Interacting Devices

Unit - 3

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chord keyboard

e-reader

gloves and rings

handheld

joystick

keyboard

mouse

pedal

pen computer

phone

reference object

stylus

tablet

touch pad

touch screen

trackball

watch

miscellaneous

Interaction Devices

- **The Standard: QWERTY (or Sholes) Keyboard**
- **Mobile devices are driving the need for future input devices**
  - **Pointing devices (mouse, touch screen)**
  - **Gestural input**
  - **Two-handed input**
  - **3-d pointing**
  - **Voice input/output**
  - **Wearable devices**
  - **Whole body involvement**
  - **Niche applications**
    - **Eye-trackers**
    - **Data Gloves**
    - **Haptic/force-feedback**
    - **Brain-controlled mouse movement**

Interaction Devices

- **Multimodal interfaces**
  - **Combine several modes of input/output**
  - **E.g., voice commands with pointing devices**
- **Likely direction**
  - **Giving users the ability to switch between modes depending on their needs**
  - **E.g., Driving a car**
    - **Operate navigation systems with touch or voice input**
    - **Invoke visual or voice output based on location (e.g., moving in traffic vs. at a stop sign)**
    - **DB adjustment for ambient noise**

Interaction Devices

- **Context-aware computing**
  - **Sensors:**
    - **Global Positioning System (GPS)**
    - **Cell-phone sources**
    - **Wireless connections**
  - **Make detailed information available about the users surroundings**
    - **Restaurants, gas stations**
    - **Museum visitors or tourists**
    - **Auto-connect to a printer based on room location**

Interacting Devices

- Computer-processor speeds and storage capabilities has been matched by improvements in many input/output devices.
- Ten-character-per-second Teletypes have been replaced by high-speed mega-pixel graphical displays for output.
- Discuss in this lecture:
  - Keyboards and Keypads
  - Pointing Devices
  - Speech and Auditory Interfaces
  - Displays – Small and Large

Keyboard Layouts

Keyboards and Keypads

- **QWERTY**
  - 1870 Christopher Latham Sholes
  - good mechanical design and a clever placement of the letters that slowed down the users enough that key jamming was infrequent
  - Beginners approximate 1 keystroke per second
  - Average office worker is 5 keystrokes per second (50 words per minute)

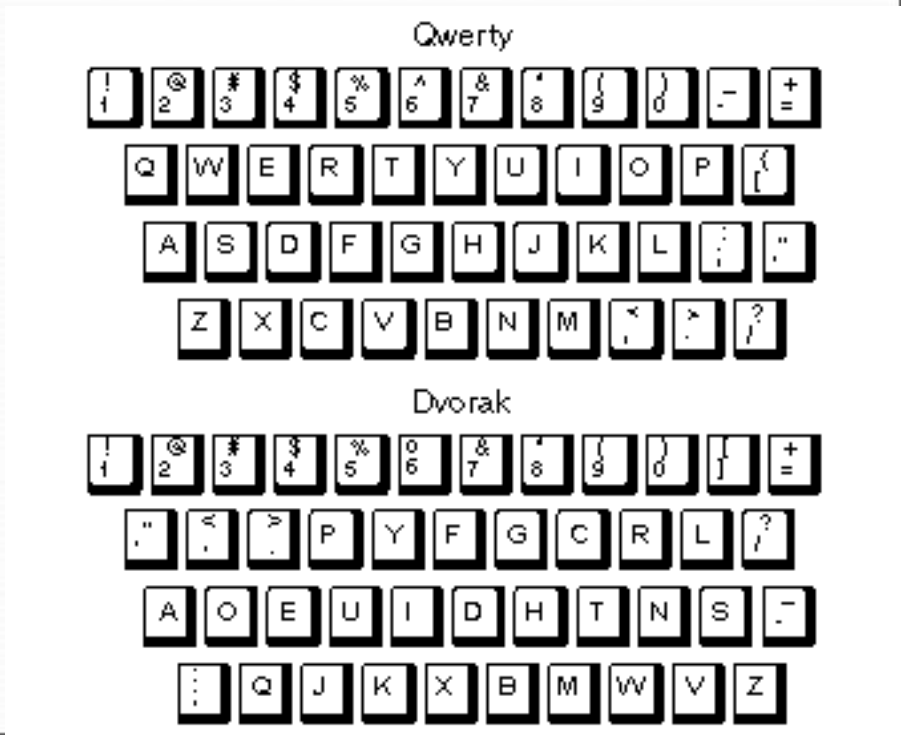
Keyboard Layouts

- **Dvorak layout**

  - 1920
  - reduces finger travel distances by at least one order of magnitude
  - 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

