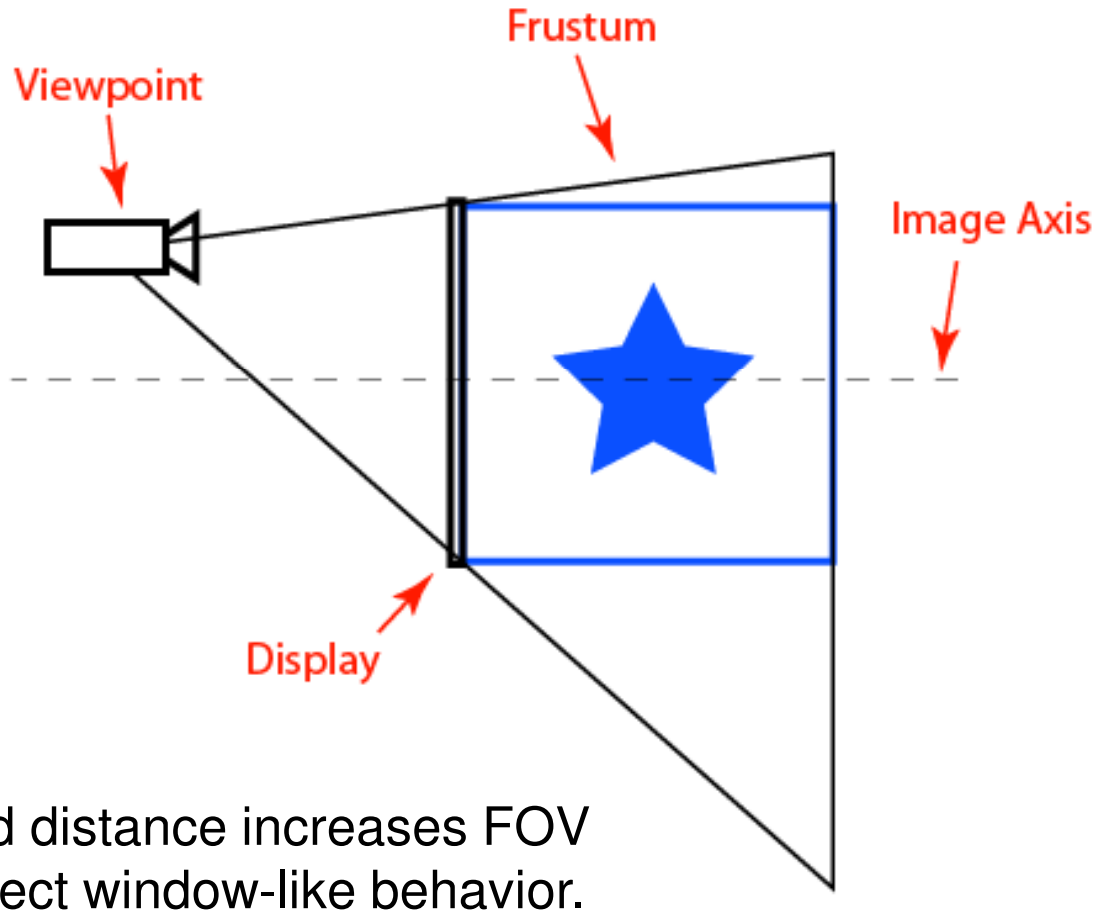
Provides *some* motion parallax, but **inaccurate** for portal simulation.
Image plane moves causing mismatch with lack of display movement.

Off-Center Perspective



Provides **accurate** motion parallax for portal simulation.
Image plane is stationary matching lack of display movement.
Image axis stays centered through display.

