

3D User Interface Hardware

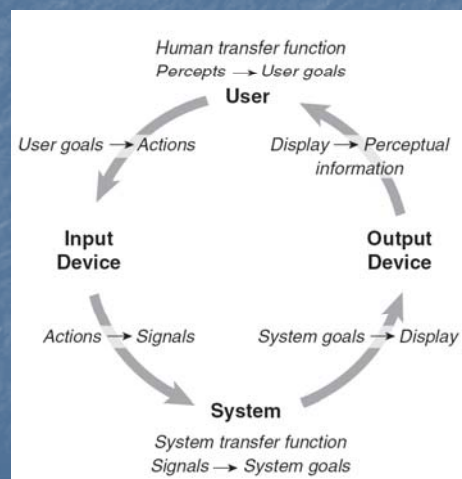
Lecture #7: Input Devices
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Interaction Workflow



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Lecture Outline

- Input device characteristics
- Desktop devices
- Tracking devices
 - position
 - eye
 - gloves
- 3D mice
- Direct human input
- Building special input devices

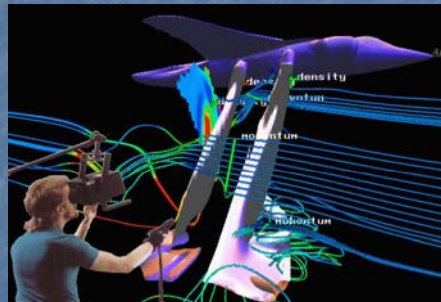
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Input Devices

- Hardware that allows the user to communicate with the system
- Input device vs. interaction technique
- Single device can implement many Its



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Input Device Characteristics

- Degrees of Freedom (DOFs) & DOF composition (integral vs. separable)
- Type of electronics: Digital vs. analog
- Range of reported values: discrete/continuous/hybrid
- Data type of reported values: Boolean vs. integer vs. floating point

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More Input Device Characteristics

- User action required: active/passive/hybrid
- Method of providing information: “push” vs. “pull”
- Intended use: locator, valuator, choice, ...
- Frame of reference: relative vs. absolute
- Properties sensed: position, motion, force, ...

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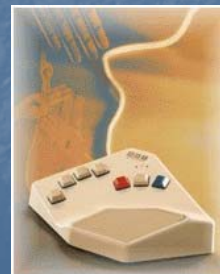
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Desktop Devices: Keyboards

- Chord keyboards
- Arm-mounted keyboards
- "Soft" keyboards (logical devices)



www.virtual-laser-keyboard.com



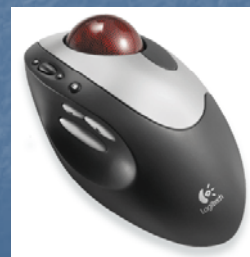
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Desktop Devices: Mice and TrackBalls

- Many varieties
- 2D input to 3DUI
- Relative devices



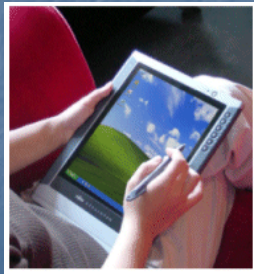
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Desktop Devices: Pen-based Tablets

- Absolute 2D device
- Either direct or indirect



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Desktop Devices: Joysticks

- Isotonic vs. Isometric



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Desktop Devices: 6-DOF Devices

- 6 DOFs without tracking
- Often isometric
- SpaceBall, SpaceMouse, SpaceOrb



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Tracking Devices: Position Trackers

- Measure position and/or orientation of a sensor
- Degrees of freedom (DOFs)
- Most VEs track the head
 - motion parallax
 - natural viewing
- Types of trackers
 - magnetic
 - mechanical
 - acoustic
 - inertial
 - vision/camera
 - hybrids

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Other Uses For Trackers

- Track hands, feet, etc.
 - “whole body” interaction
 - motion capture application
- Correspondence between physical/virtual objects
 - props
 - spatial input devices

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Tracking Physical Objects (Props)



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Magnetic Trackers

- Example: Ascension Bird
- Advantages
 - good range
 - no line of sight issues
 - moderately priced
- Disadvantages
 - metal or conductive material will distort the magnetic field
 - magnetic field can interfere with nearby monitors



