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 gains only 2-3% faster overall
    - Estimated savings of 20 hours per year and doesn’t require retraining
    - 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 non-typists will find it easier to locate the keys
  - **IBM PC keyboard**
    - Dedicated 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
    • 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/](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

- 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

- 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
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**

\[ \text{Time}_{\text{position}} = a + b \log_2 \left( \frac{\text{Distance}}{\text{Width}} + 0.5 \right) \]

**Limbs that follow Fitts Law**

- Eyes
  - (Abrams et al., 1990; Ware and Mikulic, 1987)
- Head / Neck
  - (Andres & Hartung, 1989; Jagacinski & Monk, 1985)
- Arm
  - (Fitts, 1954; Fitts & Peterson, 1964; Langfell, 1974)
- Fingers
  - (Langolf, 1974)
- Wrist
  - (Meyer et al., 1988; Crossman & Goodhue, 1983/1963)
- Feet
  - (Drury, 1975; Hoffman, 1991)

**Fitts Pointing Task on the Computer**

Score = 1106
Number of error free attempts = 12
You took 1109 milliseconds
Comparing Device Pointing Times

- Fitts Law applies to computer pointing devices and prediction:
  \[ \text{Pointing time} = a + b \log_2 (D/W + 0.5) \]

  - Mouse:
    \[ \text{a} = 1.03, \text{b} = 0.096 \]
    Average pointing time approx. 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 20% slower than mouse
    - About 20% slower than mouse
  - Joystick:
    - About 30% slower than mouse
  - Touchpad:
    - About 20% slower than 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 NLP 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

- 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

- Dimensions of difficulty
  - Isolated (discrete) words vs. continuous speech
    - Discrete: 90-98 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