Course Overview

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❖ Input-Output Devices
❖ Interaction Spaces
❖ Interaction Styles
❖ Interaction with Mobile Devices
❖ Speech-Based Interaction
❖ User Assistance
❖ Natural User Interfaces
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Chapter Overview
Interacting with Devices

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Information transfer rates

- Information transfer rates of popular I/O devices
  - output
    - computer screen
    - laser printer
    - loudspeakers
  - input
    - keyboard
    - mouse
    - microphone (speech input)
    - scanner
    - digital camera
Experiment: Combining Interaction

❖ try to use two pointing devices simultaneously
   ❖ e.g. mouse and trackpad on laptop
   ❖ two mice on a desktop

❖ Experiment 1: Move one device vertically, and the other horizontally.
   ❖ What is the resulting movement of the cursor?
   ❖ Could such a setup have advantages for certain tasks?

❖ Experiment 2: Try pressing two different buttons on the two different devices simultaneously.
   ❖ e.g. left button on the mouse, right button on the trackpad
   ❖ What is the outcome?
   ❖ Are there good uses of this setup?
Motivation

❖ the devices used for input and output determine the nature and capacity of information transferred between human and computer

❖ characteristics of the I/O devices influence user interface design to a large degree

❖ the choice of an inappropriate or inadequate design will diminish the performance of the task

❖ combinations of I/O devices can increase the usability of a system
Objectives

❖ identify the main I/O devices used in computer systems
❖ know the important characteristics of these devices
❖ evaluate the suitability of I/O devices for particular purposes or tasks
❖ be able to select an appropriate combination of I/O devices for a specific task
Input and Output Devices
Input and Output Devices

- **I/O devices are hardware elements**
  - connection between the physical human effectors (hands, vocal cords) and sensors (eyes, ears), and the input and output channels of computers
  - also enable communication between users and software
  - usually their properties and behavior can be adapted through software

- **task demands and user preferences affect the choice of input and output devices to use**
  - e.g. the need for hands-free or silent operation
  - special devices or setups for users with disabilities
Controls

❖ **usually software elements shown on the display**
  ❖ used to set preferences and make choices
  ❖ some familiar controls:
    ❖ menus
    ❖ radio buttons, check buttons, toggles, sliders
  ❖ some hardware controls:
    ❖ contrast, brightness, etc. on screens
    ❖ volume on speakers

❖ **some controls are used for both input and output**
  ❖ show users choices or current setting
  ❖ allow users to operate the control
  ❖ example: printer control
Input Devices

❖ purpose
  ❖ entering data into a computer system
  ❖ issuing instructions (commands) to a computer

❖ input device
  ❖ transforms data from the user into a form that a computer system can process
  ❖ together with appropriate software (device drivers)
Overview Input Devices

❖ need to specify the objects and actions of interaction
  ❖ what should be done
  ❖ how can it be done

❖ logical equivalence of input devices
  ❖ different devices can be used for the same input tasks
  ❖ examples
    ❖ mouse, trackpad, pen
    ❖ mouse, cursor keys
    ❖ keyboard, pen
    ❖ keyboard, microphone with speech recognition
Categories of Input Devices

❖ **keys and buttons**
  ❖ keyboards
    ❖ most common (QWERTY, Dvorak, chord, alphabetic)
  ❖ keypads
    ❖ alphabetic, numeric, telephone, calculator, special purpose (remote controls)
  ❖ buttons
    ❖ discrete entry device
    ❖ initiates the transfer of a signal when pressed
  ❖ function keys
    ❖ invoke specific actions
  ❖ cursor keys
    ❖ navigation on the screen
Keyboards as Input Devices

- QWERTY keyboard
- Dvorak keyboard
- alphabetical keyboard
- chord keyboard
- numeric keypad
QWERTY Keyboard

- uses the most common arrangement of alpha and numerical keys.
- required when input data are variable
- many users are trained for using it
- very slow for untrained users
- not designed for 10-finger typing
- keys are distributed strangely
- left hand has to work harder than the right
Ergonomical Dvorak Keyboard

Ergonomical Dvorak Keyboard - Zoom

Alphabetical Keyboard

- arrangement of keys in alphabetical order
- suitable for untrained users
  - slower than the QWERTY or Dvorak keyboards
- in general, avoid its use for PC applications
  - confusing for most users
Pointing Devices

❖ selection of entities on a computer display
  ❖ identification of the entity
  ❖ selection
  ❖ manipulation
    ❖ distinction between multiple operations
Activity: Pointing Devices

❖ identify three pointing devices

❖ what key aspects differentiate the devices
   ❖ consider technology, methods, and usability
Mouse as Input Device

