

Winter 2013

CSE 190: 3D User Interaction

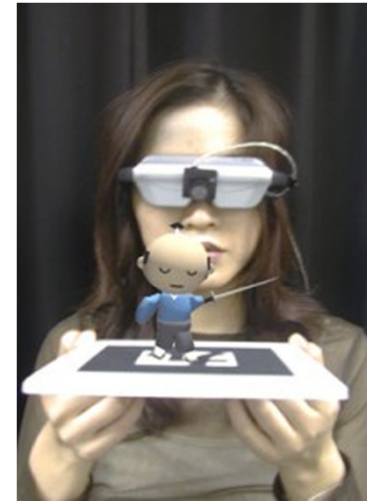
Lecture #6:
Input Devices Part 2
Jürgen P. Schulze, Ph.D.

Announcements

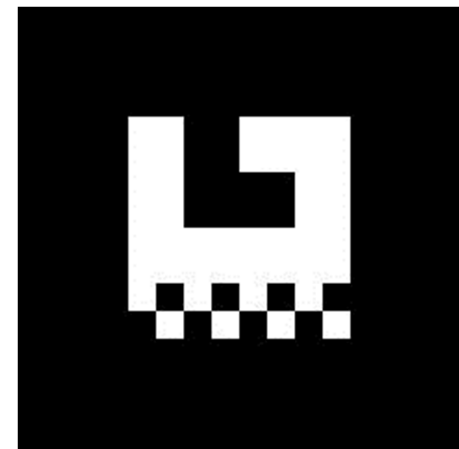
- Homework assignment #2 due Friday, February 8th at 1pm
- New, more detailed paper presentations section on course web site
- Schedule paper presentations

Optical Tracking: ARToolKit

- Developed in 1999 by Hirokazu Kato, HITLab, University of Washington
- Printable markers
- Camera based (webcam sufficient)
- Flexible marker design
- Simple programming interface
- 6 DOF tracking possible



ARToolKit



ARToolKit marker

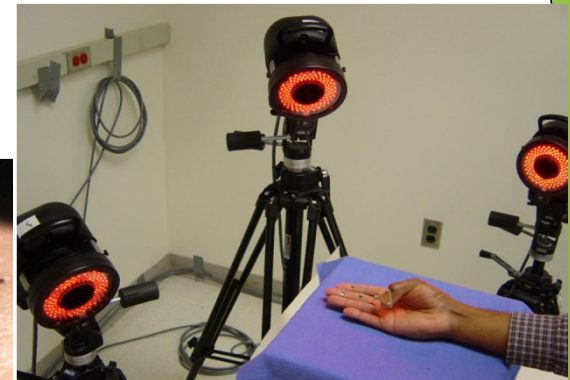
Video

- Augmented Reality by Hitlab
 - <http://www.frequency.com/video/augmented-reality-by-hitlab/2556268>



Optical Tracking: Mocap Devices

- Infrared (IR) cameras illuminate scene for easier detection of markers
- Multiple markers (highly reflective spheres) arranged in fixed, known configurations allow for 6 DOF tracking



