Winter 2013

CSE 190: 3D User Interaction

Lecture #3: Input Devices

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Announcements

- TA: Sidarth Vijay, available immediately
- Office/lab hours: tbd, check web site
- Homework project 1 due Friday

Calit2 Free Monthly Tour

- No date for next tour posted yet
- Check at:
  - http://www.calit2.net/events/popup.php?id=2026

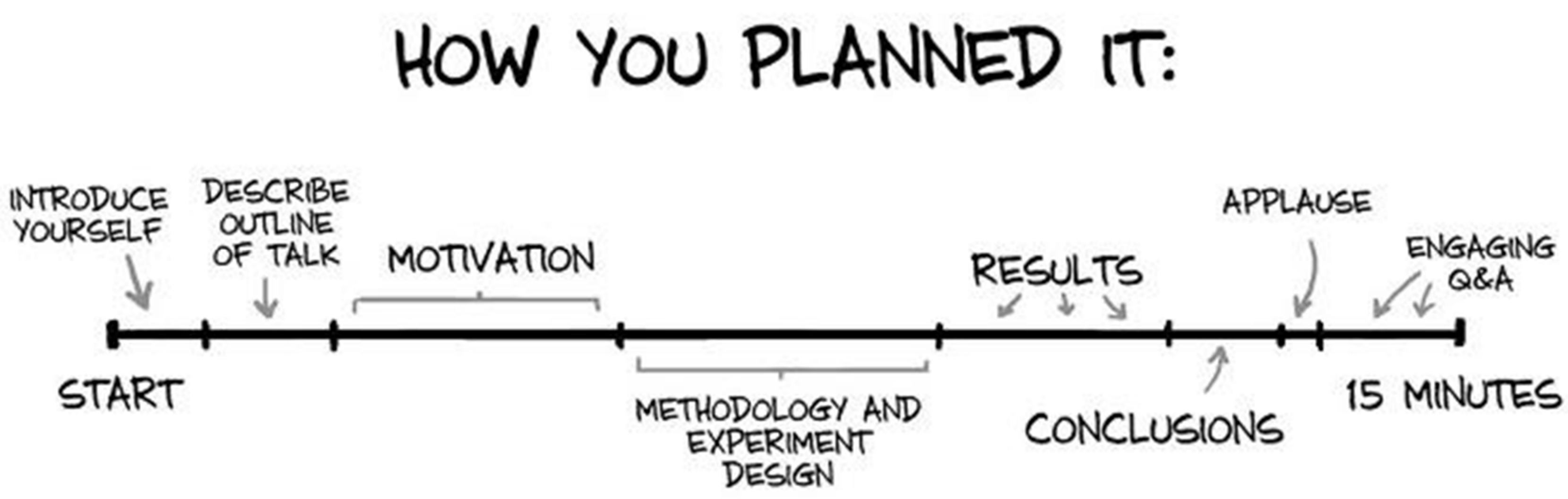
REU Paid Research Opportunity

- REU Opening for undergraduate students
- Topic: ArchaeoSTOR map: publishing archaeological geodata on the web
- Paper: COM.Geo '12 Proceedings of the 3rd International Conference on Computing for Geospatial Research and Applications
  - http://dl.acm.org/citation.cfm?id=2345355
- Contact: Aaron Gidding, agidding@ucsd.edu

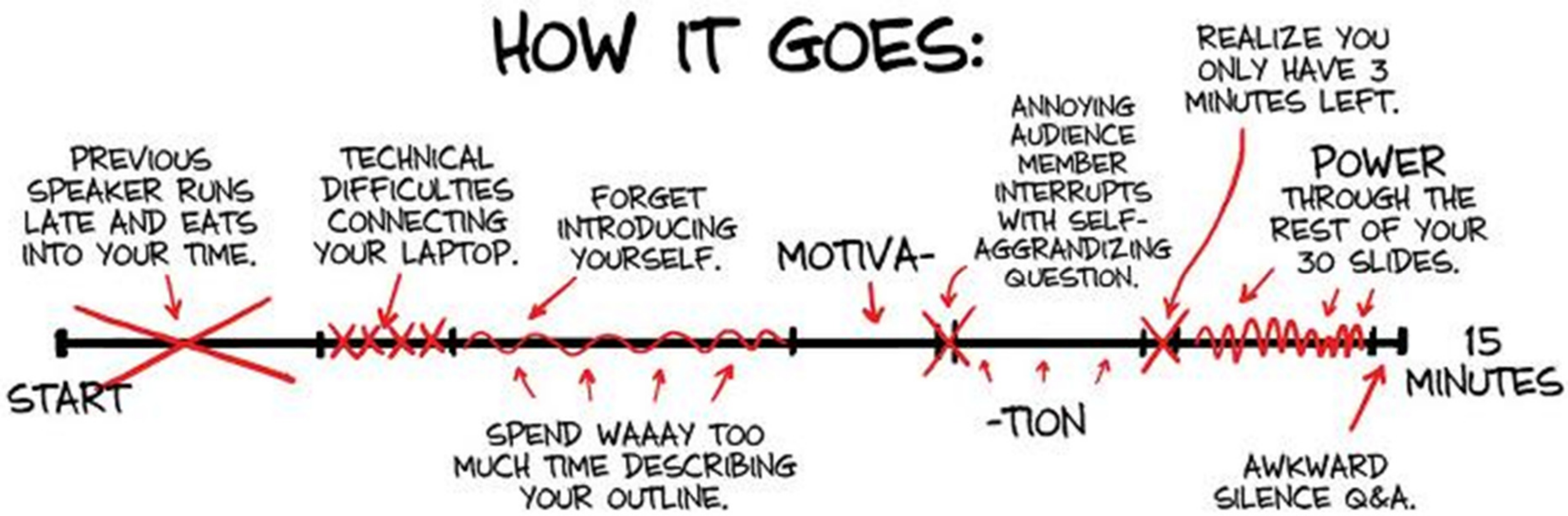
Paper Presentation

- Paper Stats
  - Title
  - Authors
  - Institute
  - Conference/Journal
  - Year
- Outline
- Related Work
- Methodology
- Results
- Conclusions
- Q&A