❖ **How many buttons are best?**
❖ ongoing human factors debate

❖ **1 (old Apple mice)**
❖ easier to double click a single button to select an item than to remember which button points and which extends

❖ **2 (Xerox, Microsoft)**
❖ one to point and the other to extend (special commands)
❖ largest population among mouse species

❖ **3 (modern mice, Unix workstations)**
❖ more functions directly available
❖ confusing at first; gets easier with practice
❖ novice or infrequent users often forget which button does what

❖ **4+ (more sophisticated mice, especially for gaming)**

❖ **other selectors**
❖ scroll wheel
❖ touch surface
Mouse Control

❖ **advantages**
- works in small spaces
- can adjust granularity of movement
- inexpensive
- user can keep eye on display
- direct relationship between hand and cursor movement on the dimensions of direction, distance, and speed
- diagonal and continuous movement, spaced control

❖ **problems**
- hand must be removed from the keyboard
- require space beside keyboard movements
- relative mode only
- mechanical mice pick up dust and other debris
- require a certain amount of learned eye-hand coordination
- awkward and difficult for first-time users
Touch Screens

❖ **advantages**
  ❖ direct manipulation
  ❖ direct eye-hand coordination
  ❖ several technologies to choose from
  ❖ pressure-sensitive, resistive, infrared, capacitive
  ❖ faster and easier to learn than other input devices;
  ❖ no command memorization needed
    ❖ user may be led through correct command sequence
    ❖ good for infrequent use
  ❖ minimal training needed, high user acceptance
  ❖ continuous motion in all directions
  ❖ no extra desk space
  ❖ no moving parts
Touch Screens (cont)

- **problems**
  - very fast, but not very accurate
    - “fat” fingers
    - limited resolution
    - difficult to select small targets
  - very slow text and data entry
  - finger/arm may obscure screen
  - overlays may lead to parallax
  - inadvertent activation
  - screen can get dirty (oil from fingers)
  - susceptible to temperature and humidity
  - arm fatigue for conventional computer monitors
    - should be limited to low-frequency usage
Speech Recognition

conversion of spoken language to commands or data

- advantages over other input methods:
  - more natural form of communication
  - less training required
  - does not require the use of hands or other limbs
  - user can carry out multiple other actions
  - opportunities for physically disabled users

- problems
  - limitations of speech recognition systems
    - error prone
  - susceptible to environmental noise
  - impractical in situations where quiet is required
  - natural language capability is not yet attainable by speech recognition systems
  - speech input is not suitable for all input tasks
Brain-Computer Interaction

- simplified versions of electroencephalograms (EEGs)
- interpretation of brain waves
- limited success as computer control and interaction devices
Natural Input Devices

- cameras and similar devices that allow interpretation of “natural” human activities
  - observation of movements for a task
  - gestures

- requires distinction between
  - control activity
    - signals to the computer that something relevant is going to happen
  - intentional activity
    - purposefully performed within a task
  - spurious activity
    - activity unrelated to the task at hand
Eye Tracking

- camera follows the gaze of a user
- often used in usability and physiology experiments
  - recording and analysis of user attention
- sometimes used as input device
  - selection of commands or letters by looking at them
Head Tracking

- head movement to convey control information to the computer
  - limited range of movements
Output Devices

❖ convert information coming from a computer system into some form perceptible by humans
  ❖ visual
  ❖ auditory (non-speech, speech)
  ❖ tactile
    ❖ tactile output for visually-impaired and blind users (e.g., Braille)
Visual Output Devices

- character-based displays
  - liquid-crystal displays [LCDs], flat-panel displays [FPDs]
  - used in stationary devices, in telephones, calculators, etc.
- graphics displays
  - CRTs, LCDs, and other FPDs, 3D
  - HRES graphic displays used in stationary output devices, cockpits, or helmet-mounted displays
- printing devices
  - color vs. black and white; dot matrix, laser, inkjet
  - fax
  - plotters (colored pens)
- microfiche or microfilm
  - require special equipment to read
- videotape
Recent Developments in I/O Devices

- **handwriting recognition/personal digital assistants**
  - 3M Palm Pilot, Go Corp., Sony, Toshiba

- **smart card**
  - thin plastic card, embedded µprocessor and memory
  - information about a user (e.g., employee ID, credit details, etc.) is stored on the card.
  - outputs information to special card readers.

- **biometric device**
  - advanced smart card that contains characteristics about a user such as fingerprints, voice prints, retina prints, or signature dynamics.
Recent Developments (cont.)

- **haptic devices**
  - make it possible for users to touch, with their hands and fingers, virtual computer models as if they were real-world physical objects
  - i.e., feel an object’s mass, explore its texture, and work with its form and shape
  - not many on the market; one of the more interesting ones is from a company called “haptic” (www.haptic.com)\
Recent Developments (cont.)