ART Tracking System

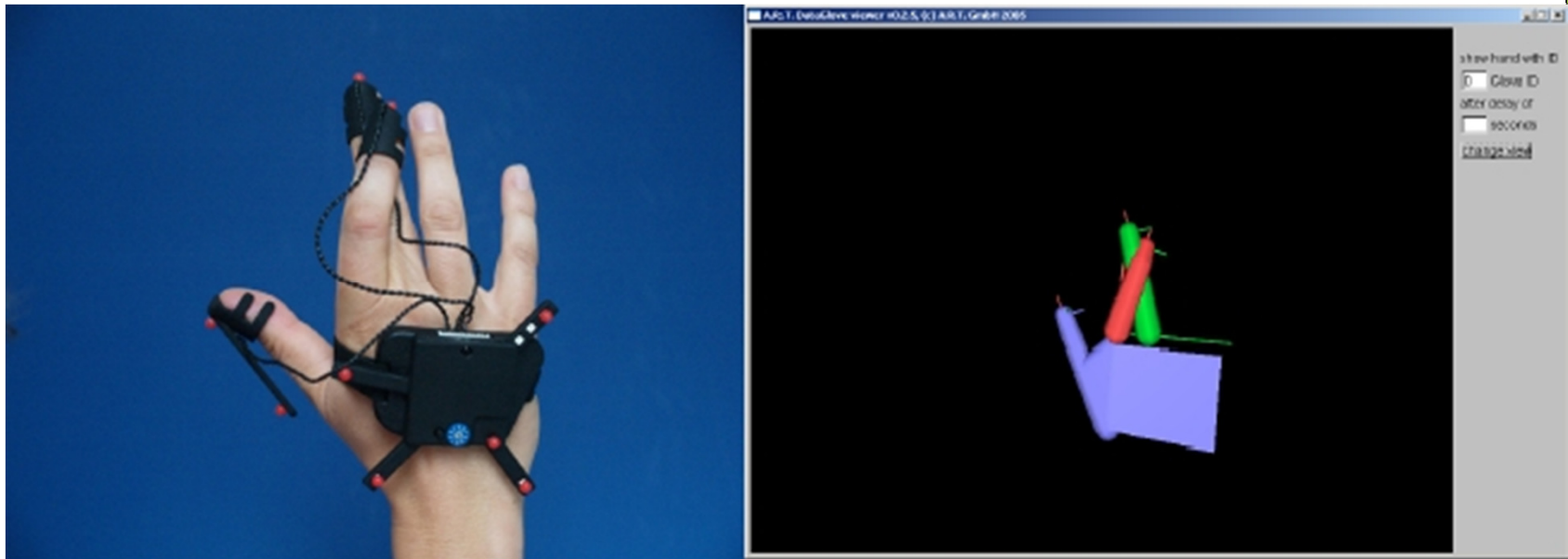


Mosquito *Aedes Aegypti*,
carries the dengue virus

Vicon Tracking System

Optical Finger Tracking

- Extension of ART system
- Tracks three fingers and the hand



Optical Tracking: HiBall

- HiBall-3100 tracker system by 3rd Tech, based on Wide-Area Tracking research project of Department of Computer Science of UNC Chapel Hill
- System is composed of:
 - HiBall Optical Sensor
 - HiBall Ceiling Beacon Arrays
- HiBall Optical Sensor is composed of 6 lenses and photodiodes arranged so that each photodiode can 'view' infrared LEDs in the Beacon Arrays mounted on the ceiling, through several of the 6 lenses.
- Tracker update rate: 2,000 Hz
- No metal or sound interference



HiBall beacon array

Ultrasonic Tracking

- Systems measure duration of an ultrasound signal to reach microphones.
- Intersense system uses combination of ultrasound and gyroscope.



Intersense



Logitech

Hybrid Devices: Haptic Feedback Devices

- PHANTOM haptic device
- Force feedback joystick
- Exoskeleton-like devices



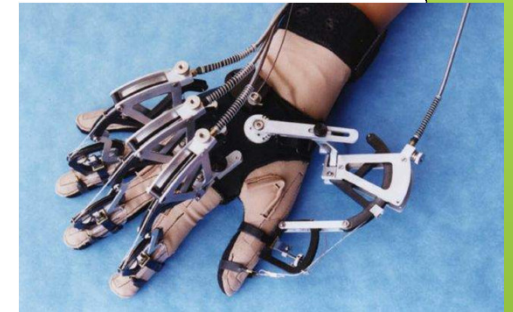
Microsoft force feedback joystick



LEXOS: Frisoli et. al., Italy



Immersion CyberForce



SensAble PHANTOM

Tracking Devices: Bend-Sensing Gloves

- CyberGlove, 5DT
- Reports hand posture
- Gesture:
 - single posture
 - series of postures
 - posture(s) + location or motion



Pinch Glove

- Pinch Gloves
 - Determine if two or more fingertips are touching
 - Use conductive cloth to close circuit
 - Tethered to controller box
 - Designed for pinching and grabbing gestures
- Recognize any gesture of 2 to 10 fingers, plus combinations of gestures
- Price at the time \$2000
- Had problems with reliability