Paper Presentation



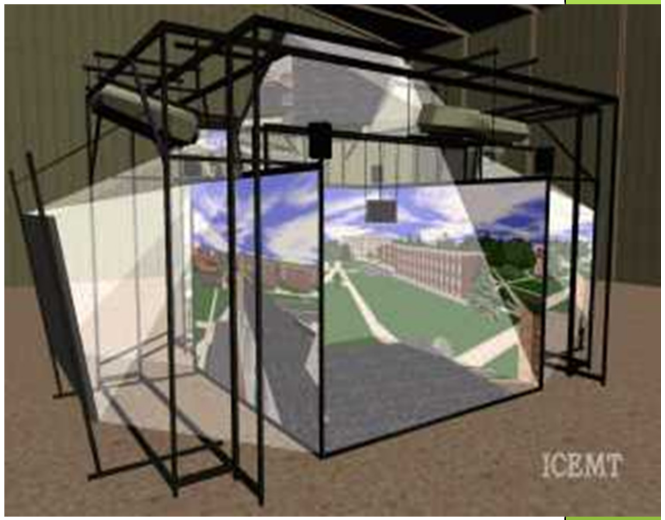
Paper Presentation

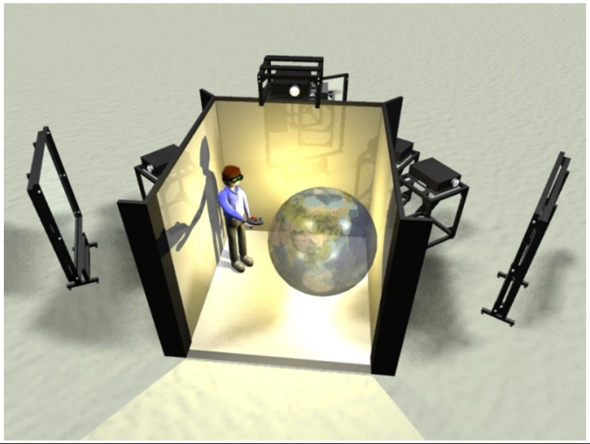


Displays

Surround Screen VE

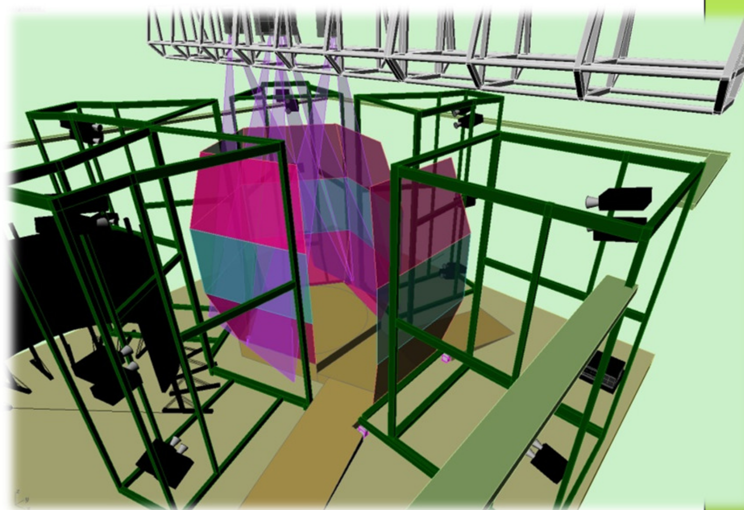
- Has 3 to 6 large screens
- Puts user in a room for visual immersion
- Usually driven by a single or group of powerful graphics engines

