Lecture 10

Interaction Devices

8.2 Keyboards
8.3 Pointing Devices

Keyboard Layouts

Where should the keys go?

- **Speed of Performance Issues**
- **QWERTY layout**
  - Basically a random layout
  - Standard in use and taught extensively
- **Dvorak layout**
  - Based on frequency of letters in words and minimizing finger travel
  - Faster than QWERTY
    - reduces finger travel distances by at least one order of magnitude
    - Actual performance shows only 2.6% faster overall
  - Acceptance has been slow despite the dedicated efforts of some devotees
  - it takes about 1 week of regular typing to make the switch, but most users have been unwilling to invest the effort
- **Chorded layouts (More than one key pressed at a time)**
  - Very fast
  - Hard to learn

Keyboard Layouts (cont.)

- **Learning Issues**
  - **ABCDE style**
    - 26 letters of the alphabet laid out in alphabetical order nontypists will find it easier to locate the keys
  - **IBM PC keyboard**
    - backslash key where most typists expect SHIFT key
    - placement of several special characters near the ENTER key
- **Repetitive Strain Injury Issues**
  - Number pad layout
  - Wrist and hand placement
  - Minimizing movement actually causes Repetitive Strain Injury (RSI)
  - Semi-circular designs for keyboard

Keyboard 2003

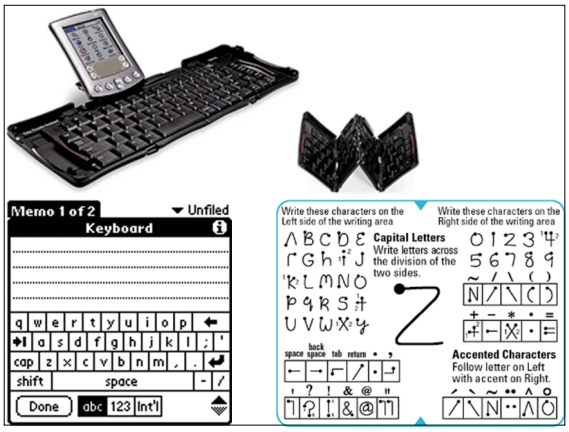
- Adesso Tru Form USB Touchpad & Keyboard
- Note contoured “ergonomic” shape

Keyboard Layouts (cont.)

- **Function keys**
  - **Learning issues**
    - typically simply labeled F1, F2, etc, though some may also have meaningful labels, such as CUT, COPY, etc.
    - users must either remember each key's function, identify them from the screen's display, or use a template over the keys in order to identify them properly
    - meaning of each key can change with each application
  - **Speed of performance issues**
    - can reduce number of keystrokes and errors
    - placement on keyboard can affect efficient use because whole hand moves
    - frequent movement between keyboard home position and mouse or function keys can be disruptive to use
    - Alternative: use closer keys (e.g. ALT or CTRL) and one letter to indicate special function
  - **Feedback (Error Rate)**
    - lights next to keys used to indicate availability of the function, or on/off status

Keyboard Layouts (cont.)

- **Keyboard and keypads for small devices**
  - Wireless or foldable keyboards
  - Virtual keyboards
  - Cloth keyboards
  - Soft keys
  - Pens and touchscreens



Keying for small devices: Fastap

- http://www.digitwireless.com/
- Letter keys raised above number keys
- Note: position of keys varies; 3rd device's small trackball

Keying Speeds

- Seconds/stroke
  - Best: 0.060
  - Average touch typist typing text: 0.158 - 0.231
  - Typing random letter: 0.462 - 0.500
  - Unskilled typing of text: 1.154
  - For UI modeling, for a single key press: 0.200

Pointing Devices

- Pointing Devices
  - Joystick (invented 1940's)
  - Trackball (invented 1940's)
  - Digitizing Tablet (invented 1960's)
  - Mouse (invented 1967)
  - Touch Screen (invented 1971)
  - Eye Tracker (invented 1980's)
  - Brain Activity Sensors (invented 1990's)
  - Haptic (touch) sensing 3D device (invented mid-1990's)

Mouse 2003

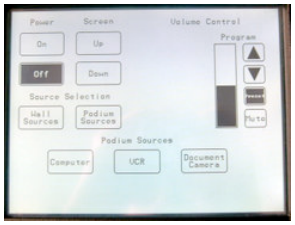
- Microsoft
- Wireless, optical
- Note ergonomic shape, integrated scrollbar