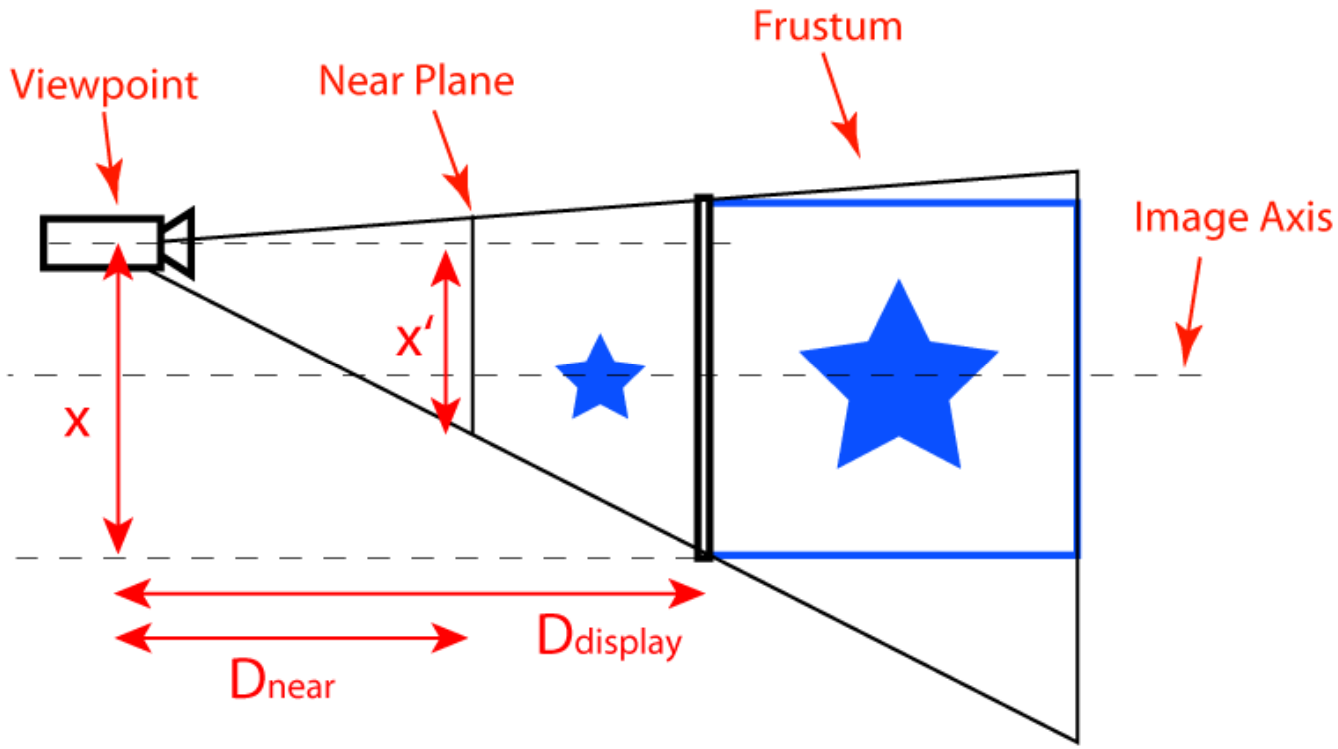
Off-Center Perspective



Reducing head distance increases FOV producing correct window-like behavior.

Off-Center Perspective – near plane

Computing moving boundaries of a near plane that is closer than the spatially locked plane, allows rendering objects floating out in front of the screen.



$$x' = x^*(D_{near}/D_{display})$$

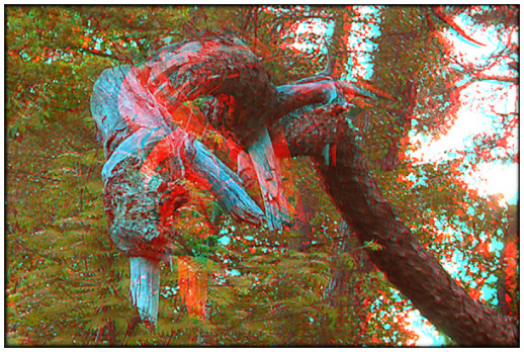
Head Tracking - Limitations

Only works for 1 person – split screen or shutter glasses

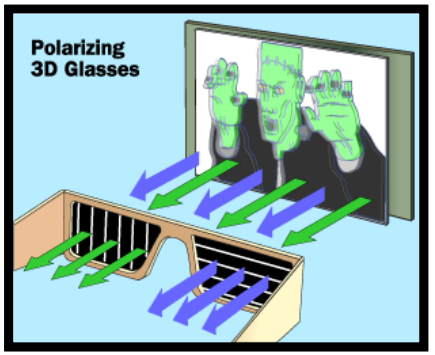
Limited Tracking Volume – increase field of view with wide angle lens or use multiple remotes.