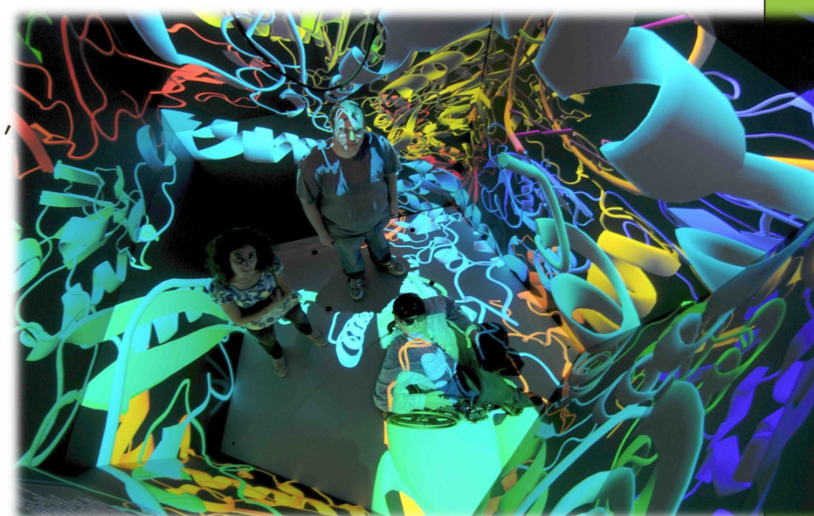




The StarCAVE

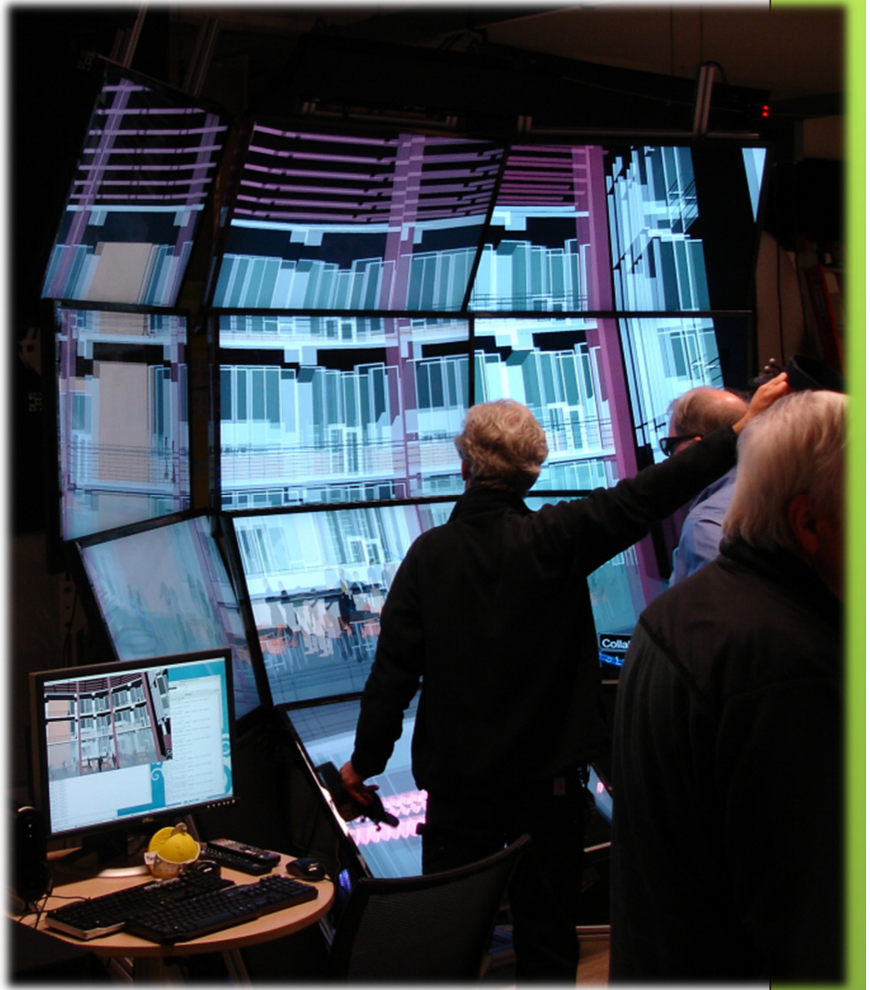
- 18 Dell XPS 710 PCs
- Dual Nvidia GeForce 285 graphics cards
- CentOS Linux
- 34 JVC HD2k projectors (1920x1080 pixels):
  ~34 megapixels per eye
- 360 degrees immersion
- Passive stereo, circular polarization
- 15 screens on 5 walls, ~8 x 4 foot each, plus floor projection
- 4-camera optical tracking system

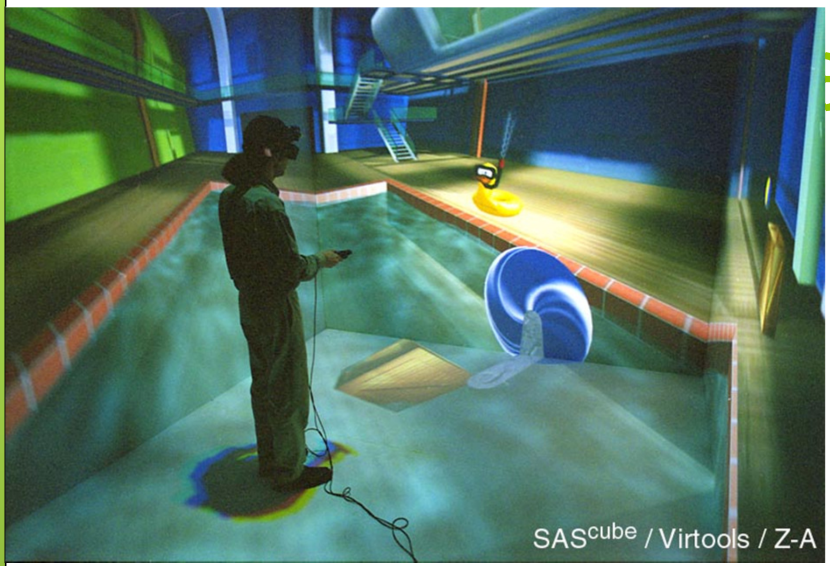


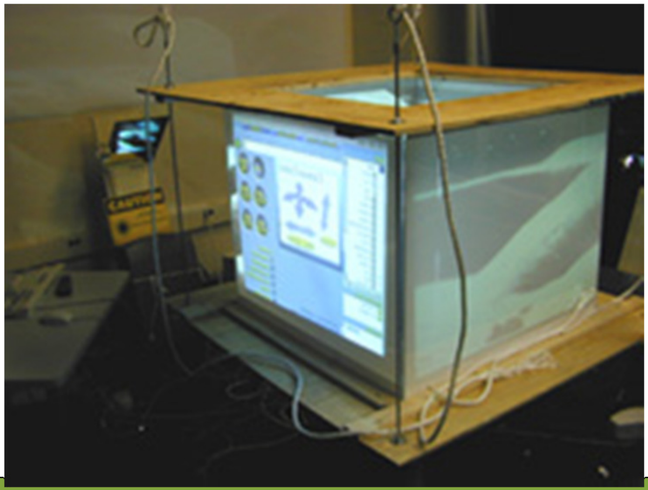


NexCAVE

- 14 42" JVC Xpol displays:
  LCD panels with polarizing filters, 1920x1080 pixels
- 8 rendering PCs
- Nvidia GeForce 480 GPUs
- 2-camera ART TrackPack optical tracking system




SAScube / Virtools / Z-A



SSVE – Advantages

- Provides high resolution and large FOV
- User only needs a pair of light weight glasses for stereo viewing
- User has freedom to move about the device
- Real and virtual objects can be mixed in the environment
- A group of people can inhabit the space simultaneously

SSVE – Disadvantages

- Very expensive (often ~$1 Million)
- Requires a large amount of physical space
- Projector calibration must be maintained
- Normally only one user head tracked
- Stereo viewing can be problematic (ghosting, focal plane far away)
- Physical objects can get in the way of graphical objects

SSVE – Interface Design

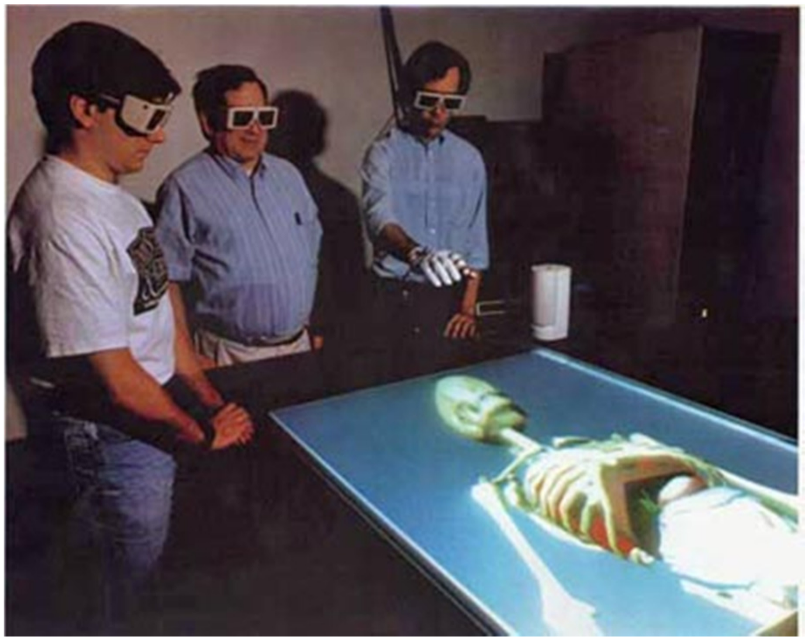
- Do not need to represent physical objects (i.e. hands) as graphical objects
- Can take advantage of the user's peripheral vision
- Do not want the user to get too close to the screens
- Developer can take advantage of the space for using physical props (i.e. car, motion platform)

