Input / Output Devices

Different ways to communicate
User - Application Dialog

The communication between user and system
How?

• How can a user communicate actions/information she requests that the application do?
• How can the application communicate the results, information or confirmation of the actions?
• How can the application communicate requests of the user to the user?
Input Devices
What stimulus dimensions can we humans detect? (input to a human)

- Consciously Controlled - State and Changes of State
- Types of receptors
  - Chemoreceptors
    - used for smell and taste
    - sensitive to chemical substances
    - also monitor blood pH.
  - Mechanoreceptors
    - stimulated by mechanical forces
    - Baroreceptors in the aortic wall sense changes in blood pressure
  - Proprioceptors
    - sense the degree of muscle contraction
    - Tendon stretch
    - Movement of ligaments
  - Thermoreceptors
    - sense temperature changes
    - located in the skin and the hypothalamus
  - Pain receptors (nociceptors)
    - naked dendrites (nerve endings) that respond to chemicals released by damaged tissues.
  - Photoreceptors
    - sensitive to light.
What stimulus dimensions can we humans detect? (input to a human)

- **Visual (Sight)**
  - Light Intensity (Visible Light)
  - Color (Visible Light)
  - Change over time (up to 60-100 changes per second in visual field)
  - 2D images
  - 3D images
  - 2D patterns and shapes (characters)
  - Movement
  - “on a clear, moonless night, the unaided human eye can detect the light from a single match up to 10 miles (16 kilometres) away.”

- **Heat**
  - Radiant Electromagnetic Radiation (infrared light) on the skin

- **Tactile (Touch – Skin, Tongue, Mucous Membranes, …)**
  - Pressure
  - Movement Across Skin
  - Temperature Differences
  - Heat & Cold
  - Vibration
  - Pain
  - Electric Shock

- **Hearing (Ears and Cochlear Organs)**
  - Approximately frequencies 20-20,000 hz
  - Simultaneous frequencies
  - Time varying frequencies
  - Position in a 3D sound field via time differences and acoustic effects like echo and reverb
  - Timbre – the qualities of the sound – trumpet vs. violin vs. xylophone
  - Sounds, Speech, Music & Noise

- **Proprioception**
  - Unconsciously monitor the position of our body.
  - Depends on receptors in the muscles, tendons, and joints.
  - Acceleration Detection

- **Taste (Tongue and Nasal Passages)**
  - Sweet, Sour, Bitter, Salty and Umami
  - Electric Shock

- **Smell**
  - Humans can recognize over 10,000 scents
• Institute for Sensory Research – Syracuse
  http://www.isr.syr.edu/somato.html
• http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/M/Mechanoreceptors.html
• Taste
  http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/T/Taste.html
• Smell
  http://www.hhmi.org/research/investigators/axel.html
What stimuli can we output (generate) – how can we communicate outwardly?

- Physical Pressure & Movement
  - Hands, Feet, Trunk, Head, Lips, Eyes
- Sound
  - Noise, Clapping, Sound, Speech and Music/Singing, …
- Position and Change in Position
  - Hands, Feet, Trunk, Head, Lips, Eyes
- Breath Pressure & Length of Time
- Heat (Body Heat)
- Conscious output is musically mediated communications
  - Unless you use MRI or something more exotic
Input (to a computer) Devices and some Output Devices
Binary state - off to on, off to on

• Devices
  – Standard PC Keyboard
  – Joystick (Switch based NOT positional)
  – Mouse Buttons
  – Touch Screen
  – TabletPC Screen (not pressure sensitive version)
  – Electrical Switch
  – Telephone Keypad

• GUI representation
  – Command Buttons
  – Radio Buttons, Check Boxes
  – Buttcons, Exapand/Collapse Menus
  – Menu items
Pressure - Degree of “on-ness”

• Devices
  – Touchsensitive MIDI Keyboard (with aftertouch )
  – Touch Screen
  – TabletPC Screen
  – Joystick (Positional with Auto Return)
  – EWI – Breath Controller
  – Guitar (Harder you strum / Louder it gets!)