Can't touch objects – *S*orry. 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)

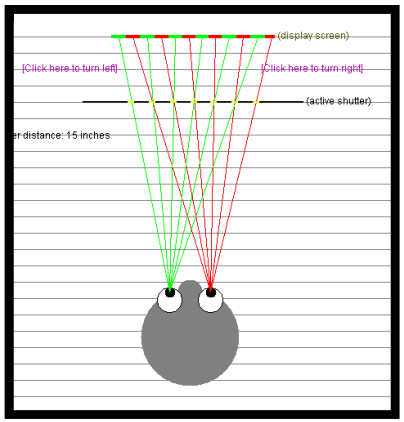


Anaglyph (red/blue): bad color fidelity, but would work, cheap



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

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



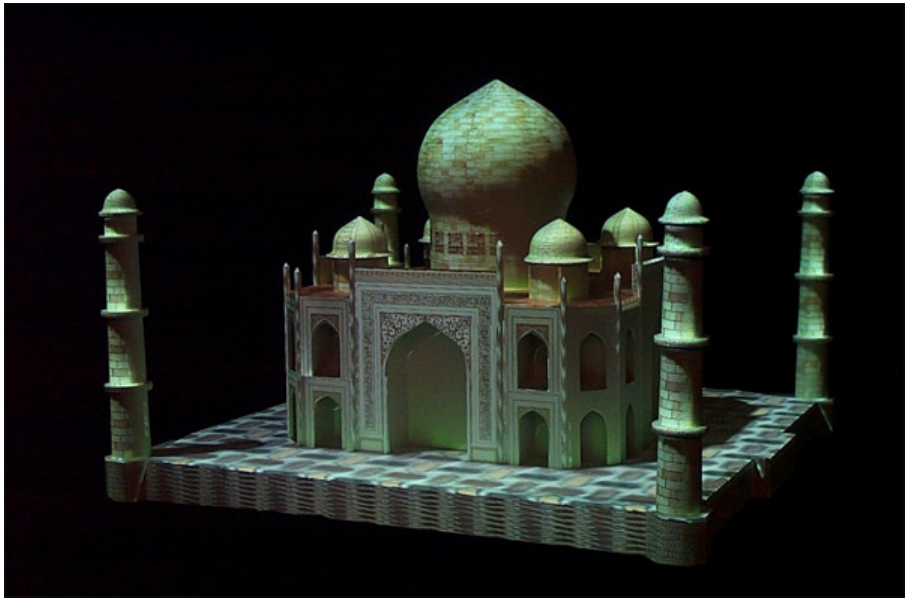
Auto-stereoscopic:
not consumer technology yet

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.

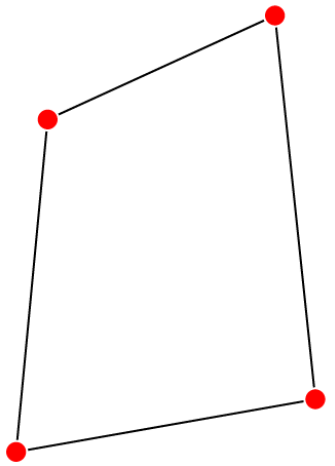
1024x768 @ 100Hz tracking of the Wii remote is quite good.

Video – Foldable Displays

Spatial Augmented Reality

Wii remote only tracks 4 points.