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Mechanical Trackers

- Example: Fakespace BOOM tracker
- Advantages
 - low latency
 - very accurate
- Disadvantages
 - big and bulky
 - usually only one sensor
 - reduced mobility
 - expensive

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Acoustic Trackers

- Example: Logitech Fly Mouse
- Also known as ultrasonic tracking
- Advantages
 - no interference with metal
 - relatively inexpensive
- Disadvantages
 - line of sight issues
 - sensitive to certain noises



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Inertial Tracking

- Example: InterSense IS300, Wiimote
- Advantages
 - no interference with metal
 - long range
 - no need for transmitter
- Disadvantages
 - subject to error accumulation
 - only track orientation



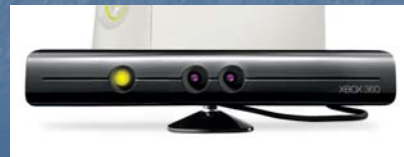
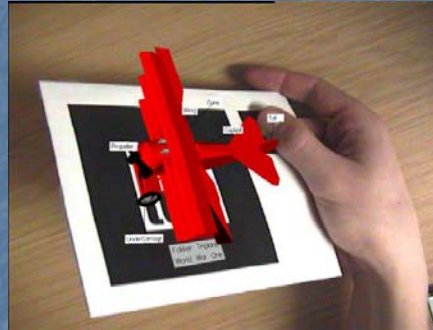
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Optical/Vision-based trackers

- Exs: Vicon, HiBall, ARToolkit
- Advantages
 - accurate
 - can capture a large volume
 - allow for untethered tracking
- Disadvantages
 - image processing techniques
 - occlusion problem



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Hybrid Tracking

- Example InterSense IS900
- Advantages
 - puts two or more technologies together to improve accuracy, reduce latency, etc...
- Disadvantages
 - adds complexity



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Tracking Devices: Eye Tracking



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Tracking Devices: Bend-Sensing Gloves

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



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Tracking Devices: Pinch Gloves

- Conductive cloth at fingertips
- Any gesture of 2 to 10 fingers, plus combinations of gestures
- > 115,000 gestures



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3D Mice

- Ring Mouse
- Fly Mouse
- Wand
- Cubic Mouse
- Dragonfly
- ...

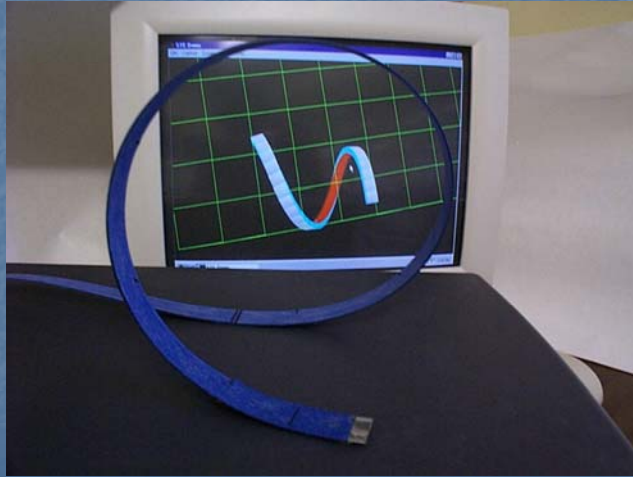


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ShapeTape



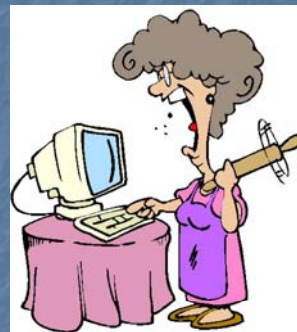
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Human Input: Speech

- Frees hands
- Allows multimodal input
- No special hardware
- Specialized software
- Issues: recognition, ambient noise, training, false positives, ...