• GUI representation
  – Line Thickness
  – Volume
  – Slider
  – Spin Control
  – Color Selector
Position – 2D

• Devices
  – Mouse
  – Joystick (positional [x,y] NOT switch based)
  – Graphics Tablet
  – Touch Screen
  – Tablet PC Stylus on Screen

• GUI representation
  – Slider
  – 2D Picker
  – Scroll Bar
  – Caret and Cursor
Light (Electromagnetic Radiation)

• Devices
  – Barcode Wand
  – Scanner
  – PC Display
  – Projector
  – Laser Printer
  – Printed Output
  – Web Cam
  – LCD/LED on a Telephone
  – RFID Reader
  – Iris Scanner

• GUI representation
  – Any GUI component
  – Foreground & Background
    Color/Intensity
  – Color / Luminance Picker
  – Images, Videos
Sound

- Devices
  - Microphone
  - Speakers
  - Oscilloscope
  - Ultrasound
- GUI representation
  - Volume Slider
  - Visualization in MP3
Important facts

• It takes the equivalent time of three to eight keystrokes to switch between devices i.e. keyboard to mouse.

• A good touch typist can type 100+ characters per minute. A bad 30 cpm. Ever try typing with a mouse?
Keyboard

- **G (Good):**
  - Text Data Entry
  - Fast typists
  - Accelerator Keys and Mnemonics

- **B (Bad):**
  - Drawing
  - Selecting from many choices
  - Limiting choices entered as text (vs. say a set of checkboxes)
Alternative Keyboards / Input Dev
Other types of keyboards
Mouse

• **G:**
  – “Gesturing” – pointing, clicking, double clicking, drag and drop
  – Selecting a region or item
  – Arranging icons visually
  – Fastest device to orient on a target on screen according to research
  – Uses gross muscle movements of arm and wrist

• **B:**
  – Drawing (fine motor skills)
  – Data entry of text
  – Purely Horizontal or vertical movements (like cascading menus!)
  – How many button is best? (1,2,3,4, …)
  – Source of repetitive strain injuries
Types of mice/trackballs

- Traditional desktop mice
  www.logitech.com
- Motion sensing mice
  www.gyration.com
- Logitech has more exotic stuff – Magellan 3D, Cyber Puck and 3D track ball
  http://www.3dconnexion.com/products/
Trackball

• G:
  – Orienting
  – Avoiding inadvertent movement while button pressing
  – Small desktop space needed

• B:
  – Of mouse, joystick and trackball - Worst for targeting
  – Drawing (fine motor)
  – Click and select motions (vs. a mouse)
Joystick

• G:
  – X,Y positioning
  – Fast, hand-eye coordinated movements
  – Small spaces
  – Absolute Position vs. Relative Modes

• B:
  – Text Input
  – Fine Positioning

• http://www.quadjoy.com/products.htm
LogiCad 3D ScreenMan

- Touch screen with dual 3D controllers on the sides
- Each controller has 6 degrees of freedom – X,Y,Z and rotation

Eraser Point – a joystick in the keyboard!
Persons with limited arm/hand mobility - headmouse
Graphic Tablet

- **G:**
  - Drawing
  - Signatures
  - Selecting

- **B:**
  - No direct feedback (requires great hand eye coordination because you are not drawing on the screen directly – no direct manipulation)
  - Hard to be accurate
  - Region selection
  - Data entry
Touchscreen

• G:
  – Kiosk / ATM selection screens

• B:
  – Data entry (keyboard is better)
  – Large area (finger tip) that is the target – fine movements are hard
Lightpen / Penscreen / Tablet PC

• **G:**
  – Direct feedback between position and the screen – direct manipulation
  – Fine motor oriented operations – drawing, signature
  – Handwriting
  – Selection of items – check, radio, list, …

• **B:**
  – Pen can obscure the visual area
  – Can fatigue the users arm
  – Handwriting as data entry can be much slower than typing.
Light Pens & Graphics Tablets
Write on displays (light pen)

- 1024 x 768 and 1280 x 1024
- 16 Million colors
- 512 pressure levels
- Accuracy down to +/- 0.02 inches!
- Cost $1800-$3600 currently
- See www.wacom.com
- (images copyright Wacom)
Handwriting Recognition

• Write on a graphics tablet/touch screen and the software will convert the bitmap image of what you have written into text file.

• G:
  – When a traditional keyboard is hard to use – Dr. doing rounds
  – No ability to type
  – PDAs

• B:
  – Slower than typing for most
  – High error rates 1 - 5% wrong characters/words!
  – Need to train software to your handwriting
  – May require use of alternative set of symbols you need to learn – Ex: Graffiti on the Palm OS
  – Slow – not good in real time
The Surfball

- Yale Center for Robotic Vision and Control [http://cvc.yale.edu/frames.html](http://cvc.yale.edu/frames.html)
The Surfball

• G:
  – 3D manipulation – Up/Down, Left/right, In/Out
  – Gaming?
  – Real time flight control

• B:
  – Text
  – Absolute positioning
  – Fatiguing
Mice, Trackballs, Joysticks, Graphics Tablets, ...