Workbenches and Variants (1)

- Similar to SSVE but one display (two at most)
- Can be a desk or a large single display (i.e. PowerWall)
- Traditionally a table top metaphor

Workbenches and Variants (2)

Workbenches and Variants (3)



zSpace

- Full HD resolution
- Active stereo screen
- Passive glasses
- Tracked glasses and stylus
- Stylus with infrared markers and gyroscope

Workbenches – Advantages

- High resolution
- For certain applications, makes for an intuitive display
- Can be shared by several users

Workbenches – Disadvantages

- Limited movement
- Typically only one user head-tracked
- No surrounding screens
- Physical objects can get in the way of graphical objects
- Stereo can be problematic

Workbenches – Interface Design

- Ergonomics are important especially when designing interfaces for table displays
- User can take advantage of direct pen-based input if display surface permits
- No need to make graphical representations of physical objects

Head Mounted Displays

- Device has either two CRT or LCD screens plus special optics in front of the users eyes
- User cannot naturally see the real world
- Provides a stereoscopic view that moves relative to the user

HMDs – Advantages

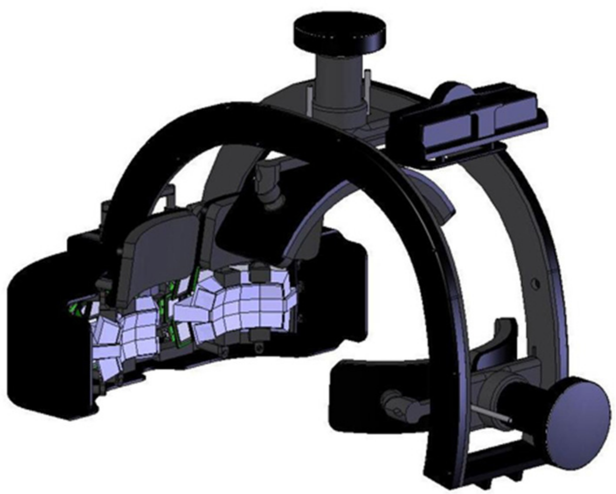
- Provides an immersive experience by blocking out the real world
- Fairly easy to set up
- Does not restrict user from moving around in the real world
- Average quality HMD is relatively inexpensive
- Can achieve good stereo quality

HMDs – Disadvantages

- Average quality HMDs have poor resolution and field of view (FOV)
- Does not take advantage of peripheral vision
- Isolation and fear of real world events
- Good quality devices cost in the $100,000 range
- Heavy and do not fit well

HMDs – Interface Design

- Physical objects require a graphical representation
- Limits the types of input devices that can be used



Oculus Rift

- Recent Kickstarter project
- >90 degrees horizontal field of view
- 110 degrees diagonal field of view
- More than 2x field of view of competition
- 640 x 800 pixels per eye
- 7" display
- 1000 Hz head tracking

Virtual Retinal Displays (VRD)

- Scan images directly onto the retina
- Invented at the HIT Lab in 1991
- Used for both virtual and augmented reality
- Commercially being developed at Microvision, Inc.

VRDs – Advantages

- Lightweight relative to the user
- Ability for high resolution and FOV
- Potential for complete visual immersion
- Can achieve good stereo quality

VRDs – Disadvantages

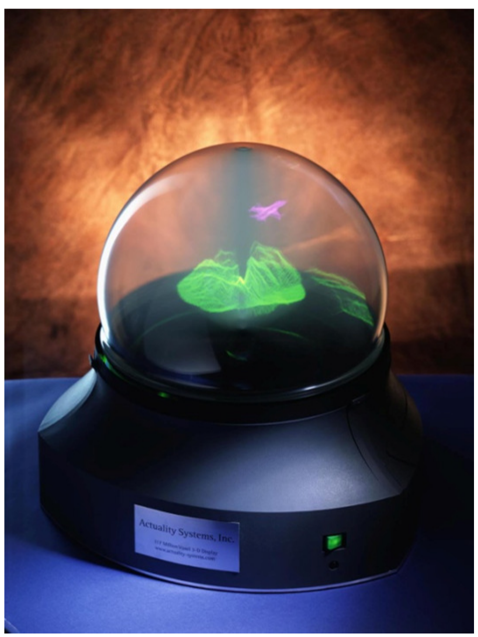
- Currently has low resolution and FOV is small
- Displays are currently monochrome

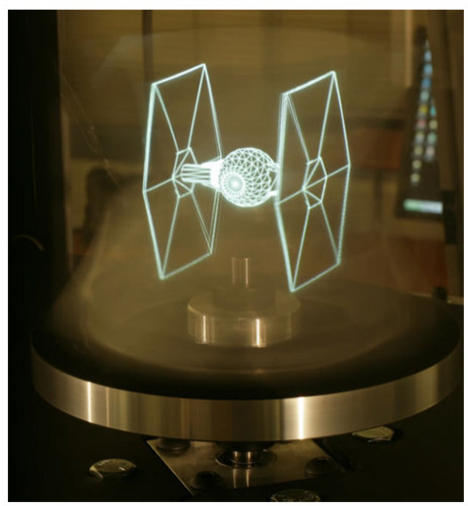
VRDs – Interface Design

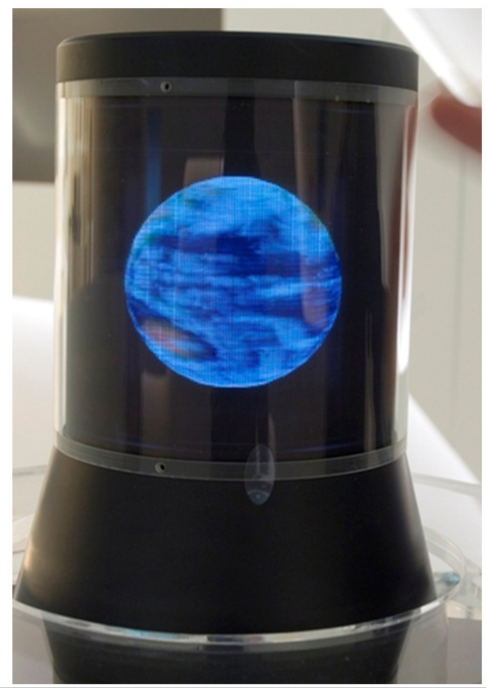
- Avenue of research
- Questions arise about eye movement