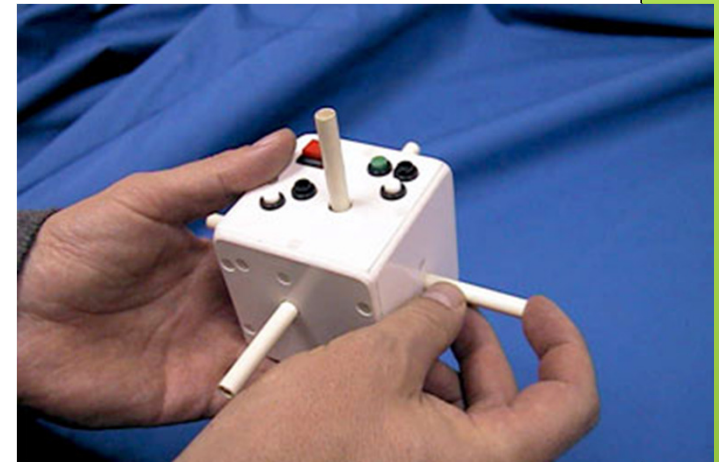


www.fakespacelabs.com



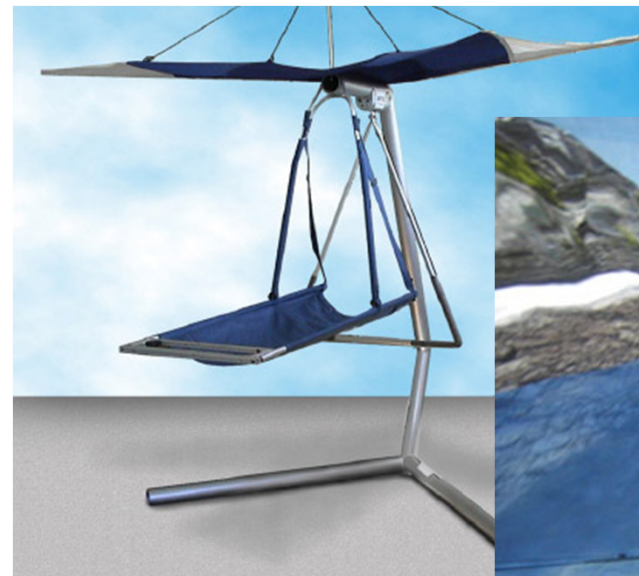
Special Purpose Device: Cubic Mouse

- Developed 1999 at Fraunhofer IMK by B. Frohlich and J. Plate
- Cube shaped box with three rods represents a physical coordinate system prop
- 6DOF tracker is inside cube
- Rods used to manipulate x-, y-, and z- coordinates of an object (for example a cutting plane)
- Major application area: volume rendering for oil and gas industry



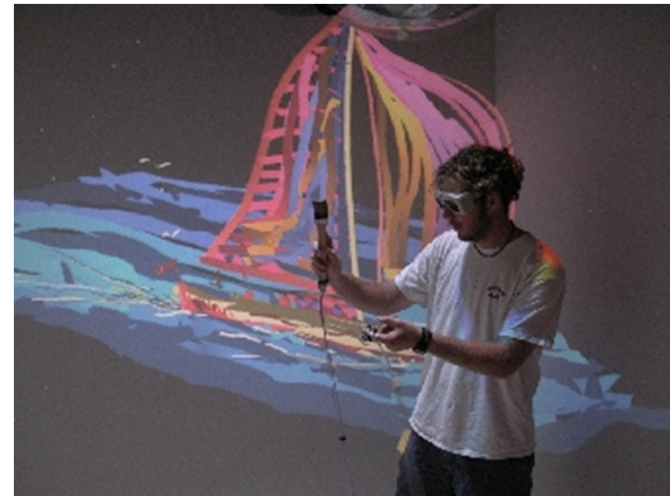
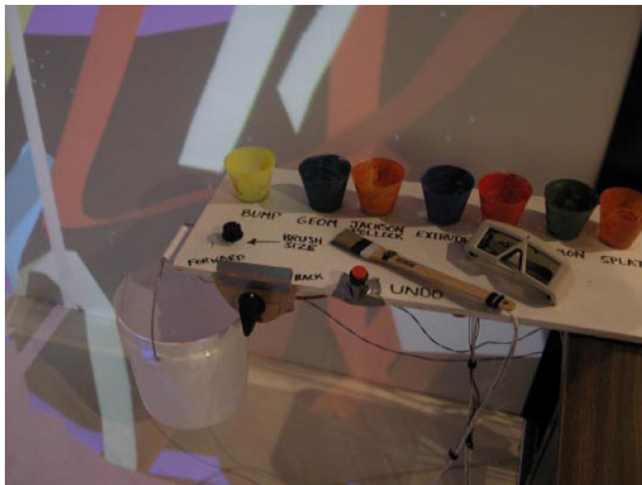
Application-Specific Devices

- Virtual Hang-gliding over Rio de Janeiro, L. Soares et. al.
- Virtual canoe, Siggraph 2005: Real-time water simulator with pre-computed database of 3D fluid dynamics. Creates realistic wakes and force feedback of water resistance.