<http://www.lindamoran.net/images/yelling.jpg>

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Human Input: Bioelectric Control

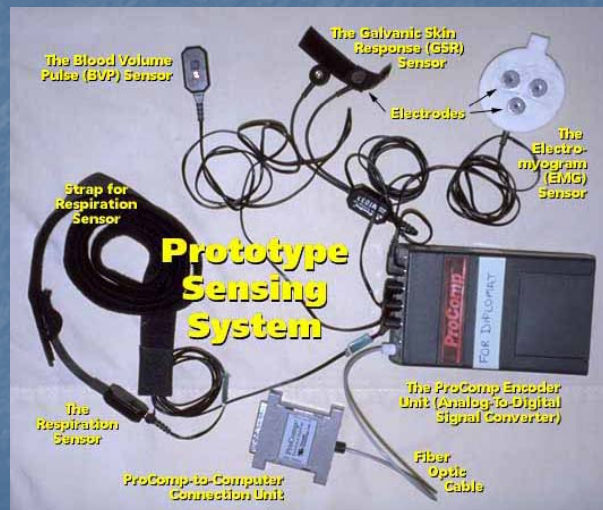


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Human Input: Body Sensing



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More Human Input

- Breathing device - OSMOSE
- Brain-body actuated control
 - muscle movements
 - thoughts!



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Why Build 3D UI Devices?

- Assist in designing new interaction techniques
- Improve upon existing techniques
- Provide interfaces for specific 3D interactions and applications
- Give users more expressive power
- Develop new interaction styles
- Develop new and improved 3D interface hardware
- Fun!!!!



<http://www.uni-weimar.de/cms/medien/virtual-reality/research/interfaces/input-device-and-interaction-techniques.html>

<http://www.labri.fr/perso/hachet/CAT/>

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Tools of the Trade

- Sensors, buttons, switches, controllers, etc...



www.futurlec.com

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3D Input Device Building Strategies

- Device function
 - What will the device sense?
 - force
 - motion
 - button presses
 - what physical device types are required?
 - need to choose appropriate sensors
 - digital/analog
 - pressure, bend, potentiometers, thermistors
 - conductive cloth (great sensing material)
- Sensor housing
 - How will sensors be placed in the physical device?
 - physical constraints
 - physical comfort
 - How to build the housing?
 - milling machine
 - vacuform device
 - 3D printer
 - Lego bricks
 - modeling clay



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Device Ergonomics

- Good ergonomic design is crucial
 - device housing
 - control types
- Issues to consider
 - device should be lightweight
 - avoid fatigue
 - simple to use
 - easy to reach buttons and controls
 - avoid undue strain
 - don't want to cause user pain

CyberGrasp by Immersion



<http://www.it.bton.ac.uk/staff/lp22/CS133/haptics.html>

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Connecting Devices to the Computer

- Need to connect device to the computer
 - USB
 - serial port
 - Bluetooth
- Often need a microcontroller (not always)
 - small computer that can interface with other electronic components
 - PIC (www.microchip.com)
 - BasicX-24 -- easy to use
 - programming in Basic
 - has nice development kit
- A typical approach
 - build electronics with prototyping board
 - write code in IDE and download to board
 - test and debug
 - put electronics on circuit board
 - write device driver



www.basicx.com

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Software for the Device

- Need to have software to use device in applications
- Several strategies
 - write driver from scratch
 - need to know something about OS – low level support functions
 - understanding of serial/USB communication protocols
 - typical functions – open, close, read, write
 - plug into API
 - utilize existing software – provide drivers for many devices and machinery to create new ones
 - VRPN – developed at U. North Carolina
 - VRJuggler – developed at Iowa State
 - interface device toolkits
 - Phidgets
 - I-CubeX

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Case Study 1 – Interaction Slippers

- Providing more powerful methods of expression
- Offload functionality to the user's feet
- Input Device
 - pair of commercial house slippers
 - embedded Logitech Trackman Live!™ – wireless trackball
 - conductive cloth
- Allows for toe and heel tapping
- Interact with the Step WIM
 - miniature version of the world place on the floor
 - toe tap to invoke the WIM



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Case Study 2 – Reinventing the Pinch™ Glove