Auto-Stereoscopic Displays

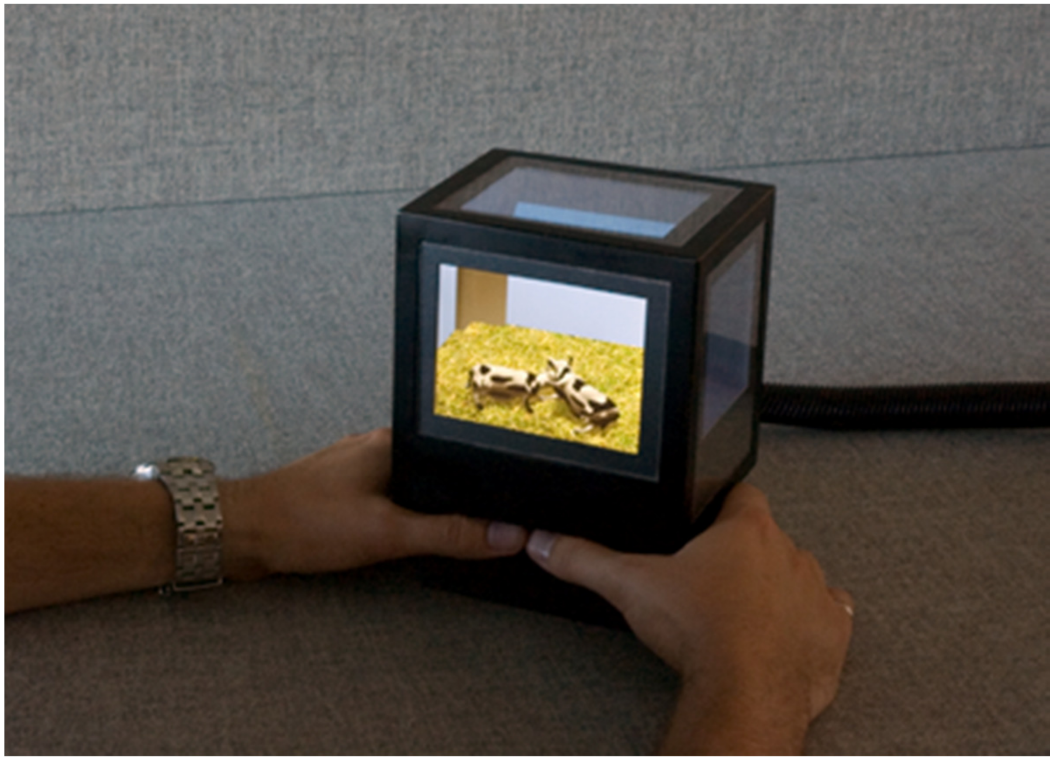
- Lenticular
- Volumetric
- Holographic





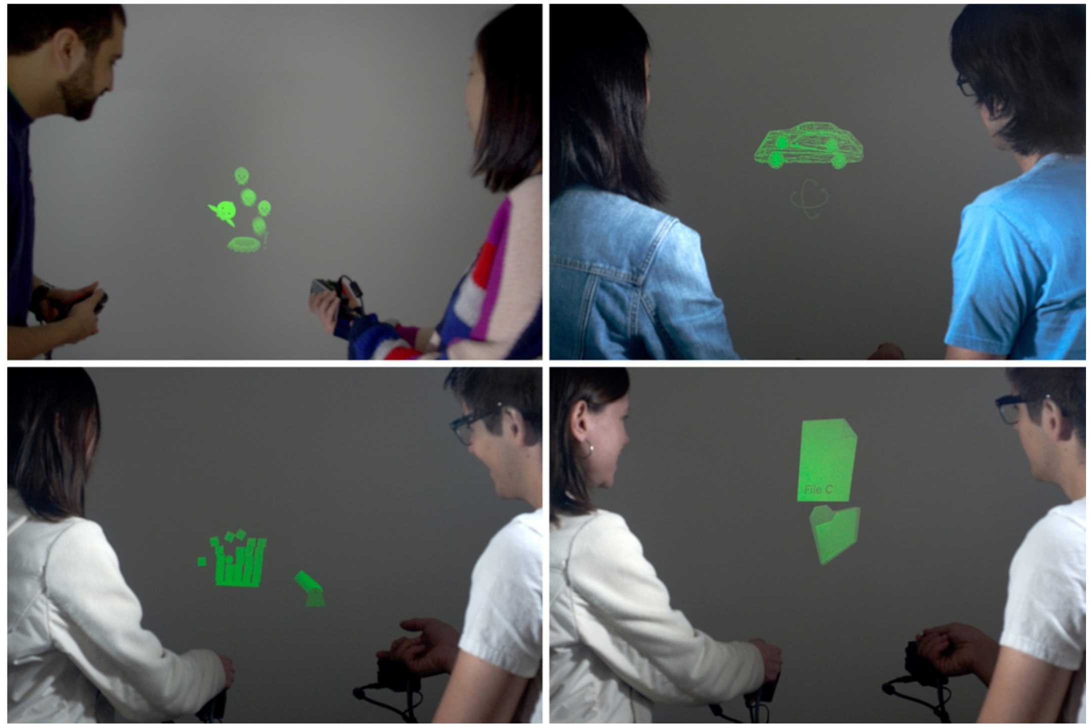


Simulated Autostereo – pCubee



University of British Columbia
http://hct.ece.ubc.ca/research/pcubee/

Other Display Technologies



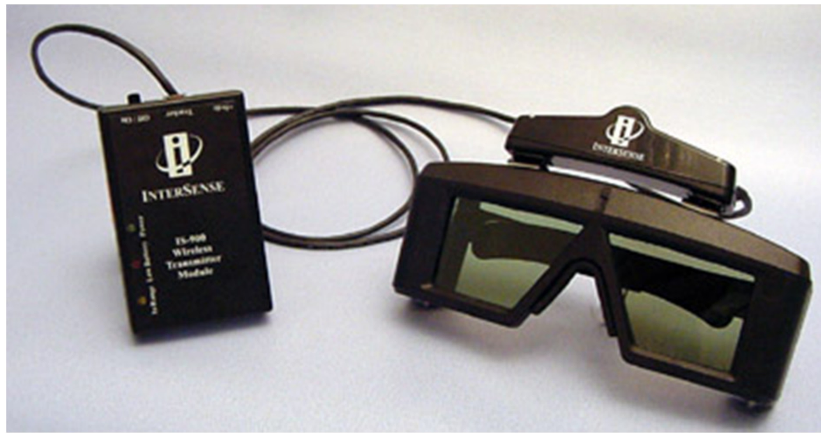
SidebySide/Motion Beam
Disney Research, Pittsburgh

Which Visual Display to Use?

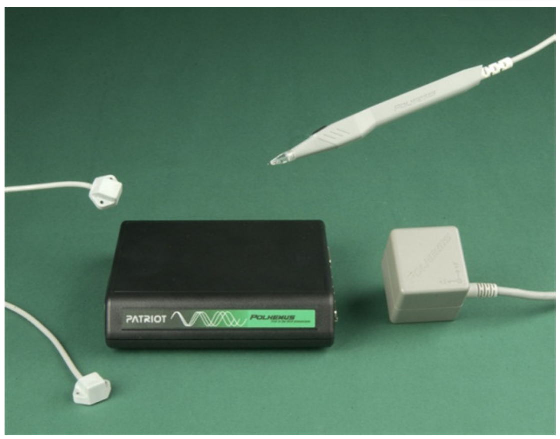
- Consider lists of pros and cons
- Consider depth cues supported
- Consider level of visual immersion