Cave Painting

- Physical props (brush, color palette, bucket) allow intuitive painting
- By Daniel Keefe, Brown University (now Univ. of Minnesota), ACM Symposium on Interactive 3D Graphics, 2001



3D Input Devices Today



PlayStation Move



Nintendo Wiimote



Microsoft Kinect



Leap Motion



Razer Hydra

Gaming devices at consumer prices!

Video game motion controllers

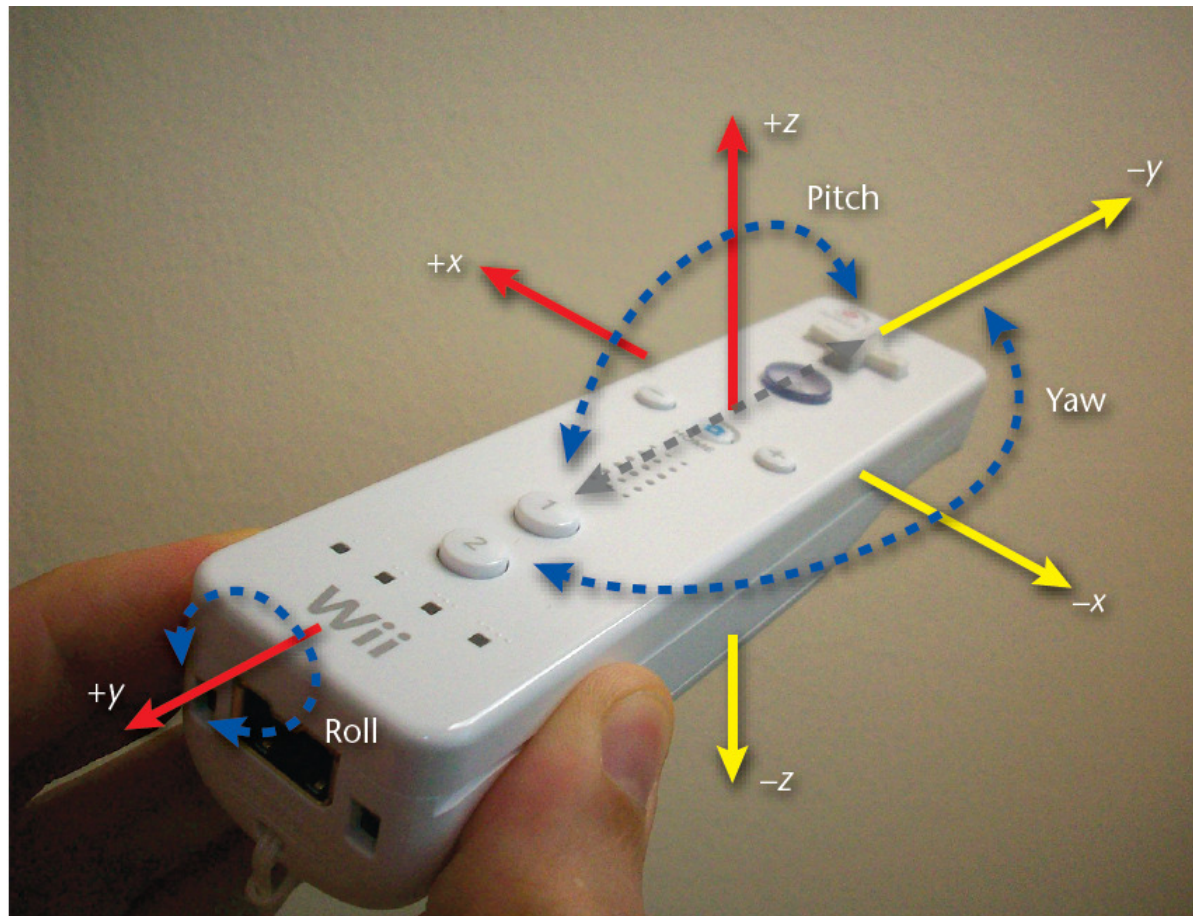
- Nintendo Wiimote
- Microsoft Kinect
- PlayStation Move