Keyboards Layouts

- QWERTY
  - Keep frequently used letters apart,
  - Slow down users to avoid key jamming
- Dvorak
  - Reduces finger travel time
  - Increases speed, reduces errors



Other Keyboard Layouts

- Potential for higher rates of information input
  - Courtroom recorders (300 words per minute)
  - Piano Keyboard
    - Allows several finger presses at once
    - Responsive to different pressures and durations
  - Chord keyboards
  - One-handed keyboards
    - Useful for tasks requiring one hand manipulation of an object

Keyboards and Keypads

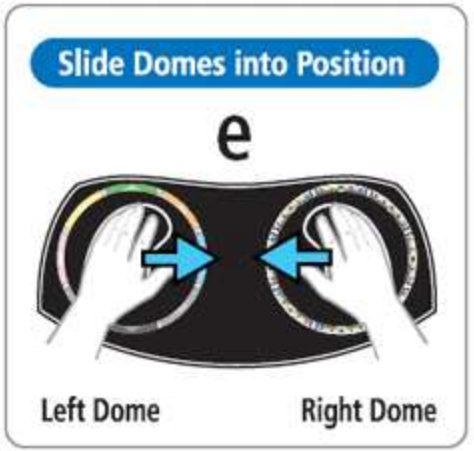
- Reduction of ulnar abduction and pronation
- Ulnar tunnel syndrome
  - Ulnar tunnel syndrome is caused by pressure on the ulnar nerve at the wrist
  - This nerve is found on the pinkie-finger side of the wrist

Number Pads

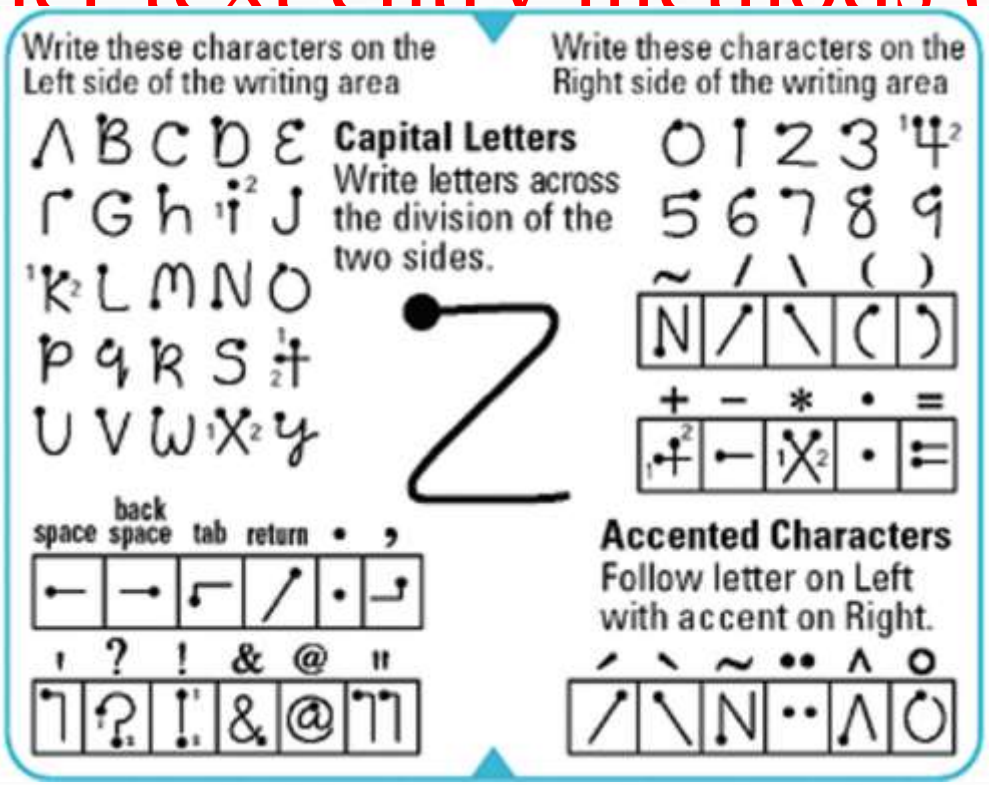
- Number Pads – phone pads versus calculator pads
  - Most computer keyboards use the calculator layout
  - Performance is slightly better with the phone layout

