Physical I/O devices
Part 1: haptic input

SGN-5406 Virtual Reality 2012
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based on material by
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Outline

Physical I/O devices

Part 1: Input (haptic sensors)
- Passive
  - No feedback
  - Movement support
- Active
  - Intentional feedback

Part 2: Output (non-visual displays)
- Haptic
- Kinesthetic
- Vestibular
- Tactile
- End-effector
- Force feedback
- Olfactory

3D “fly” mouse
Wiimote
PS Move
Kinect
VR Gloves
3D Probes
Accelerometers
Etc...

Keyboard
Mouse
Joystick
Touch screens
Steering wheel
3D “desk” mouse
(SpaceNavigator)
Etc...

Combination of input+output
Surgery simulator
Novint Falcon
CyberGrasp glove
Virtual keyboard + force feedback

Etc...

SGN-5406 Virtual Reality 2012
Input

INPUT DEVICES IN GENERAL
Input Devices

- Accept the input from user
- Means of interaction with VR environment
  - Active Input:
    - Explicit commands to VR system issued by the user
    - Pushing a button
    - Selecting an object
  - Passive input:
    - Events triggered by system automatically,
    - Walking into an area,
    - Being in environment for certain amount of time, etc.
    - System may even monitor some biological parameters of the user, heat rate, body temperature, etc.
Fitt’s law

- Used by interaction designers.
- Fitt’s Law states that the time to acquire a target is a function of the distance to and size of the target.

\[ T = a + b \times \log_2 \left( \frac{D}{W} + 1 \right) \]

- Defines an index of difficulty
- For a haptic virtual environment or tele-operated system, haptic feedback can minimize the difficulty (T)
Degrees of Freedom

- DoF – Degrees of Freedom.
- Rotation or translation along the axes.

6 DoF:
1. Moving up and down
2. Moving left and right
3. Moving forward and backward
4. Tilting forward and backward (pitching);
5. Turning left and right (yawing);
6. Tilting side to side (rolling).
Navigation in 3D

Translation along X, Y, Z

Rotation on X, Y, Z
Passive vs. active input devices

- **Passive input devices**
  - Events triggered by the system monitoring the participant
  - No feedback → user does not have any feedback for the event
  - Some feedback → user feels feedback, but it's not controlled by the computer program

- **Active input devices**
  - Event specifically triggered by the user
  - Computer program gives intentional feedback to the user
Input devices

PASSIVE (MOVEMENT SUPPORT)
“Classic” input devices

Keyboard:
- Made for text input, not for VR
- Still used as a controlling device in simulations (e.g. games)

Mouse
- 2 DoF – translation in X and Y plane
- 1, 2 or 3 buttons
- Sometimes a scroll option
- Gestures – Apple Magic Mouse, MS touch mouse
“Classic” input devices

**Joystick**
- Symbol of video games in 80ies
- 2+ DoF
- Used in flight simulators

**Gamepad**
- 2x2 DoF
- Integrates two separate thumb sticks
- Additional function buttons 8+
3D "desk" mouse

- Used in CAD applications
- Provides hand support
Graphics Tablets

- Tablet is a passive grid of wires,
- Wires act as transmitter and receiver coils
- Wires generate signal registered in LC coil in pen.
- In second step wires act as receivers to register signal from pen.
- Pressure sensitive (sensor in the pen)
Digital Pens

- Two IR light sources in the base.
- IR sensor in the pen.
- Sometimes pressure sensitive.
- Pressure sensor in the pen.
- Uses normal paper.
- Wacom Inkling.
Leapfrog Fly Pentop Computer

- Uses “Anoto” microdot paper
- IR sensor in a pen.
- Special paper with unique dot pattern.
- Position and orientation of pen calculated based on pattern.
- Captures drawings and handwriting.
- User could issue commands by drawing symbols which pen recognizes.
Several technologies

iOS devices, Android phones, Nokia Phones, Nintendo DS, 3DS etc.

Two major approaches:
- Capacitive
- Resistive
Touch screens

• Input and output devices, sometimes in the same piece of hardware.

• Touch Screen - Not a Haptic display!

• Touch Screen – two components in one device:
  • Video display – output component
  • Touch sensitive layer – input component

• Touch screen is a Video display.

• Touch screen is a Haptic input device.
Resistive touch

- Touch screen – two parallel electroconductive layers.
- When an object touches the surface, it causes deformation.
  - As layers touch circuit closes.
  - Position of the touch can be detected.
  - Frequent deformations cause physical damage to the surface.
- Not very durable.
- Works with plastic stylus
- Works with gloves
- More precise than capacitive technology.
Capacitive touchscreens

- Touch sensitive layer - a grid of electrodes.
- When an electric conductor gets near, capacitance changes.
- Human finger is an electric conductor.
- Less precise than Resistive technology.
- More durable.
- Can operate behind protective glass.
- Works with fingers not with stylus.
Capacitate touchscreens

**Pros:**
- Precision
- Better multitouch
- No need to apply pressure (touch is enough)

**Cons**
- Does not work with gloves
Other input controllers

- Car controller
- Race car controller
- F-sim controller
- F-18 controller
- Virtual DJ
Input devices

PASSIVE (NO FEEDBACK)
Movement support

OK/Cancel

MINORITY REPORT

IN THE YEAR 2099...