- Pinch Gloves
 - determines if two or more fingertips are touching
 - uses conductive cloth
 - designed for pinching and grabbing gestures
 - at the time \$2000
 - had problems with reliability
- Wanted to build custom device
 - less expensive (\$200)
 - more flexibility
 - not just pinching gestures
 - plug-n-play
 - allow for a variety of switches



www.fakespacelabs.com



Conductive Cloth Button

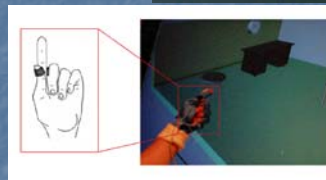
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Flex and Pinch Input

- Dealing with input device limitations
 - bend sensing gloves vs. pinch gloves
 - improve existing interaction techniques
- Input Device
 - 16 conductive cloth contacts
 - used with bend sensing glove
 - Can be placed anywhere
- Improve image plane interaction techniques
 - allow user to activate selection with primary hand
 - multiple flex button configurations



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CavePainting Table

- Improve a specific application
 - explore prop-based interaction
 - used for painting 3D scenes
- Input Device
 - tracked paint brush
 - paint cup props
 - uses conductive cloth
 - bucket Tool
 - misc. knobs and switches
- Hold down brush button to paint
- Dip paint brush into paint cups to change strokes
- Use bucket to throw paint



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FingerSleeve

- Inspiration for creating novel interaction techniques
- Pop through buttons
 - use light and firm pressure
- Input Device
 - worn on index finger
 - made from elastic fabric and flexible plastic
 - 6 DOF tracker attached to the back of the sleeve
 - interesting design issues with button style and placement
- Principle
 - light pressure used for temporary action
 - actions confirmed by firm pressure
- ZoomBack Technique
 - temporary and permanent travel
- Snapshot Technique



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Case Study 3 – 3motion

- 3D gesture interaction system
 - developed by Keir et al. 2005, Digital Design Studio, Glasgow School of Art
 - designed as inexpensive tracking solution
 - used for gesture tracking
- Components
 - single chip 3-axis linear accelerometer
 - several buttons
 - wireless bluetooth communication
 - software SDK
- Tested in gaming environment and character manipulator
- Used on cell phone to play virtual golf
- Can you say, "Wii"?



<http://research.navisto.ch/publications.html>

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From Lab to Production (1)

Chord Gloves
Mapes and Moshell (1995)



Pinch™ Gloves
By Fakespace

Cubic Mouse



Fröhlich and Plate (2000)



Cubic Mouse
By Fakespace

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From Lab to Production (2)

The CAT (Computer Action Table)



Hachet et al. (2003)
HiBall 6D Tracker



The CAT
By
Immersion SAS

www.immersion.fr



Welch (1996)
<http://www.cs.unc.edu/~tracker/media/html/hiball.html>



HiBall
By 3rd Tech

<http://www.3rdtech.com/HiBall.htm>

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Prototyping Toolkits – Phidgets

- Phidgets (Greenberg and Fitchett 2001) – building blocks for low cost sensing/control

- uses USB
- clean separation of hardware and software
- simple API
- Don't need to worry about
 - microprocessors
 - communication protocols
 - soldering

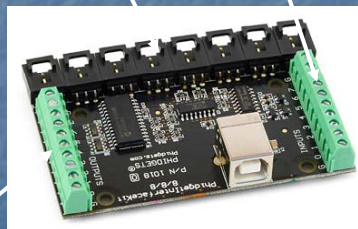
- Variety of sensors

- touch
- light
- force
- vibration
- rotation

- Other tools

- accelerometers
- switches
- RFID tags
- etc...

Analog inputs Digital Inputs



Digital Outputs

www.phidgets.com



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Prototyping Toolkits – I-CubeX

- I-Cube (Mulder 1995) – uses the Musical Instrument Device Interface (MIDI)
 - MIDI – protocol for communicating control information
 - also uses Bluetooth (wireless)
 - similar advantages to Phidgets
 - no microcontroller programming
 - no circuit design
 - software API
- Variety of Sensors
 - air
 - touch
 - bend
 - temperature
 - magnetic
 - light
 - tilt



infusionsystems.com

3D Acceleration Sensor



Touch Sensor



BioBeat Sensor



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Next Class

- Selection and Manipulation
- Readings
 - 3DUI Book – Chapter 4

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