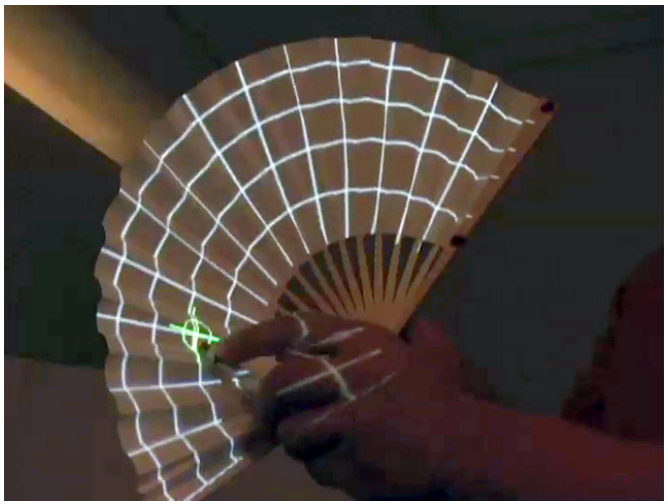
- Limits the number of objects
- Limits the geometric complexity



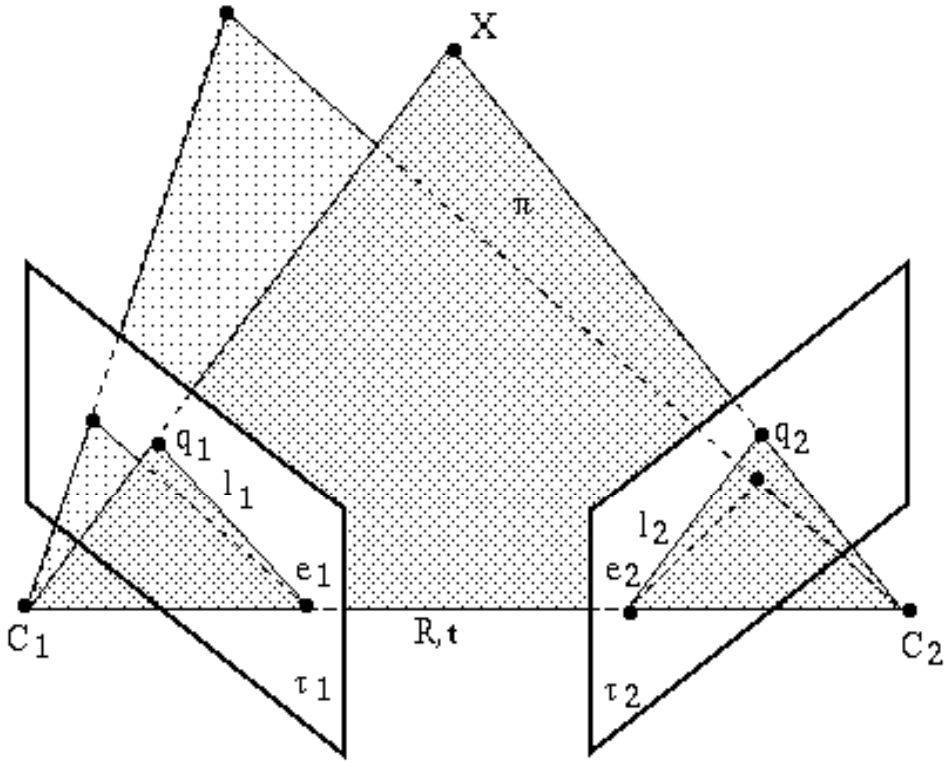
4 points can track arbitrary quadrilateral

Assumptions reduces necessary points

- square surface
- constrained to a plane



Spatial Augmented Reality



- If the projection parameters are known, we have epipolar geometry.
- Calculate the projector-camera fundamental matrix.
- Four points of geometric relationship, yields camera pose estimation.
- Registration onto surfaces in 3D space should be possible.

Other ideas…

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.

Gesture Recognition – current use is limited compared to state of the art. Unique challenges in recognizing variations in speed, size, and orientation with either accelerometer or camera data.