- Generally require a visual display for feedback to the user!
Voice Recognition

• G:
  – Supports users with limited mobility
  – Supports a natural way that people communicate
  – Compatible with telephone infrastructure
  – Simple choices (Yes/No, A/B/C, Up/Down)
  – No ability to use a keyboard
  – Illiterate users

• B:
  – Low rates of accuracy (90-99%)
  – Requires training
  – Slow method of communicating (versus keyboard)
  – Complex interactions are difficult
• Interactive demo of speech
  http://www.chass.utoronto.ca/~danhall/phonetics/sammy.html

• Praat tool http://www.fon.hum.uva.nl/praat/
Handwriting Recognition

• Write on a graphics tablet/touch screen and the software will convert the bitmap image of what you have written into text file.

• **G:**
  – When a traditional keyboard is hard to use – Dr. doing rounds
  – No ability to type

• **B:**
  – High error rates 1 - 5% wrong words!
  – Need to train software to your handwriting
  – Slow – not good in real time
Telephone Keypad & Handset (Voice Response Unit - VRU)

- **G:**
  - Simple interactions
  - Short menus (4 choices or less)
  - Remote access to applications
  - Query oriented apps
  - Numeric input

- **B:**
  - Requires hearing and dexterity
  - Complex menus / cascading menus
  - Transaction oriented apps
  - Alphabetic input
Barcode

- http://www.howstuffworks.com/upc.htm
Barcode

- Coding methods:
  - Code 11
  - Code 39
  - Code 93
  - Code 128
  - Codabar
  - Interleaved 2 of 5
  - EAN 13
  - EAN 8
  - PDF417
  - Telepen
  - UPC A
  - UPC E
  - 2 and 5 digit supplementals associated with EAN and UPC barcodes.
  - Patch Codes: types 1, 2, 3, 4, 6 and T.

- Linear (1 D) and 2D symbologies
OCR

- Optical Character Recognition software
- Scan a page of text and convert the bitmap to a text file.
RFID
(Radio Frequency Id)

- Reads an item via Radio Frequency communications. Can get the unique id of an item i.e. a specific can of soda out of all the cans of soda in the whole store!

- [http://www.rfid.org/](http://www.rfid.org/)
- Images © Zebra [http://www.zebra.com/PA/Printers/R_140.pdf](http://www.zebra.com/PA/Printers/R_140.pdf)
Digital Pen?

- Logitech & Anoto
  (http://www.anotofunctionality.com/navigate.asp?PageID=73)
- Records the strokes you make
- Stores 40 “pages” in the pen
- Write email away from the computer!
- A tiny camera reads a grid off the paper to track your motions.
- Requires special paper (a grid of dots invisible to the naked eye)
- $200.00
The Eye – a great computational subsystem

- [http://retina.anatomy.upenn.edu/~lance/retina/retina.html](http://retina.anatomy.upenn.edu/~lance/retina/retina.html)
Eye Position & Gaze Tracking

- Images copyright SMI.
- http://www.smi.de/3d/index.htm
Other Input Devices

- WebCam / Video Camera
- Phone Keypad
- Accelerometers / movement detectors – mouse that can be used in space.
- Microphone
- Scanner – 2D and 3D
- Special scientific sensors
  - Physical – Light, Heat, Pressure, Temperature, Weight, Mass
  - Electrical – Voltage, Resistance, Capacitance
  - Geographic Location / Position - GPS – Global Positioning System
  - Gamma Radiation
Oil Industry

- Drilling “tool strings” – sets of sensors set down the hole behind the drill
- Steerable drilling!!!
- Transmits the information via sound waves through the “mud” pumped down to the drill head to power the drill
- Sensor types
  - Electrical resistance
  - Sound
  - Temp
  - Gamma Ray Adsorption
- [http://www.oilfield.slb.com/content/services/drilling/index.asp?](http://www.oilfield.slb.com/content/services/drilling/index.asp?)
MRI / PET?