❖ **wearable computer**
  ❖ Private Eye™ (Reflection Technology)
    ❖ user wears a single high-resolution LCD over one eye, while looking out the other eye; image projected at infinity
    ❖ coupled with a portable computer, and other input devices
  ❖ Wearable Computer™ (Computing Devices International)
    ❖ portable, body-mounted, voice-activated computer
    ❖ recently tested in Bosnia, presently being adopted by the U.S. Armed Services
  ❖ Sixth Sense
    ❖ combination of camera and projector

❖ **helmet-mounted display with speech interface**
  ❖ military applications, “aim-fire” scenarios
Touchy Mouse

❖ Logitech’s WingMan Force Feedback mouse
  ❖ www.logitech.com

❖ incorporates tactile feedback
  ❖ user can feel the edges, contours, densities of virtual objects
  ❖ can make navigation more intuitive

❖ uses a special mousepad with rods connected to tiny motors
Recent Research Areas

❖ **texture sensation**
  ❖ sandpaper system (MIT)
    ❖ uses a motor-driven, force-feedback joystick that uses tiny virtual springs to simulate motion while the user moves the joystick over patches of computationally created textures displayed on a screen

❖ **tracking**
  ❖ Active Badge™ system (Olivetti/DEC)
    ❖ tracks people inside a building
    ❖ used as a communications device
    ❖ can be turned off for privacy
Recent Research Areas (cont.)

- gesture, speech, and gazing
  - two-handed gesturing by voice, and selection by gaze (CMU)
  - “Turn that block upside down.”
Future Trends

❖ **smart rooms**
  ❖ can identify people and interpret their actions
    ❖ house that knows where your kids are and tells you if they are getting into trouble
  ❖ can supervise students during exams ;-
  ❖ research being conducted at MIT
    ❖ Person Finder - Pfinder
      ❖ incorporates video cameras for recognizing faces, expressions, gestures
      ❖ microphones for speech recognition

❖ **smart home**
  ❖ performs activities according to user’s preferences and usual actions
Future Trends (cont.)

- **smart clothes**
  - sort of a personal assistant that you wear
    - tells you the name of people you meet, directions to your next meeting, etc.
  - built-in computer, camera, microphones, other sensors
  - camera built into the frame of eyeglasses that captures images
  - face-recognition software that tells you the name of the person you are looking at by whispering his or her name into your ear
Capabilities and Limitations of I/O Devices
“Degrees of Freedom”

❖ **dimensions**
  ❖ spatial
    ❖ 1D
    ❖ 2D
    ❖ 2.5D
    ❖ 3D

❖ **temporal**
  ❖ 1D
Information Transmission

❖ transfer of information between the device and a human
  ❖ or another device

❖ measured in bits/second
  ❖ best estimate if no exact measures are available

❖ examples
  ❖ screen
    ❖ 2,000 x 1,000 pixels
    ❖ 32 bits color depth
    ❖ 100 Hertz refresh rate
  ❖ keyboard
    ❖ ~ 100 keys
    ❖ ~ 5 modifier keys
    ❖ ~ 10 keys/second typing rate
Persistence

- **duration of the availability of the signal**
  - transient
    - fleeting
    - overwritten by succeeding signals
  - permanent
    - stays available as long as needed
Navigation

❖ “movement” of the user within the interaction space
  ❖ screen: pointing device
  ❖ sound, video: forward, rewind, pause
Activity: Input Device Characteristics

- select an input device and analyze its capabilities and limitations based on the previous categories
  - degrees of freedom
  - information transmission
  - persistence
  - navigation

- do these categories capture the essential characteristics of the device?
  - if not, suggest additional ones
Activity: Output Device Characteristics

- select an output device and analyze its capabilities and limitations based on the previous categories
  - degrees of freedom
  - information transmission
  - persistence
  - navigation
Important Concepts and Terms

- auditory input/output
- brain-computer interaction (BCI)
- button
- camera
- controls
- cursor keys
- display
- handwriting recognition
- human-machine interface
- icon
- input devices
- joystick
- key
- keyboard
- microphone
- monitor
- mouse
- output devices
- pointing devices
- printing devices
- scanner
- screen
- speech recognition
- speech synthesis
- sound
- switch
- tactile input/output
- trackball
- touch screen
- usability
- use case scenarios
- visual input/output
Additional Reading


Chapter Summary

❖ overview of important devices for input to and output from the computer

❖ the characteristics of a device determine its suitability for particular methods and tasks

❖ the selection of I/O devices and methods influences the usability of a user interface substantially

❖ research in novel I/O devices and methods tries to overcome the limitations of screen and paper as most important output, and keyboard and mouse as input devices