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IMGD 5100:
Immersive HCI

Classifying 3D Input Devices

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Motivation

- The mouse and keyboard are good for general desktop UI tasks
  - Text entry, selection, drag and drop, scrolling, rubber banding, …
  - Fixed computing environment
  - 2D mouse for 2D windows
- How can we design effective techniques for 3D?
  - Use a 2D device?
  - Use multiple *n*-D devices?
  - Use new devices?
  - Use 2D interface widgets?
  - Need new interaction techniques!

Motivation (cont.)

- Gaming and Virtual Reality
  - Tight coupling between *action* and *reaction*
  - Need for precision
- VR can give *real* first-person experiences, not just views
  - Head-mounted Display
    - In order to look behind you, turn your head!
  - Selecting/manipulating an object
    - Reach your hand out and grab it!
  - Travel
    - Just walk (well, not quite)!
- Doing things that have no physical analog is more problematic

Common Input Devices

Mouse

Keyboard

Joystick

TrackBall

TrackPoint

TrackPad

Tablet

MightyMouse

Multi-Touch
TrackPad

Game Controllers

Atari 2600
(1977)

Intellivision
(1980)

PlayStation2
(2000)

Xbox 360
(2005)

PlayStation3
(2008)

"Natural" Motion Controllers

WiiMote
(2007)

Microsoft
Kinect (20102)

WiiMotionPlus
(2009)

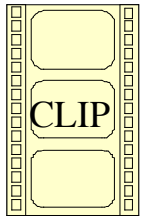
Leap Motion
(2013)

Razor Hydra
(2013)

PlayStation
Move (2010)

Multi-Touch Surfaces

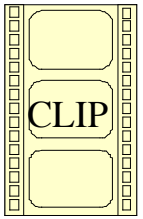
- High resolution
- Co-located interaction



http://www.ted.com/talks/jeff_han_demos_his_breakthrough_touchscreen.html

Prototypes of Controllers

Nintendo "Revolution"
Controller (prototype)



Nintendo Wii + Nunchuck
(released)

Prototypes of Controllers (cont.)

PlayStation3 Controller
(prototype)

PlayStation3 SIXAXIS
(released)

Hand-Held Devices

- Becoming interesting!

Apple iPhone 4
(2010)

Apple iPad
(2010)

Motorola DROID
(2009)

Nintendo DS Lite
(2006)

Sony PlayStation
Portable (2004)

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Classification Schemes

- Relative vs. Absolute movement
- Integrated vs. Separable degrees of freedom
- Digital vs. Analog devices
- Isometric vs. Isotonic devices
- Rate control vs. Position control
- Special-purpose vs. General-purpose devices
- Direct vs. Indirect manipulation

More on Classifications

- Relative vs. Absolute movement
  - Mouse vs.Tablet
- Integrated vs. Separable degrees of freedom
  - Mouse has integrated X, Y control
  - Etch-a-sketch has separate X, Y control
    - Motions that are easy with one are hard with the other
- Analog devices allow more sensitivity
  - For example, analog game controllers

Isometric vs. Isotonic Input Devices (Zhai)

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- No motion vs. No resistance
- Actually a continuum of elasticity
  - TrackPoint (mostly isometric) vs. mouse (mostly isotonic)
  - Many devices are re-centering (*e.g.*, joysticks)

Rate Control vs. Position Control (Zhai)

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- Mouse is normally used for position control
- Mouse scroll-wheel
  - Position control
  - Click-drag for rate controlled scrolling
- Trackballs typically use position control
- Joysticks: Control position (cross-hair), or Control velocity (aircraft)
- Rate control eliminates need for clutching/ ratcheting
- **Isotonic-rate control and isometric-position control tend to produce poor performance** (Zhai)

Special-Purpose vs. General-Purpose Input Devices (Buxton)

- Game controllers are designed to support many types of games
  - Game developer decides on mapping
  - No "standard" mappings -> each game different
- Some special-purpose devices exist
  - Light guns
  - Steering wheels
  - RPG keyboard/joystick
  - Drum kits, dance pads, bongos, *etc.*

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Direct vs. Indirect Manipulation