Keyboards Layouts

- Keyboard for those with disabilities
  - Combination of small hand movements and small finger presses selects the letters and controls the cursor
  - No finger or wrist movement is needed
  - Helpful to users with carpal tunnel syndrome or arthritis
  - Each dome slides into one of eight zones to type a character
  - Either dome can slide first or move both at the same time.
  - Domes slide toward the center of their color or character zones. (not directly at the characters)
  - Slide the right dome to the zone of the character you wish to type; slide the left dome to the color of that character.



Other text entry methods (cont.)



Another method is to handwrite on a touch sensitive surface, typically with a stylus using Graffiti® on the Palm devices

Pointing Devices

Pointing devices are applicable in six types of interaction tasks:

- **1. Select:**
  - **user chooses from a set of items.**
  - **used for traditional menu selection, identification of a file in a directory, or marking of a part in an automobile design.**
- **2. Position:**
  - **user chooses a point in a one-, two-, three-, or higher-dimensional space**
  - **used to create a drawing, to place a new window, or to drag a block of text in a figure.**
- **3. Orient:**
  - **user chooses a direction in a two-, three-, or higher-dimensional space.**
  - **direction may simply rotate a symbol on the screen, indicate a direction of motion for a space ship, or control the operation of a robot arm.**
- **4. Path:**
  - **user rapidly performs a series of position and orient operations.**
  - **may be realized as a curving line in a drawing program, the instructions for a cloth cutting machine, or the route on a map.**
- **5. Quantify:**
  - **user specifies a numeric value.**
  - **usually a one-dimensional selection of integer or real values to set parameters, such as the page number in a document, the velocity of a ship, or the amplitude of a sound.**
- **6. Text:**
  - **user enters, moves, and edits text in a two-dimensional space. The**
  - **pointing device indicates the location of an insertion, deletion, or change.**
  - **more elaborate tasks, such as centering; margin setting; font sizes; highlighting, such as boldface or underscore; and page layout.**

Pointing Devices

Direct control devices (easy to learn and use, but hand may obscure display)

- Lightpen
- Touchscreen
- Stylus

Indirect control devices (take time to learn)

- Mouse
- Trackball
- Joystick
- Trackpoint
- Touchpad
- Graphics tablet

Non-standard devices and strategies (for special purposes)

- Multitouch tablets and displays
- Bimanual input
- Eye-trackers
- Sensors
- 3D trackers
- DataGloves
- Boom Chameleon
- Haptic feedback
- Foot controls
- Tangible user interfaces
- Digital paper

Criteria for success

- Speed and accuracy
- Efficacy for task
- Learning time
- Cost and reliability
- Size and weight

Direct-control pointing devices

- **lightpen**
  - enabled users to point to a spot on a screen and to perform a select, position, or other task
  - it allows direct control by pointing to a spot on the display
  - incorporates a button for the user to press when the cursor is resting on the desired spot on the screen
  - lightpen has three disadvantages: users' hands obscured part of the screen, users had to remove their hands from the keyboard, and users had to pick up the lightpen

Direct-control pointing devices (cont.)

- **Touchscreen**
  - allows direct control touches on the screen using a finger
  - early designs were rightly criticized for causing fatigue, hand-obscuring-the-screen, hand-off-keyboard, imprecise pointing, and the eventual smudging of the display
  - lift-off strategy enables users to point at a single pixel
  - the users touch the surface
  - then see a cursor that they can drag around on the display
  - when the users are satisfied with the position, they lift their fingers off the display to activate
  - can produce varied displays to suit the task
  - are fabricated integrally with display surfaces

Direct-control pointing devices (cont.)