Tablet

- Wacom Intuos2
- Drawing surface as well as control

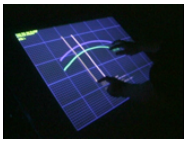
Touch Screen

Podium Controls



- No learning required; good for children
- Walk-up and use situations
- Finger activation requires large space for button
- Can be stylus activated such as PDA

Multi-Touch Interaction Research - Jeff Han



- Bi-manual, multi-point, and multi-user interactions on a graphical interaction surface
  - force-sensitive
  - table style implementation measures 36"x27"
  - rear-projected sensing resolution of better than 0.1" at 50Hz
- http://mrl.nyu.edu/~jhan/ftirtouch

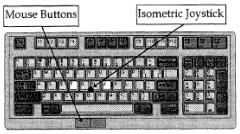
Finger Touchpad

- Portable computer: Apple Powerbook G3
- Button below touchpad

Joystick 2003

- Logitech WingMan Joystick
- Note multiple controls and ergonomic shape

Finger Joystick



- Portable computer: IBM Trackpoint II on IBM laptop computers
- Isometric joystick

Joystick - Mouth

- Special accessibility: Infogrip Quadjoy
- Isometric joystick controlled by mouth, selection by sip and puff switch

Head Mouse

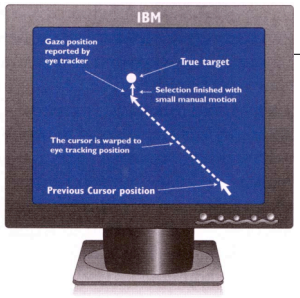
- Special accessibility: Infogrip Headmaster plus
- Move head to move cursor, puff on tube to select

Footmouse

- Special accessibility: Hunter Digital “No Hands” Mouse
- Left pedal for mouse clicks, right for cursor movement

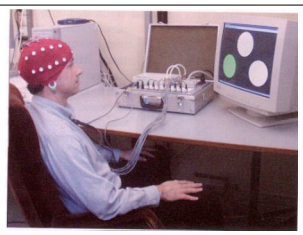
Eye Tracker

- Special accessibility: Eye aRe glasses
- Detects simple eye movement



MAGIC
pointing on screen.
(IBM, 2001)

Brain Tracker

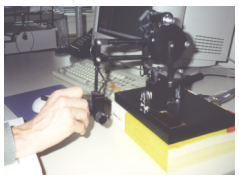


- Special accessibility: EEG system
- 22.0 seconds on average to select a letter

SpaceBall

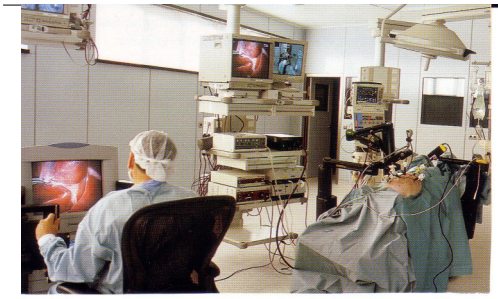
- Spaceball
- Move or rotate 3D by gently pushing, pulling or twisting the ball. Cursor then moves in the direction of the force or twist applied.

3D Haptics Device



- 3D control + touch display: SensAble PHANToM
- Commercially available

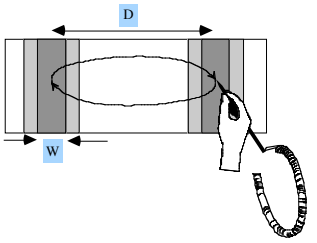
Telesurgery with Haptics



How do we know which device is best?

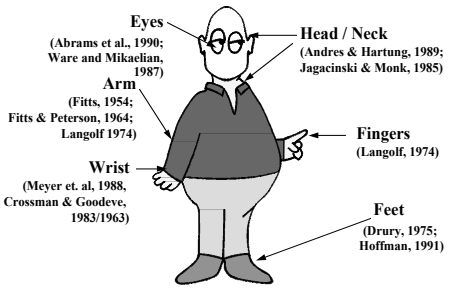
- Tasks
  - Pointing
  - Dragging
  - Typing/Pointing (Mode Switching)
  - Drawing
- Performance Measures (ISO 9241, Part 9)
  - Learning time
  - Practiced performance time
  - Accuracy (error rate)
  - Satisfaction of use
  - Fatigue and strain