- Direct
  - Clutch and drag an icon with mouse or stylus
  - Touch screens, PDAs use direct manipulation
  - Works well for things that have a physical analog
- Indirect
  - Use some widget to indirectly change something
- Problems with direct manipulation
  - Some things do not have a physical analog
  - Precision may be lacking
  - Selection/de-selection may be messy

3D Input Devices

SpaceBall

SpaceMouse

CyberGlove II

HMD with
3-DOF tracker

Tracked Paddle for 2D Interaction

PHANTOM Omni
Haptic Device

Motion-Capture/Tracking Systems

- Used heavily in movies and TV
  - Capture actual motion, and re-use
  - Example, Fox Sports NFL guy
- Can be done interactively, or offline
- Can capture three or more (six) Degrees of Freedom (DoF)
  - Position, Orientation, or Both
- Many technical approaches
- No really good, general approaches

Tracking Technologies

- Mechanical
- Magnetic
- Ultrasonic
- Inertial
- Optical
- Time of flight
- Hybrid

Mechanical Tracking

- Rigid linkage, potentiometers at joints
- Pros:
  - High accuracy
  - High resolution
- Cons:
  - Limited range of motion
  - Cumbersome

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Magnetic Tracking

- Transmitter creates a magnetic field
  - Transmitter is the origin
- Receivers are tracked using changes in magnetic field
- Pros:
  - Fairly lightweight
  - Six DoF
- Cons:
  - Very noisy near ferrous metal
  - Limited working range

Ultrasonic Tracking

- Transmitter sends pulses
- Receivers hear tones
- Distance is computed
- Can use "costellations" for orienation
- Pros:
  - High accuracy
  - High resolution
- Cons:
  - Requires line-of-sight (hearing)

Inertial Tracking

- Accelerometers
  - Tilt
  - Acceleration
- Gyroscopes
  - Measure movement
- Pros:
  - Not anchored to a place in space
- Cons:
  - Accumulated error can cause drift
  - Only moderate accuracy

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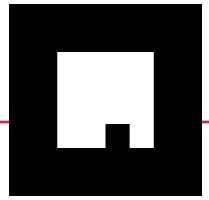
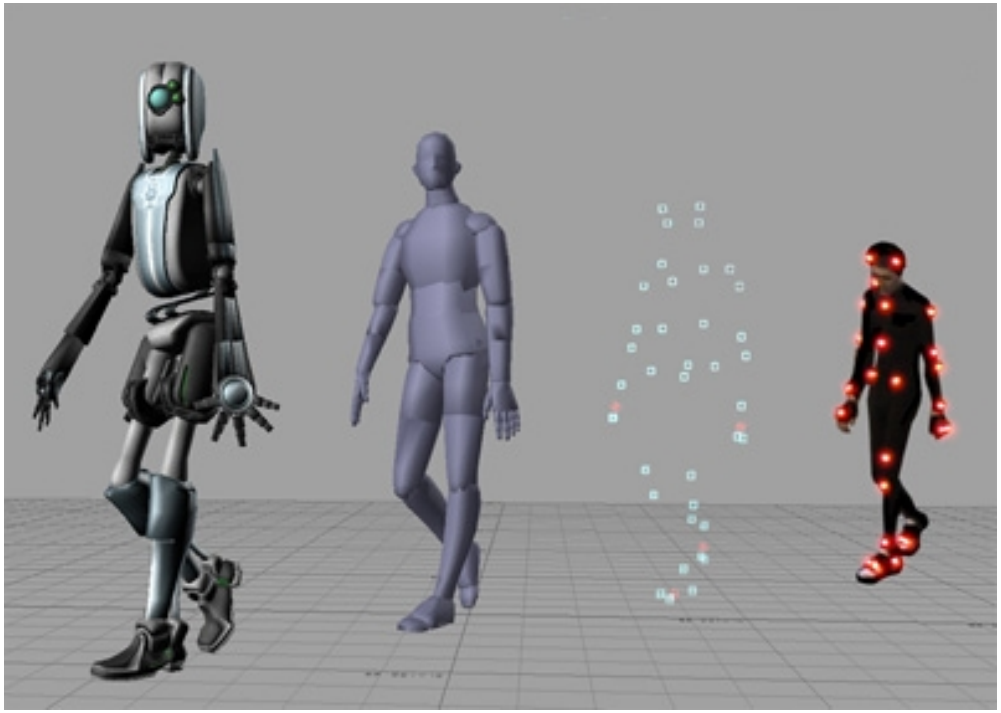
Optical Tracking

- Multiple fixed cameras capture markers
- Known camera parameters (FOV, focal length, position, orientation)
- Use equations to compute position in 3-D space
- Markers can be simple points, or glyphs
- ARToolKit
  - http://sourceforge.net/projects/artoolkit/



Optical Tracking (cont.)