Tablet PCs and Mobile Devices:

- **Natural to point on the LCD surface**
- **Stylus**
- **Keep context in view**
- **Pick up & put down stylus**
- **Gestures and handwriting recognition**

Indirect pointing devices

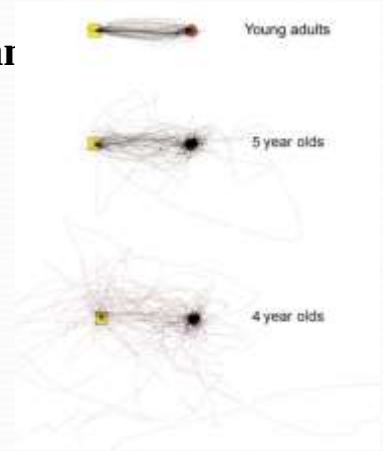
- **mouse**
  - the hand rests in a comfortable position, buttons on the mouse are easily pressed, even long motions can be rapid, and positioning can be precise
- **trackball**
  - usually implemented as a rotating ball 1 to 6 inches in diameter that moves a cursor
- **joystick**
  - are appealing for tracking purposes
- **graphics tablet**
  - a touch-sensitive surface separate from the screen
- **touchpad**
  - built-in near the keyboard offers the convenience and precision of a touchscreen while keeping the user's hand off the display surface

Comparison of pointing devices

- **Human-factors variables**
  - **speed of motion for short and long distances**
  - **accuracy of positioning**
  - **error rates**
  - **learning time**
  - **user satisfaction**
- **Other variables**
  - **cost**
  - **durability**
  - **space requirements**
  - **weight**
  - **left- versus right-hand use**
  - **likelihood to cause repetitive-strain injury**
  - **compatibility with other systems**

Comparison of pointing devices (cont.)

- **Some results**
  - **direct pointing devices faster, but less accurate**
  - **graphics tablets are appealing when user can remain with device for long periods without switching to keyboard**
  - **mouse is faster than isometric joystick**
  - **for tasks that mix typing and pointing, cursor keys a faster ar users to a mouse**
  - **muscular strain is low for cursor keys**

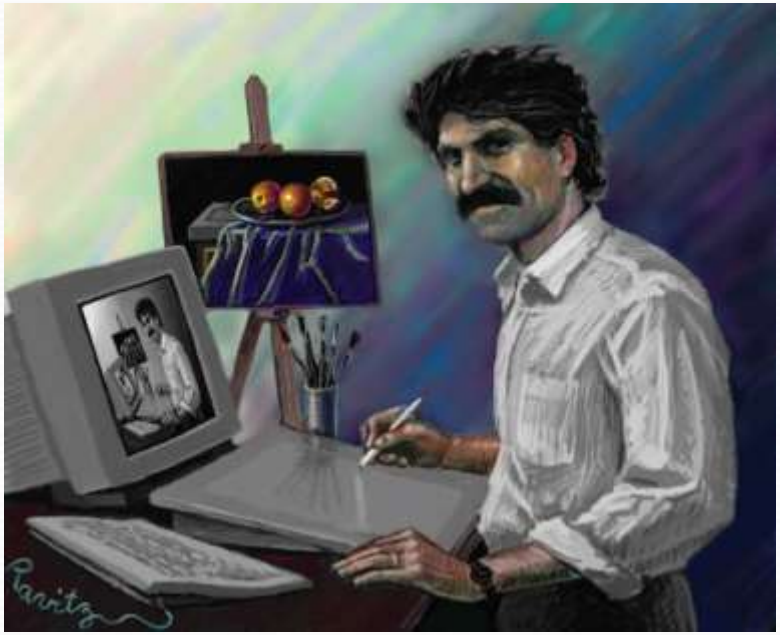


- **Fitts' Law**
  - **Index of difficulty = log2 (2D / W)**
  - **Time to point = C1 + C2 (index of difficulty)**
  - **C1 and C2 and constants that depend on the device**
  - **Index of difficulty is log2 (2*8/1) = log2(16) = 4 bits**
  - **A three-component equation was thus more suited for the high-precision pointing task:**
  - **Time for precision pointing = C1 + C2 (index of difficulty) + C3 log2 (C4 / W)**

Novel devices

1. Foot controls
2. Eye-tracking
3. Multiple-degrees-of-freedom devices
4. DataGlove
5. Haptic feedback
6. Bimanual input
7. Ubiquitous computing and tangible user interfaces
8. Handheld devices
9. Smart pens
10. Table top touch screens
11. Game controllers

Novel devices (cont.)