Fitts Law

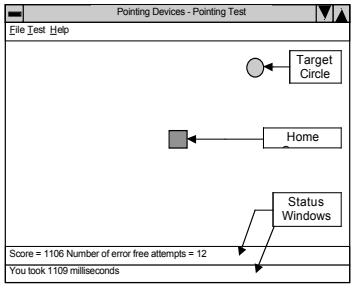


$$Time_{position} = a + b\log_2(\frac{Distance}{Width} + 0.5)$$

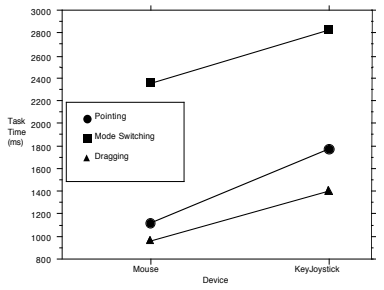
Limbs that follow Fitts Law



Fitts Pointing Task on the Computer



Pointing Time: Skilled Users
(Douglas & Mithal, 1997)



Comparing Device Pointing Times

- Fitts Law applies to computer pointing devices and prediction!
  Pointing time = a + b log2 (D/W + .5)
  - Mouse
    - a= 1.03; b=.096
    - Average pointing time approximately 1.1 sec (NOTE: This is about 5 times slower than keying.)
    - Fastest and most accurate pointing device
  - Tablet
    - About same speed as mouse
    - Slightly higher error rate than mouse
  - Trackball
    - About 30% slower than mouse
  - Joystick
    - About twice as slow as the mouse
  - Touchpad
    - About 20% slower than the joystick

What is the best pointing device?

- Mouse is the superior device for pointing
  - Positioning time is faster overall, at every size/distance
  - Error rate significantly lower
  - Learning is the most rapid
  - Rate of movement nearly maximal with respect to hand/eye coordination (Fitts Law)
- Semantics of mouse actions integrated into OS
  - one, two, three button mouse
  - single, double, triple clicking; dragging
  - Menu functions: pull-down, pop-up, hierarchical
- When is the mouse not the superior device?
- Other variables
  - Other tasks: drawing
  - Cost, durability, space requirements, weight
  - likelihood to cause repetitive-strain injury
  - compatibility with other systems

8.4 Speech & Auditory Interfaces
8.5 Displays

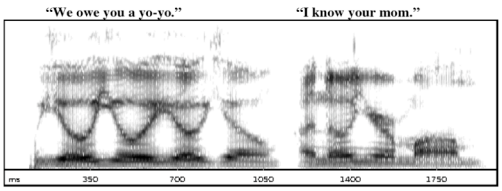
Auditory interfaces

- **Audio tones, audiolization, and music**
  - **Sound feedback can be important:**
    - **to confirm actions**
    - **offer warning**
    - **for visually-impaired users**
    - **music used to provide mood context, e.g. in games**
    - **can provide unique opportunities for user, e.g. with simulating various musical instruments**

Speech Interfaces

- Human Language Processing
  - Stages
    - Speech Recognition
    - Natural Language Understanding (NLP)
    - Natural Language Production (NLP)
    - Speech Synthesis
  - Speech processing totally separate from NLP
  - Speech recognition and NL understanding much harder than NL production and speech synthesis
  - Speech processing is usually real-time interaction
  - NLP is usually text processing and not real-time interaction

Speech Recognition- A very hard problem!



Speech recognition

- Speech recognition still does not match the fantasy of science fiction:
  - Only successful for limited vocabulary tasks with acceptable failures
  - Most suitable when hands cannot be used
  - Voice-controlled editor versus keyboard editor
    - lower task-completion rate
    - lower error rate
  - May be disturbing in some environments
  - Does not require natural language systems
  - Most useful in specific applications, such as to benefit handicapped users

Speech recognition

- Dimensions of difficulty
  - Isolated (discrete) words vs. continuous speech
    - Discrete: 90- to 98-percent reliability for 20 to 200 word vocabularies
    - Continuous
      - Difficulty in recognizing boundaries between spoken words
      - Words acoustically confusable
        - » "we owe you a yo-yo"
        - » "recognize speech" or "wreck a nice beach"
  - Vocabulary size
    - Search increases exponentially with vocabulary size
  - Speaker dependent vs. independent
    - Speaker dependent must be trained: go through vocabulary twice
    - Speaker independent very limited application
  - Noisy environment