- But this is a very hard question to answer empirically

Input Devices

3D Spatial Input Hardware – The Past



Intersense IS-900



Polhemus Patriot

3rd Tech Hi Ball

These Devices cost thousands of Dollars!

3D Spatial Input Hardware – Today

PlayStation Move

Nintendo Wiimote

Microsoft Kinect

Leap Motion

Razer Hydra

These Devices cost hundreds of Dollars!!

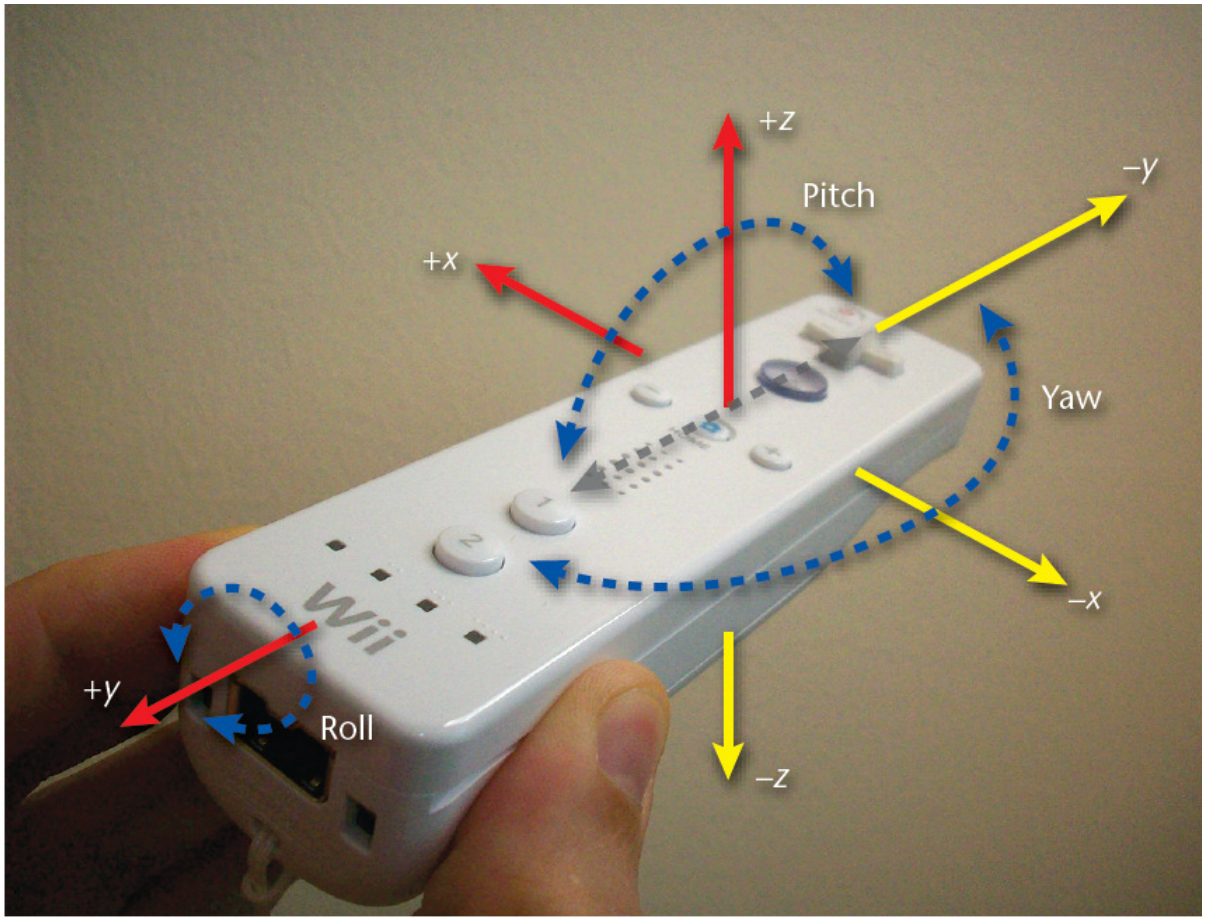
Outline

- Discuss video game motion controller hardware characteristics
  - Nintendo Wiimote
  - Microsoft Kinect
  - PlayStation Move
- Quick start guide for programming
- Case Studies

