IMGD 5100:
Immersive HCI

Classifying 3D Input Devices

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But First…

- Who are you?
  - Name
  - Interests
  - Strengths
  - Would like to do a project on…
    - "I don't know" is okay.

Let's talk about the paper…

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)

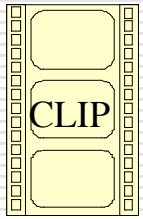
Microsoft
Kinect (2010?)

WiiMotionPlus
(2009)

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)

CLIP

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)

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)

- 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)

- 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)

WPI

- 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.*

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

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

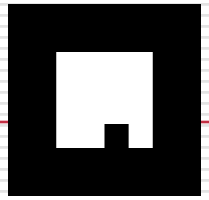
- Transmitter sends pulses
- Receivers hear tones
- Distance is computed
- Can use "costellations" for orienation
- Pros:
  - High accuracy
  - High resolution
- Cons:
  - Requires line-of-sight (hearing)

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

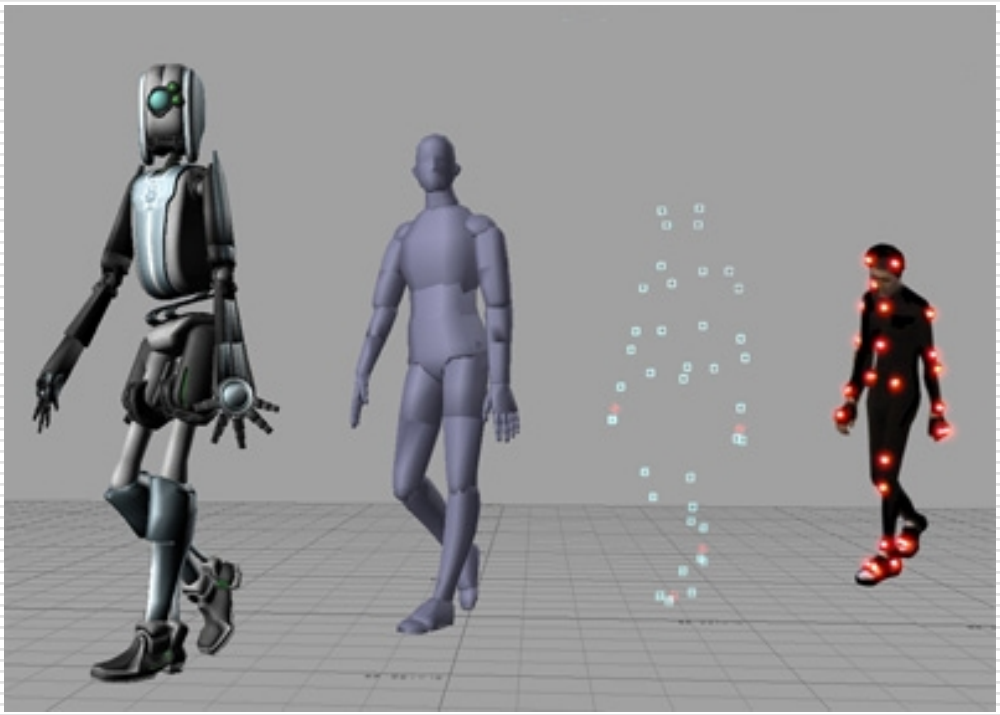
Optical Tracking

- 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
- http://www.youtube.com/watch?v=dTKlNGSH9Po

Hybrid Tracking Techniques

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

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

Mapping Devices to Actions

- For each (user, task, environment)
  - For the four basic VR tasks
    - For each device DOF
      - Choose a mapping to an action

- We also need to easily switch between actions!

Placing Devices in Context

- Table?

Device	Rel/Abs	Int/Sep	Dig/Ana	Isom/Isot	Rate/Pos	Spec/Gen	Dir/Ind
Mouse	Relative	Integrated	Digital	Isotonic	Position	General	Both
Glove	Absolute	Integrated		Isotonic			
…							
…							
…							

Verification and Comparison

- Framework for user studies
- Interesting to fill in the empty spaces
  - Isotonic position control for rotation?
  - Other novel combinations?
- Very active field right now
  - ACM CHI, IEEE VR, 3DUI Symposium, ACM SIGGRAPH

More Info

- Shumin Zhai at Google, used to be at IBM Almaden, and U. of Toronto
- Bill Buxton at Microsoft Research, used to be at U. of Toronto, and Alias|Wavefront (now part of Autodesk)