I'm sorry ma'am. Your cognitive scores are incredible but you simply don't have the upper body strength to do this 8 hrs a day.

OK/Cancel

Minority Users: copyright 2003 Tom Chi and Kevin Cheng

http://okcancel.com/comic/3.html
Wiimote

- Primary input device for Nintendo Wii console.
- Introduced in Nov. 2006.
- "Motion Sensing":
  - Position – relative to screen.
  - Orientation – relative to screen.
  - Motion – relative to previous position.
- Detailed specs:

http://wiibrew.org/wiki/Wiimote
1. Motion (relative to previous position of device) – acceleration along X,Y,Z-axes – using ADXL 330 Accelerometer (Analog Devices).

2. Orientation – using ”sensor bar”.

Sensors
Sensors bar

- Not a sensor at all.
- Source of IR light – any source of IR light will suffice.
- Detection – CMOS Optical sensor on Wiimote (PixArt).
- Essentially the same like in a webcam.
- Accurate up to 5m.
- Distance from ends of sensor bar calculated by triangulation.
Wiimote hacks

Johny Lee

TED talk at http://youtu.be/QgKCrGvShZs
Sony Move

- Video Tracking.
- RGB LCD Light Ball as a marker.
- Optical ball tracking.
- 3 Axis linear accelerometer.
- 3 Axis angular rate sensor.
- Magnetometer for calibration.
- Requires constant calibration.
Microsoft Kinect

- Developer PrimeSense for Microsoft.
- Input for Xbox 360 Game console

- Components:
  - RGB camera
  - Range camera
  - IR light source
  - Multiarray microphone

- Range Camera extracts depth information from a video signal.
Microsoft Kinect

- IR light source continuously projects infrared structured light pattern.
- Range camera captures IR image.
- Depth information is calculated based on the geometric deformations of projected light pattern.
- If human shape is detected, this information is used to articulate a virtual skeleton.

• Motion Capturing.
Kinect effect

- Works by projecting structured light in IR range
  - Pseudorandom pattern

- New interaction styles
  - Promo video available at http://youtu.be/T_QLguHvACs
Blobo

- Manufacturer: Ball-It Oy, Suo

- You can find it in R-Kioski.
  - Not anymore

- Linear acceleration.

- Angle acceleration.

- Pressure.
Data Glove

- Typical VR input device in utopian days.
- Measures position and orientation of joints in human hand.
- Very complex devices.
- Each joint adds one or more DoF.
- 20+ degrees of freedom.
Data Glove Drawbacks

- Requires user specific calibration.
- Each person has hands of different size.
- Very complex, and expensive.
- Need high bandwidth to transmit data.
- Cumbersome and hard to disengage.
- Hygienic issues if equipment is shared – bad for public spaces.
Data Glove History

**VPL DataGlove 1987**
- Fiber optic, 10 DOF
- Polhemus position tracker

**Exos Dextrous Hand Master 1989**
- 20 DOF, 8-bit, 200 Hz, + Polhemus

**Mattel/Nintendo PowerGlove 1989**
- Electric resistance, for joint orientation.
- Ultrasonic triangulation to determine the position of hand.
Pinch Glove

- Does not measure the precise orientation of joints.
- Conductive patches on fingers and palms.
  - When two patches touch circuit is closed.
  - Information about gesture is extracted.
  - No information about touch intensity.
- Patches act as ON/OFF switches.
- Fixed set of gestures which can be programmed.

**Advantages:**
- Simple, robust design.
- No need for callibration.
Pinch glove
3D probes

Three-dimensional probe
3D probes

- Microscribe 3D
- Mechanical arm with 6 - Joints - 6DoF
- A coordinate system is associated with each joint.
- Position of the tip is calculated using kinematic calculation.
- Position is calculated based on orientation of each joint in kinematic chain in reference to the previous joint.
New Directions

Magnetometers in mobile devices
- Digital compass

Accelerometers in mobile devices:
- Angle acceleration (orientation)
- Directional acceleration (motion)

GPS – Geo Positioning System as input device:
- Used for location aware applications.
- Used in Augmented Reality systems.
Input devices
ACTIVE (INTENTIONAL FEEDBACK)
Active input devices

- **Combination of input and output device**
  - Computer system might selectively give feedback to the used during the data input

- **Example – touchscreen keyboard with haptic feedback**
  - Device vibrates on “keypress”
Use case – surgery simulator

• Allows virtual surgery simulation
  • Device can simulate the resistance of different tissues
Use case – Novint Falcon

- **Gaming device**
  - 6 DoF input
  - 6 DoF output
  - Force feedback

- **Supports a range of games**
  - Pistol grip attachment
  - Demo at http://youtu.be/wuKH7alJqhY

Novint Falcon pistol grip
Use case – Gyber grasp

- Cyber glove with high DoF input and force feedback
- Allows to “feel” the object in tele-robotic applications
- Works by constraining hand motion (end-effector feedback)