Summary

> 24 million Wiimotes
Sophisticated I/O capabilities
- IR camera, Accelerometer, Buttons
Vibration, Speaker, LEDs,I2C port
Only $40 USD

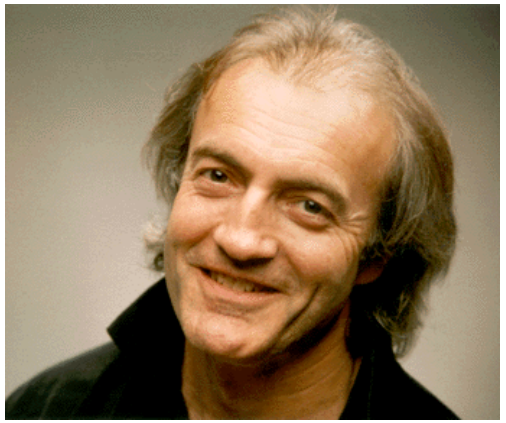
Vast number of applications
limited only by creativity

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

Jeff Han – FTIR/Perceptive Pixel

Andy Wilson – Surface/Xwand

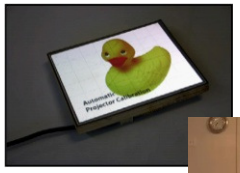
Paul Dietz – Diamond Touch/iPhone parent



Bill Buxton –Multi-touch/Maya/Alias

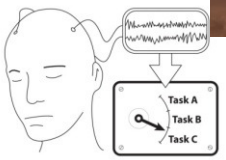
UIST – User Interface Software & Technology
Also consider: SIGGRAPH & SIGCHI

Other Research Work

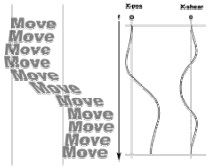


Projector-Based Location Discovery and Tracking

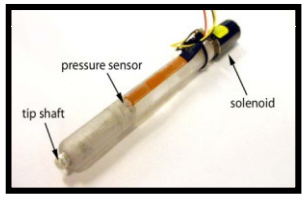
Interaction Techniques using the Wii Remote