- Active vs. Passive Markers



Kinect

- Structured light + sensor

Kinect Star Wars

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Kinect Fusion

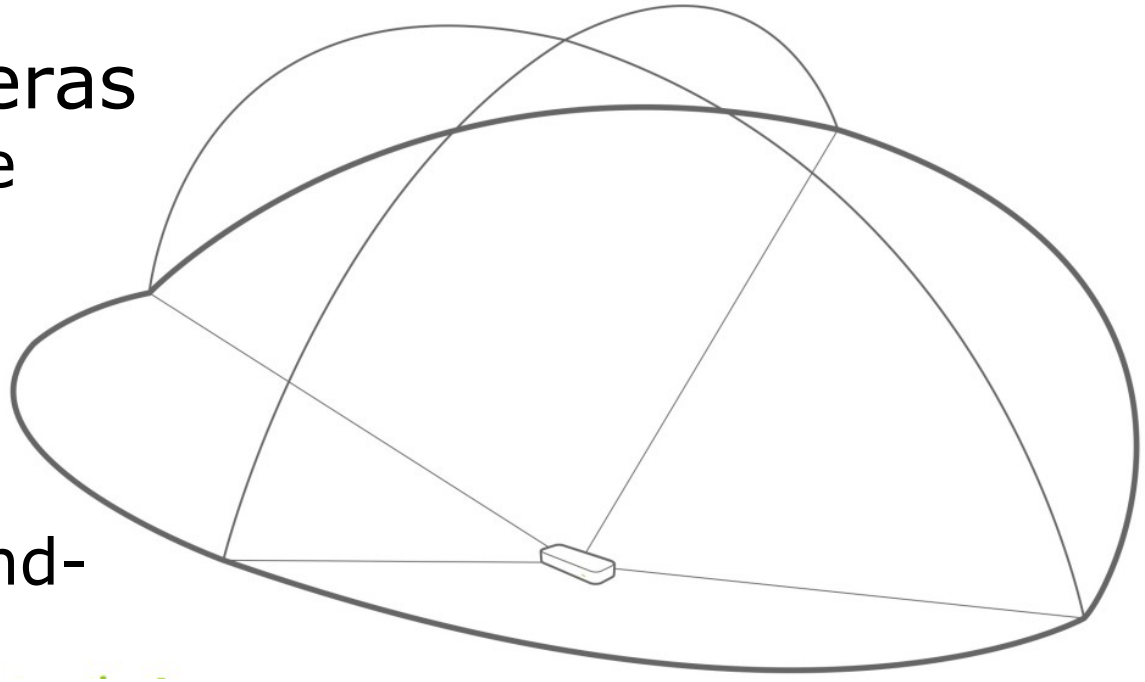
Kinect IllumiRoom

PlayStation MOVE

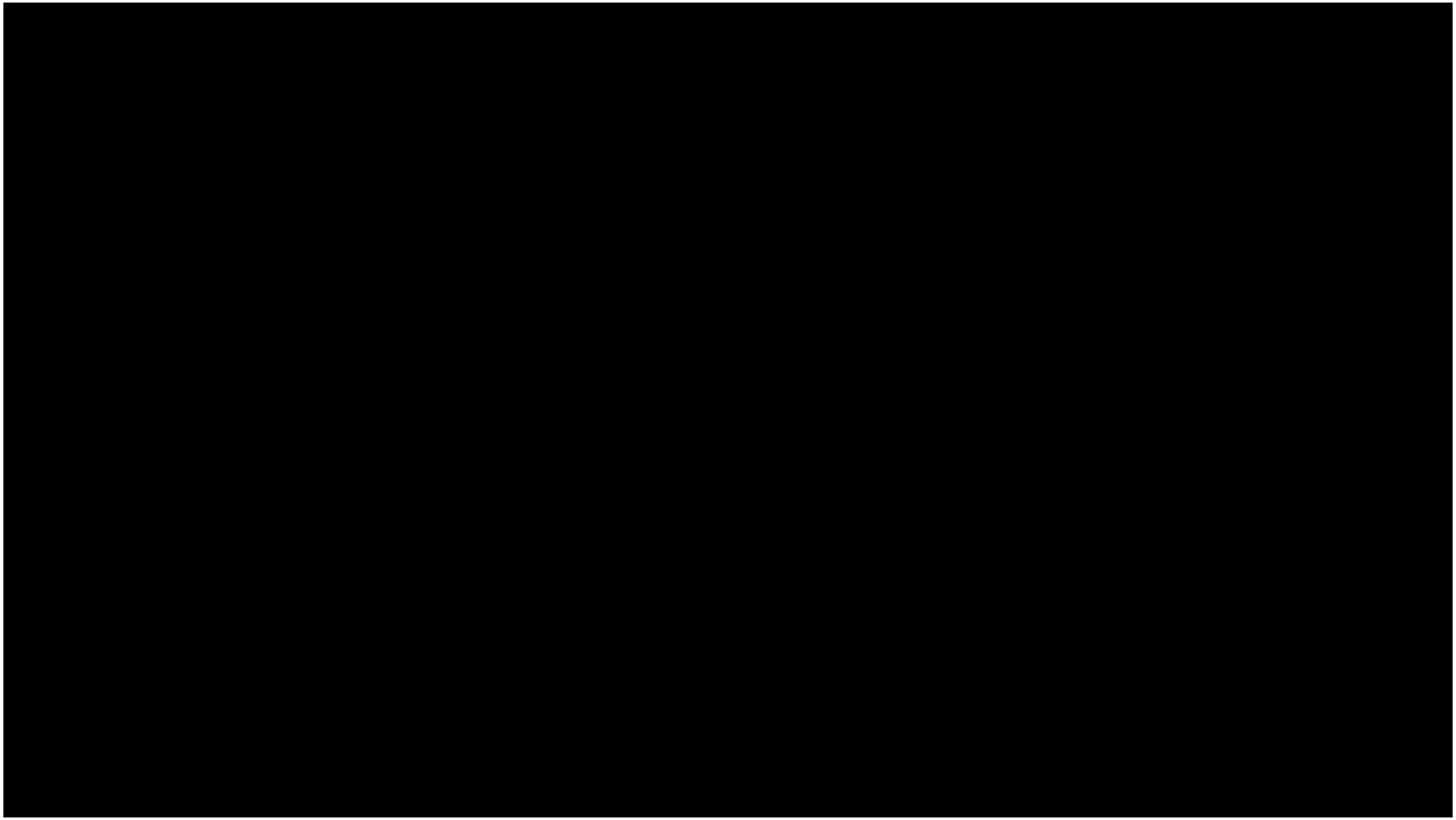
- Camera tracker + inertial tracker

Leap Motion

- Three IR LEDs
  - Illuminate hands, etc.
- Two stereo cameras
  - Sends grey-scale images to Leap Motion Service
  - Not depth map!
  - Software tracks fingers using hand-information
  - Temporal coherence



Leap Motion



Leap Motion UX Design, Part 1

Leap Motion UX Design, Part 2

Leap Motion UX Design

- http://blog.leapmotion.com/category/ux/

Hybrid Tracking Techniques

- Compensate negative characteristics of one approach with another
  - Inertial and Magnetic
  - Inertial and Optical
  - WiiMote+MotionPlus
  - PlayStation Move

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Other Options

- Some alternatives
  - Speech
  - Gestures: pointing to fly
  - Device actions (*e.g.*, buttons, joysticks)
  - Head/gaze directed
- Hybrid
  - Speech and gesture (*e.g.*, "Put that, there.")

Special-Purpose Input Devices

- Some applications are more "real" with a device that matches the real action
  - Steering wheel
  - Light gun
  - Flight-simulator motion platform
  - Snowboard/surfboard
  - Pod racer
  - Motor cycle
- Today, since sensors are cheap, we can turn almost *anything* into an input device