Speech Processing

- Stored Speech systems
- Speech Synthesis systems

Stored Speech synthesis

- **Voice information systems**
  - Stored speech commonly used to provide information about tourist sites, government services, after-hours messages for organizations
  - Low cost
  - Voice prompts
  - Deep and complex menus frustrating
  - Slow pace of voice output, ephemeral nature of speech, scanning and searching problems
  - Applications
    - Voice mail
    - Handheld voice recorders
    - Audio books
    - Instructional systems

Speech Synthesis

- Converts text to language sounds (phonemes)
- Can choose pitch, speed, type of voice
- Does not handle continuous speech well
  - Conversion is one word to a sequence of sounds
  - Lacks cadence
  - Lacks emphasis in loudness and speed of delivery

Speech synthesis

- Speech generation
  - Michaelis and Wiggins (1982) suggest that speech generation is "frequently preferable" under these circumstances:
    - The message is simple.
    - The message is short.
    - The message will not be referred to later.
    - The message deals with events in time.
    - The message requires an immediate response.
    - The visual channels of communication are overloaded.
    - The environment is too brightly lit, too poorly lit, subject to severe vibration, or otherwise unsuitable for transmission of visual information.
    - The user must be free to move around.
    - The user is subjected to high G forces or anoxia

Demo

Displays

- **The display has become the primary source of feedback to the user from the computer**
  - **The display has many important features, including:**
    - Physical dimensions (usually the diagonal dimension and depth)
    - Resolution (the number of pixels available)
    - Number of available colors, color correctness
    - Luminance, contrast, and glare
    - Power consumption
    - Refresh rates (sufficient to allow animation and video)
    - Cost
    - Reliability

Displays

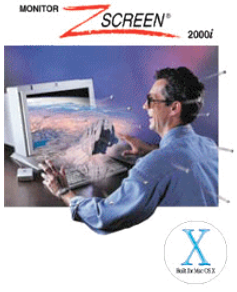
Human Factors Issues:

- **Realism and Quality (Psychophysics)**
- **Portability**
- **Privacy**
- **Simultaneity (Screen Real Estate)**

Novel Display technology

- Electronic ink
  - Paper like resolution
  - Tiny capsules with negatively and positively charged particles
- Braille displays
  - Pins provide output for the blind
- 3D Display with Stereo Glasses
  - Two images displayed, one for each eye
  - Depends on brain of viewer to “fuse” the image as 3D (depth)

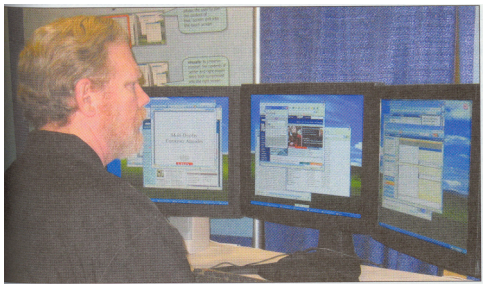
3D Display with Stereo Glasses



Displays – Large

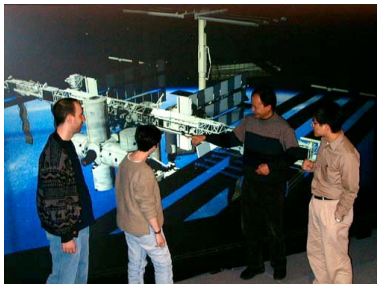
- **Large displays**
  - Multiple desktop displays
  - Informational wall displays
  - Interactive wall displays

Multi Display (Desktop)



Multiple Displays (Avionics)

Princeton Wall Display



"Walkaround" display with Stereo Glasses

Displays Head Mounted

- **Heads-up and helmet mounted displays**
  - A heads-up display can, for instance, project information on a partially silvered widescreen of an airplane or car
  - A helmet/head mounted display (HMD) moves the image with the user
  - 3D images

Head Mounted Display

Head Mounted Display & Data Glove (Virtual Reality)

Small displays (Mobile phone)

- **640 x 480 is *large* display!**
  - **Custom designs to take advantage of every pixel**
  - **Okay for linear reading, but making comparisons can be difficult**
- **Currently mobile devices used for brief tasks, except for game playing**
- **Multi-media (and function)**
  - **Camera phones**
  - **MP3 players**
  - **Web browsing difficult**
- **Optimize for repetitive tasks**

Animation, image, and video

- **Accelerated graphics hardware**
- **More information shared and downloaded on the web**
- **Scanning of images and OCR**
- **Digital video**
- **CDROMS and DVDs**
- **Compression and decompression through MPEG**
- **Computer-based video conferencing**