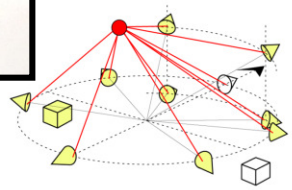
Low-Cost EEG for Task Classification



Kinetic Typography



Haptic Pen



Multi-channel Audio Rendering

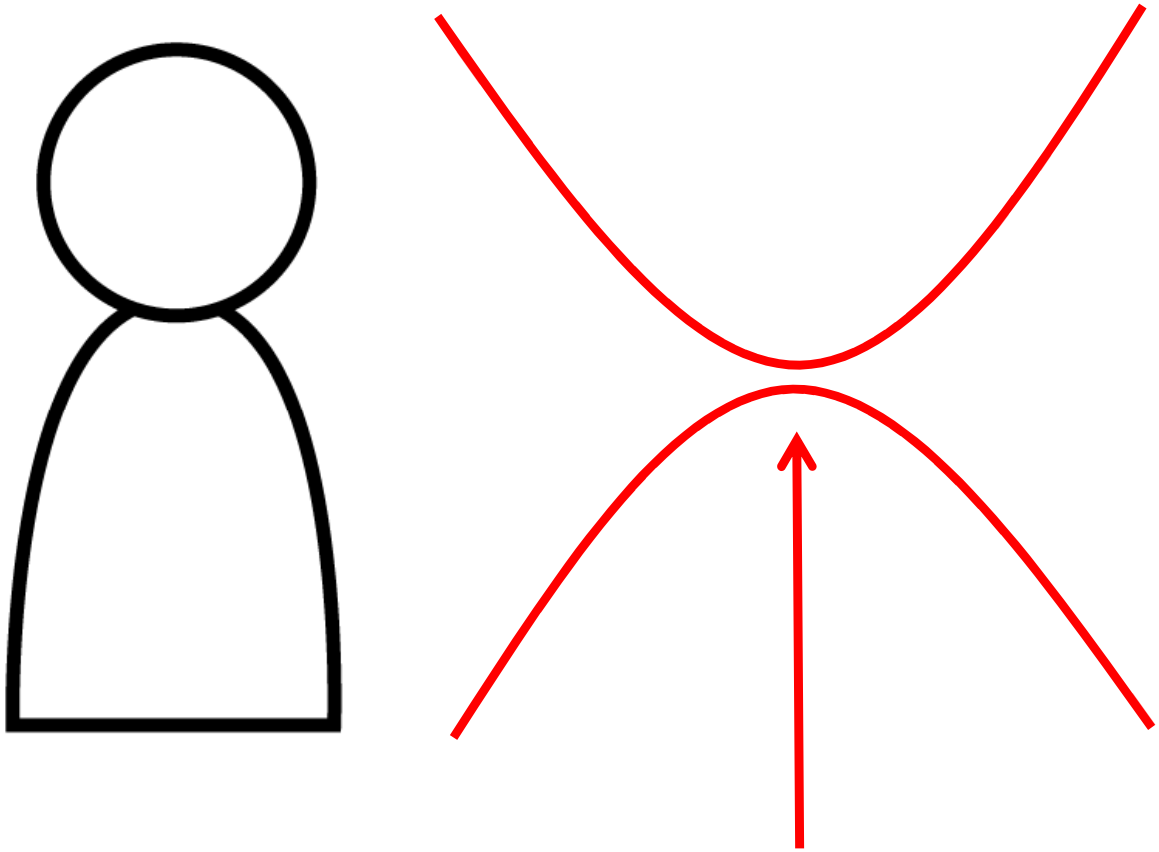
$14 steadycam

Johnny Chung Lee
johnny@cs.cmu.edu
http://johnnylee.net

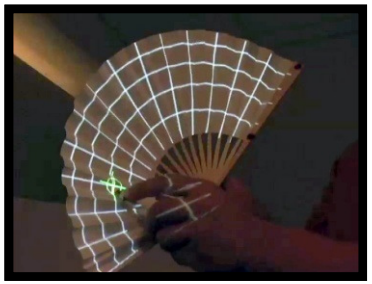
What next?

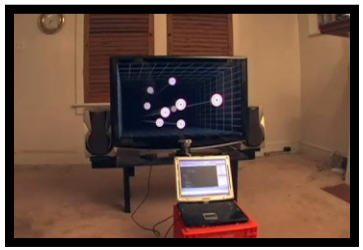
Star Trek – Next Generation, 24th century

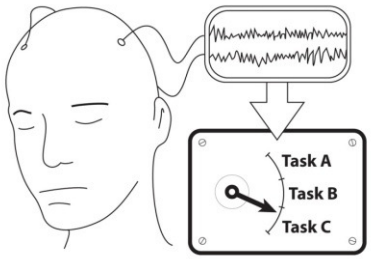
Crysis, EA, 21st century

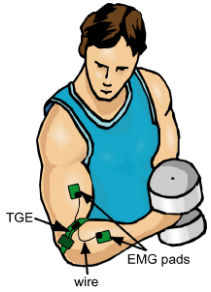


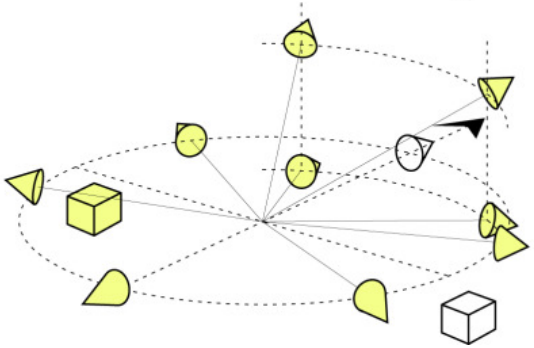
Immersion
Interactivity






Task A
Task B
Task C


TGE
EMG pads
wire

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