The Wiimote Device

- Wiimote features
  - uses Bluetooth for communication
  - senses acceleration along 3 axes
  - optical sensor for pointing (uses sensor bar)
  - provides audio and rumble feedback
  - standard buttons and trigger
  - uses 2 AA batteries
- Supports two handed interaction
  - can use 2 Wiimotes simultaneously
- Easily expandable

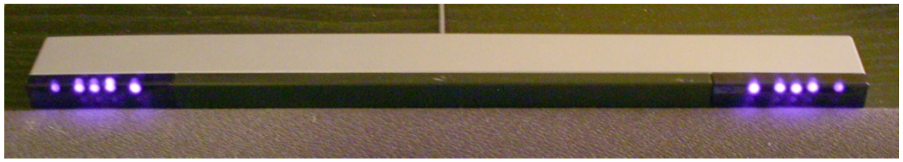
The Wiimote – Coordinates



The Wiimote – Optical Data

- Data from optical sensor
  - uses sensor bar
    - 10 LED lights (5 of each side)
    - accurate up to 5 meters
  - triangulation to determine depth
    - distance between two points on image sensor (variable)
    - distance between LEDs on sensor bar (fixed)
  - roll (with respect to ground) angle can be calculated from angle of two image sensor points
- Advantages
  - provides a pointing tool
  - gives approximate depth
- Disadvantages
  - line of sight, infrared light problems
  - only constrained rotation understanding

Sensor Bar



The Wiimote – Motion Data

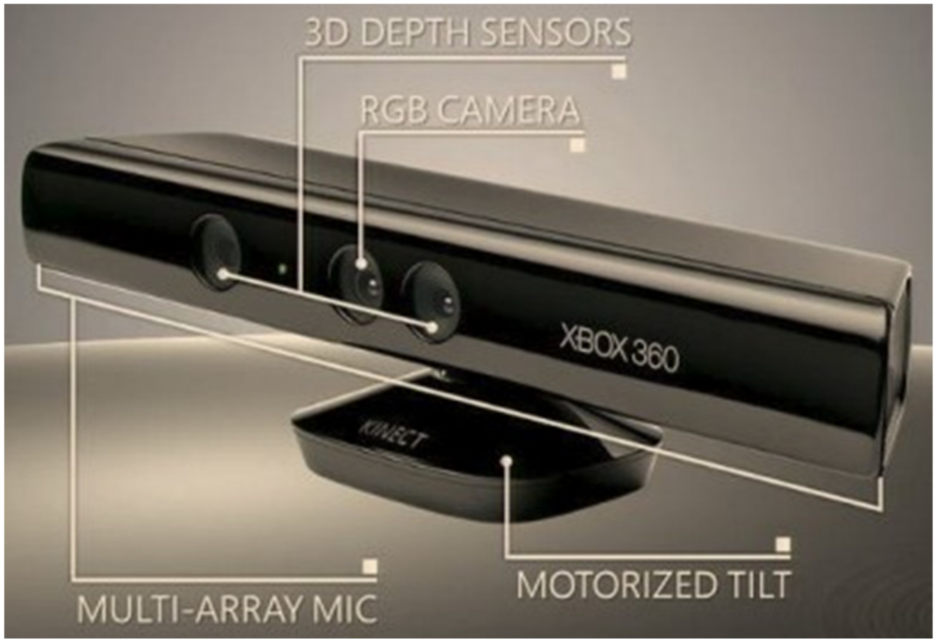
- Data from 3-axis accelerometer
  - senses instantaneous acceleration on device (i.e., force) along each axis
  - arbitrary units (+/- 3g)
  - always sensing gravity
    - at rest acceleration is g (upward)
    - freefall acceleration is 0
  - finding position and orientation
    - at rest – roll and pitch can be calculated ea
    - in motion – math gets more complex
    - error accumulation causes problems
    - often not needed – gestures sufficient
- Advantages
  - easily detect course motions
  - mimic many natural actions
- Disadvantages
  - ambiguity issues
  - player cheating
  - not precise (not a 6 DOF tracker)

The Wii Motion Plus

- Current Wiimote device
  - gives user a lot of useful data
  - not perfect
    - ambiguities
    - poor range
    - constrained input
  - Wii Motion Plus
    - moving toward better device
    - finer control
    - uses dual axis angular rate gyroscope
    - true linear motion and orientation

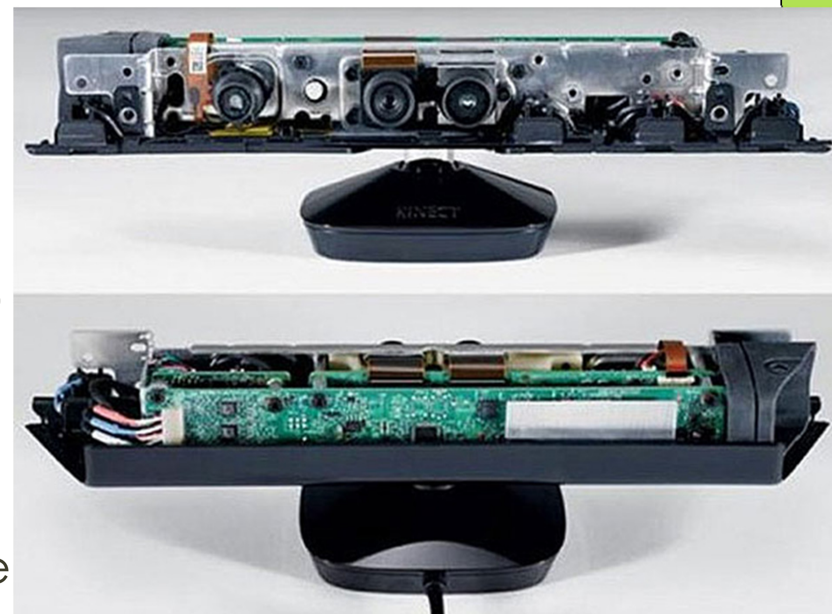
Microsoft Kinect

- Kinect features
  - RGB camera
  - depth sensors
  - multi-array mic
  - motorized tilt
  - connects via USB
- Supports controller-less interface
- Full body tracking



Kinect – Hardware Details

- RGB Camera
  - 640 x 480 resolution at 30Hz
- Depth Sensor
  - complimentary metal-oxide semiconductor (CMOS) sensor (30 Hz)
  - infrared laser projector
  - 850mm to 4000mm distance range
  - Windows version has shorter range
- Multi-array mic
  - set of four microphones
  - multi-channel echo cancellation
  - sound position tracing
- Motorized tilt
  - 27° up or down