Speech and auditory interfaces

- Speech recognition still does not match the fantasy of science fiction:
  - demands of user's working memory
  - background noise problematic
  - variations in user speech performance impacts effectiveness
  - most useful in specific applications, such as to benefit handicapped users

Speech and auditory interfaces (cont.)

Opportunities

- When users have vision impairments
- When the speaker's hands are busy
- When mobility is required
- When the speaker's eyes are occupied
- When harsh or cramped conditions preclude use of a keyboard

Technologies

- Speech store and forward
- Discrete-word recognition
- Continuous-speech recognition
- Voice information systems
- Speech generation

Obstacles to speech recognition

- Increased cognitive load compared to pointing
- Interference from noisy environments
- Unstable recognition across changing users, environments, and time

Obstacles to speech output

- Slow pace of speech output when compared to visual displays
- Ephemeral nature of speech
- Difficulty in scanning/searching

Speech and auditory interfaces (cont.)

- **Discrete word recognition**
  - recognize individual words spoken by a specific person; can work with 90- to 98-percent reliability for 20 to 200 word vocabularies
  - Speaker-dependent training, in which the user repeats the full vocabulary once or twice
  - Speaker-independent systems are beginning to be reliable enough for certain commercial applications
  - been successful in enabling bedridden, paralyzed, or otherwise disabled people
  - also useful in applications with at least one of the following conditions:
    - speaker's hands are occupied
    - mobility is required
    - speaker's eyes are occupied
    - harsh or cramped conditions preclude use of keyboard
  - voice-controlled editor versus keyboard editor
    - lower task-completion rate
    - lower error rate
  - use can disrupt problem solving

Speech and auditory interfaces (cont.)

- **Continuous-speech recognition**
  - **Not generally available:**
    - **difficulty in recognizing boundaries between spoken words**
    - **normal speech patterns blur boundaries**
    - **many potentially useful applications if perfected**
- **Speech store and forward**
  - **Voice mail users can**
    - **receive messages**
    - **replay messages**
    - **reply to caller**
    - **forward messages to other users, delete messages**
    - **archive messages**
- **Systems are low cost and reliable.**

Speech and auditory interfaces (cont.)

- **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
  - Voice mail
  - Handheld voice recorders
  - Audio books
  - Instructional systems

Speech and auditory interfaces (cont.)

- **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**

Speech and auditory interfaces (cont.)

- **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**

Displays – Small and Large

- **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 – Small and Large (cont.)

Usage characteristics distinguish displays:

- **Portability**
- **Privacy**
- **Saliency**
- **Ubiquity**
- **Simultaneity**

Display technology

- **Monochrome displays**
  - **are adequate, and are attractive because of their lower cost**
- **RGB shadow-mask displays**
  - **small dots of red, green, and blue phosphors packed closely**
- **Raster-scan cathode-ray tube (CRT)**
  - **electron beam sweeping out lines of dots to form letters**
  - **refresh rates 30 to 70 per second**
- **Liquid-crystal displays (LCDs)**
  - **voltage changes influence the polarization of tiny capsules of liquid crystals**
  - **flicker-free**
  - **size of the capsules limits the resolution**
- **Plasma panel**
  - **rows of horizontal wires are slightly separated from vertical wires by small glass-enclosed capsules of neon-based gases**
- **Light-emitting diodes (LEDs)**
  - **certain diodes emit light when a voltage is applied**
  - **arrays of these small diodes can be assembled to display characters**

Display technology (cont.)

- **Electronic ink**
  - **Paper like resolution**
  - **Tiny capsules with negatively and positively charged particles**
- **Braille displays**
  - **Pins provide output for the blind**

Displays – Large and Small (cont.)

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

Displays – Large and Small (cont.)

- **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

Mobile device displays

- Currently mobile devices used for brief tasks, except for game playing
- Optimize for repetitive tasks
- Custom designs to take advantage of every pixel
- DataLens allows compact overviews
- Web browsing difficult
- Okay for linear reading, but making comparisons can be difficult

Animation, image, and video

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