CS-525V: Building Effective Virtual Worlds

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 Desktop Input Devices

- Mouse++
- Keyboard
- Joystick
- TrackBall
- TrackPoint
- TouchPad
- Tablet
- MightyMouse
Game Controllers

Atari 2600 (1977)

Intellivision (1980)

PlayStation2 (2000)

Xbox 360 (2005)

Wii Remote+ Nunchuk (2006)

Source: http://www.axess.com/twilight/console/
Prototypes of Controllers
Prototypes of Controllers (cont.)
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)

- 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
- Tracked Paddle for 2D Interaction
- HMD with 3-DOF tracker
- 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
- 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 orientation

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
Optical Tracking (cont.)

- Active vs. Passive Markers
Hybrid Tracking Techniques

- Compensate negative characteristics of one approach with another
  - Inertial and Magnetic
  - Inertial and Optical
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?

<table>
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<th>Device</th>
<th>Rel/Abs</th>
<th>Int/Sep</th>
<th>Dig/A na</th>
<th>Isom/Isot</th>
<th>Rate/Pos</th>
<th>Spec/Gen</th>
<th>Dir/Ind</th>
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<td>Digital</td>
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<td>Position</td>
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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 IBM Almaden
☐ Bill Buxton at U. of Toronto (Alias|Wavefront)