The Wiimote Device

- Wiimote features
 - Uses Bluetooth for communication
 - Senses acceleration along 3 axes
 - Optical sensor for pointing, with sensor bar
 - Provides audio and rumble feedback
 - Standard buttons and trigger
 - Runs on 2 AA batteries
- Supports two-handed interaction
 - 2 Wiimotes can be active simultaneously



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 easily
 - 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)



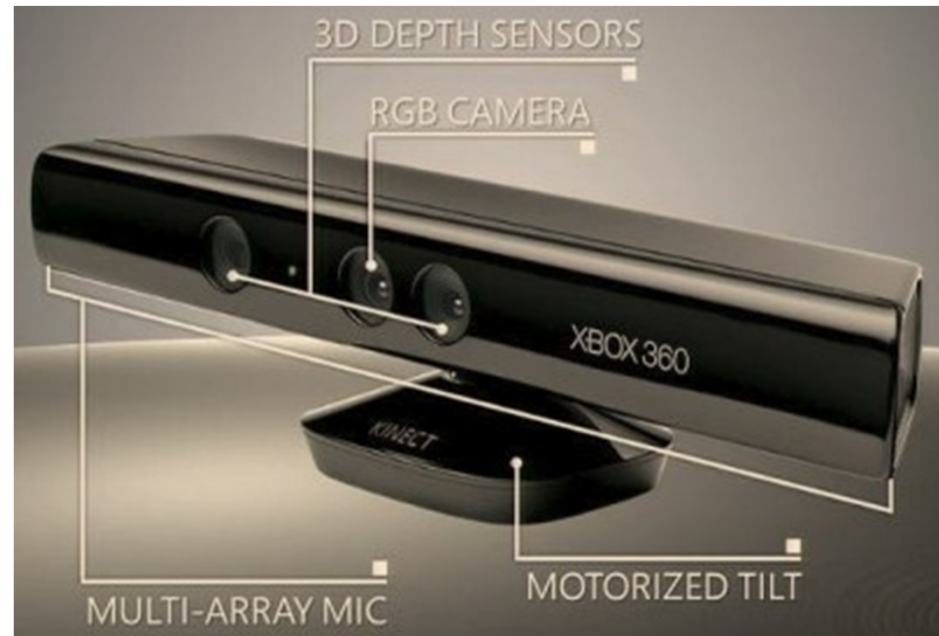
The Wii Motion Plus

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



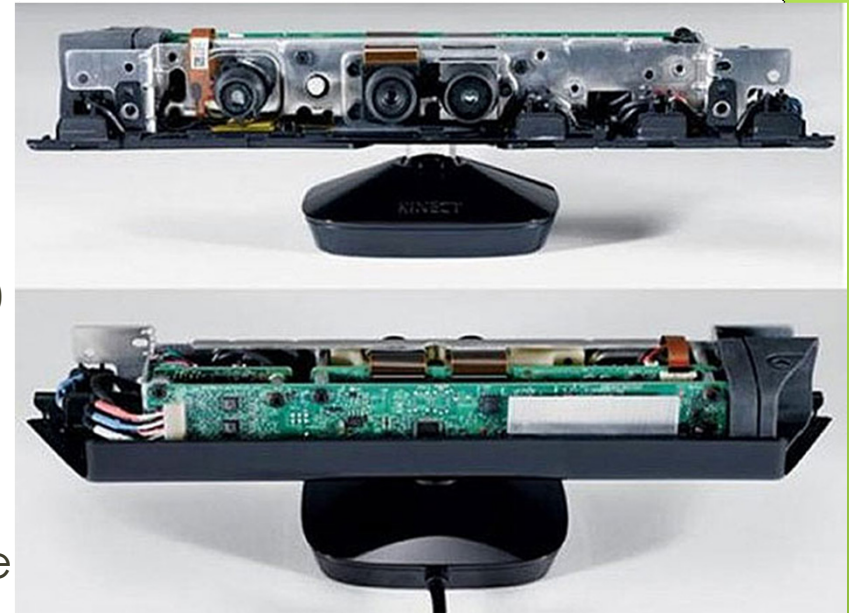
Microsoft Kinect

- Kinect features
 - RGB camera
 - depth sensors
 - multi-array mic
 - motorized tilt
 - connects via USB
- Supports controller-less interface
- Full body tracking
- 2 versions: for Xbox (\$100) and PC (\$250)