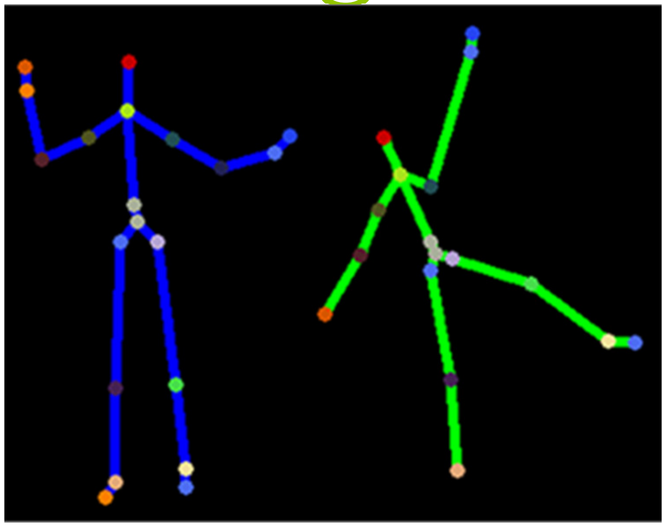
www.hardwaresphere.com

Kinect – Extracting 3D Depth

- Infrared laser projector emits known dot pattern
- CMOS sensor reads depth of all pixels
  - 2D array of active pixel sensors
    - photo detector
    - active amplifier
- Finds location of dots
- Computes depth information using stereo triangulation
  - normally needs two cameras
  - laser projector acts as second camera
- Depth image generation

Kinect – Skeleton Tracking

- Combines depth information with human body kinematics
  - 20 joint positions
- Object recognition approach
  - per pixel classification
  - decision forests (GPU)
  - millions of training samples



PlayStation Move

- Consists of
  - Playstation Eye
  - 1 to 4 Motion controllers
- Features
  - combines camera tracking with motion sensing
  - 6 DOF tracking (position and orientation)
  - several buttons on front of device
  - analog T button on back of device
  - vibration feedback
  - wireless

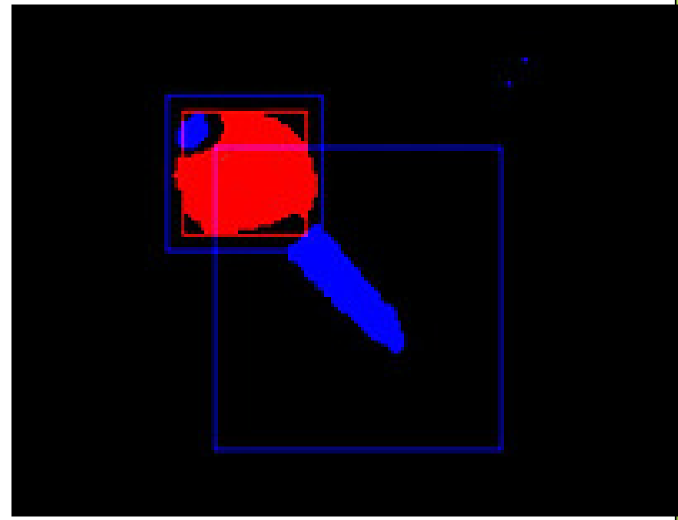
PlayStation Move – Hardware

- PlayStation Eye
  - 640 x 480 (60Hz)
  - 320 x 240 (120Hz)
  - microphone array
- Move Controller
  - 3 axis accelerometer
  - 3 axis angular rate gyro
  - magnetometer (helps to calibrate and correct for drift)
  - 44mm diameter sphere with RGB LED
    - used for position recovery
    - invariant to rotation
    - own light source
    - color ensures visual uniqueness

www.hardwaresphere.com

PlayStation Move – 6 DOF Tracking

- Image Analysis
  - find sphere in image
    - segmentation
      - label every pixel being tracked
      - saturated colors more robust
    - pose recovery
      - convert 2D image to 3D pose
      - robust for certain shapes (e.g., sphere)
  - fit model to sphere projection
    - size and location used as starting point
    - 2D perspective projection of sphere is ellipse
    - given focal length and size of sphere, 3D position possible directly from 2D ellipse parameters



PlayStation Move – 6 DOF Tracking

- Sensor Fusion
  - combines results from image analysis with inertial sensors (Unscented Kalman Filter)
  - contributions
    - camera – absolute 3D position
    - accelerometer
      - pitch and roll angles (when controller is stationary)
      - controller acceleration (when orientation is known)
      - reduce noise in 3D position and determine linear velocity
    - gyroscope
      - angular velocity to 3D rotation
      - angular acceleration

Kinect Programming

- Two main approaches
  - NITE and Open NI
  - Microsoft Kinect SDK

OpenNI™

Kinect – Microsoft SDK

- Uses subset of technology from Xbox 360 developer version
- Access to microphone array
- Sound source localization (beam forming)
  - connection with Microsoft Speech SDK
- Kinect depth data
- Raw audio and video data
- Access to tilt motor
- Skeleton tracking for up to two people
- Examples and documentation

Kinect SDK – Joints

- Two users can be tracked at once
- <x,y,z> joints in meters
- Each joint has a state
  - tracked, not tracked, inferred
- Inferred – occluded, clipped, or no confidence
- Not tracked – rare but needed for robustness

Conclusions – Which to Choose?

- Wiimote
- Positives
  - cost ~ $40
  - buttons
  - something to hold in hand
- Negatives
  - not true 6 DOF
  - challenging to program
  - reasonable accuracy
  - no company support

Conclusions – Which to Choose?

- Microsoft Kinect
- Positives
  - cost ~ $130
  - full body tracking
    - joint position
    - joint orientation (not yet)
  - multimodal input
  - good SDK and support
- Negatives
  - no buttons (temporal segmentation problem)
  - more data to process
  - not really designed with physical props in mind
  - latency issues (gesture recognition)

Conclusions – Which to Choose?

- PlayStation Move
- Positives
  - accurate and fast 6 DOF tracking
  - buttons
  - multimodal input
  - good SDK and support
- Negatives
  - cost ~ $400 to $500
  - requires PS3 (positive as well)
  - does not track full body (more restrictive)