- Images copyright Encarta
  
Output Devices
VDT – Video Display Terminal

- CRT & LCD Panel, Projectors
- All Pixels Addressable Display
  - The shapes, text, graphics displayed are not fixed but “drawn” to the screen.
  - May just support standard character set – character mode terminal
How many screens can you use?
3D Visual Displays
Printer

- Outputs to paper or similar material
- All pixels addressable or character mode
Electronic Paper

• Electrically erasable and setable. Requires no power while displaying image.
• [http://www.gyriconmedia.com](http://www.gyriconmedia.com)
• [http://www.media.mit.edu/micromedia/elecpaper.html](http://www.media.mit.edu/micromedia/elecpaper.html)
Braille output devices

• History of braille
  http://www.brailler.com/braillehx.htm
Com board
Write on displays

- 1024 x 768 and 1280 x 1024
- 16 Million colors
- 512 pressure levels
- Accuracy down to +/- 0.02 inches!
- Cost $1800-$3600 currently
- See [www.wacom.com](http://www.wacom.com)
- (images copyright Wacom)
Specialized devices for a specific vertical (stock traders)

Circa 1870

Circa 2003
Voice Synthesis

• **Voice Browsers** [http://www.w3.org/TR/NOTE-voice](http://www.w3.org/TR/NOTE-voice)

• AT&T Labs has a nice demo page [http://www.research.att.com/~ttsweb/cgi-bin/ttsdemo](http://www.research.att.com/~ttsweb/cgi-bin/ttsdemo)

• Nice page at Bell Labs has a speech synthesis demo applet [http://www.bell-labs.com/project/tts/voices.html](http://www.bell-labs.com/project/tts/voices.html)
Speech

• **G:**
  - Supports users with limited mobility
  - Supports a natural way that people communicate
  - Compatible with telephone infrastructure
  - Simple choices (Yes/No, A/B/C, Up/Down)
  - Illiterate users

• **B:**
  - What language to speak – what dialect
  - Slow method of communicating (versus screen)
  - Complex interactions are difficult
  - 1 Dimensional vs. 2D of visual screen
  - No persistence of choices / ability to “cursor” through menu items, requires memory of items before selection – not “scannable” like a screen
Screen Readers

- [http://www.readplease.com](http://www.readplease.com)
- Execute readplease demo here. Using the text from website.
Robotic Arms, etc.

- www.abb.com
The Hand – a wonderful example of design

- Images copyright Scavone 2002
  [http://www.dartmouth.edu/~anatomy/wrist-hand/muscles/](http://www.dartmouth.edu/~anatomy/wrist-hand/muscles/)
Robotic hands

- On hand based [http://www.osci.ttu.edu/AngelaWeb/thesis.html](http://www.osci.ttu.edu/AngelaWeb/thesis.html)
- [http://www.caip.rutgers.edu/~bouzit/lrp/hand.html](http://www.caip.rutgers.edu/~bouzit/lrp/hand.html)
Other Output Devices

- Music, Sounds, Speech
- 3D GUI vs. 2D GUI
- Smell / odor generators
- Special scientific effectors
  - Physical – Light, Heat, Pressure, Temperature, Movement/Motion
  - Electrical – Voltage, Resistance, Capacitance
Wearable Computing

- http://www.media.mit.edu/wearables/
• [http://kaz.med.wisc.edu/TDU.htm](http://kaz.med.wisc.edu/TDU.htm)
Finger Array

• [http://kaz.med.wisc.edu/49-point.html](http://kaz.med.wisc.edu/49-point.html)
Ultimate Interface Device
Computer Vision

- [http://www.visualprosthesis.com/etumble.htm](http://www.visualprosthesis.com/etumble.htm)
- [http://www-2.cs.cmu.edu/~cil/vision.html](http://www-2.cs.cmu.edu/~cil/vision.html)
Brain Controlled Computers

• Matt Nagle has a chip that was placed on his brain that translates his thoughts to a computer. He is connected to the computer via a cable that is screwed into his head.

• John Donoghue, a professor of neuroscience at Brown University, his company Cyberkinetics has developed an implant called BrainGate.

• [Link to Guardian article](http://www.guardian.co.uk/life/feature/story/0,13026,1448140,00.html)
• [Link to Cyberkinetics](http://donoghue.neuro.brown.edu/motor.php)
• See video [here](http://a1112.g.akamai.net/7/1112/492/03312000/www.wired.com/news/audio/wmp/high/CyberkineticsDemo.wmv)
• Q: What should the UI look like for a direct brain interface (no screen with a cursor)?
• Advanced Topics in Computer and Human Vision
http://www.wisdom.weizmann.ac.il/~armin/AdvVision02/course.html
– Interesting research presentations
Links

• http://www.microsoft.com/speech/
• Machine Emotional Intelligence http://www.etc.tuiasi.ro/cin/Courses/Epiom/Literature/Picardetal.pdf