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.hardware sphere.com

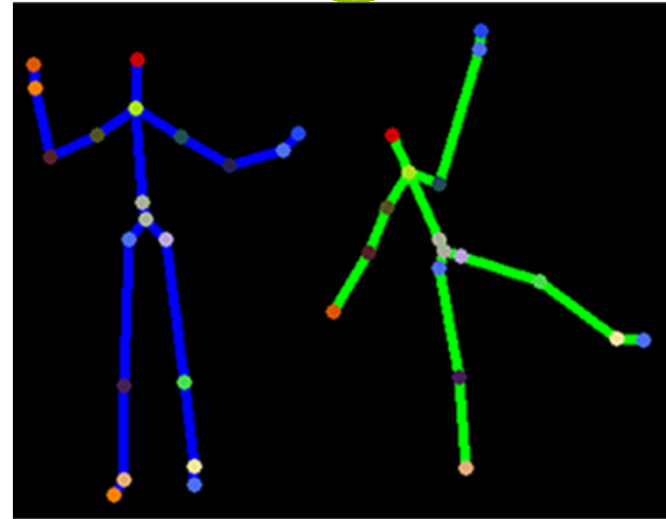
Kinect – Extracting 3D Depth

- 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



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

PlayStation Move

- Consists of
 - Playstation Eye
 - 1 to 4 Motion controllers
 - Eye + 1 controller = ca. \$80
- 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

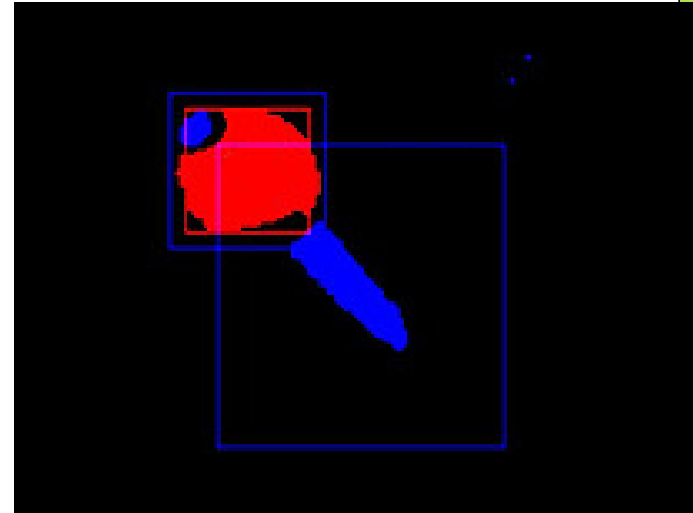
- PlayStation Eye
 - 640 x 480 (60Hz)
 - 320 x 240 (120Hz)
 - microphone array
- Move Controller
 - 3 axis accelerometer
 - 3 axis angular rate gyro
 - magnetometer (helps to calibrate and correct for drift)
 - 44mm diameter sphere with RGB LED
 - used for position recovery
 - invariant to rotation
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



www.hardware sphere.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

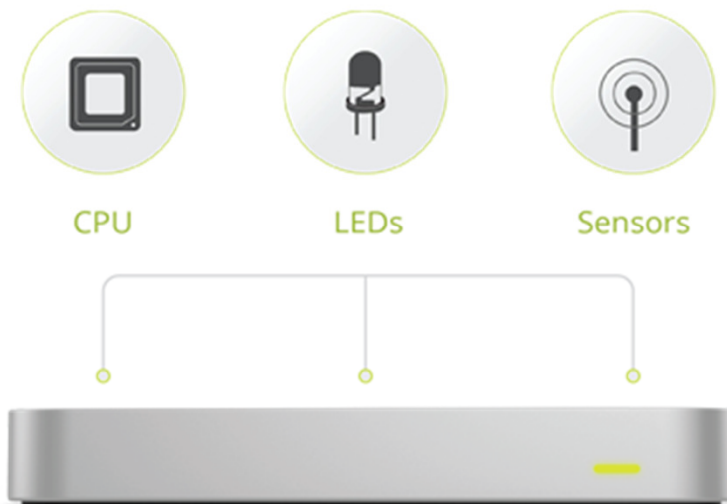


PlayStation Move – 6 DOF Tracking

- 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

Leap Motion

- Short range finger tracking
 - To date no access to depth map
- Inexpensive (\$70 on pre-order)
- Not yet available (promised for early 2014)
- SDK available today
- Developer units being shipped
- More and more demo videos available



Video

- Leap Motion promotional video
 - <https://www.leapmotion.com/>