CPE/CSC 486: Human-Computer Interaction

Franz J. Kurfess

Computer Science Department

California Polytechnic State University

San Luis Obispo, CA, U.S.A.

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Course Overview

- **Introduction**

- **Cognitive Foundations**

- **Input-Output Devices**

- **Interaction Spaces**

- **Interaction Styles**

- **Interaction with Mobile Devices**

- **Speech-Based Interaction**

- **User Assistance**

- **Natural User Interfaces**

- **Case Studies**

- **Project Presentations**

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Chapter Overview
Interacting with Devices

- ❖ **Agenda**

- ❖ **Motivation**

- ❖ **Objectives**

- ❖ **Input Devices**
  - ❖ Survey
  - ❖ Characteristics
  - ❖ Performance
  - ❖ Advantages and Problems

- ❖ **Output Devices**
  - ❖ Survey
  - ❖ Characteristics
  - ❖ Performance
  - ❖ Advantages and Problems

- ❖ **Important Concepts and Terms**

- ❖ **Chapter Summary**

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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

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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?

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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**

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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**

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Input and Output Devices

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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

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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

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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)

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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

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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

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Keyboards as Input Devices

❖ **QWERTY keyboard**

❖ **Dvorak keyboard**

❖ **alphabetical keyboard**

❖ **chord keyboard**

❖ **numeric keypad**

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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**

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Ergonomical Dvorak Keyboard

http://www.ergocanada.com/images/dvorty_2001dqe.jpg

Ergonomical Dvorak Keyboard - Zoom

http://www.ergocanada.com/images/dvorty_2001dqe_right.jpg

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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

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Pointing Devices

❖ **selection of entities on a computer display**

    ❖ identification of the entity

    ❖ selection

    ❖ manipulation

        ❖ distinction between multiple operations

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Activity: Pointing Devices

❖ **identify three pointing devices**

❖ **what key aspects differentiate the devices**

    ❖ consider technology, methods, and usability

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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

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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

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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

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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

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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

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Brain-Computer Interaction

❖ **simplified versions of electroencephalograms (EEGs)**

❖ **interpretation of brain waves**

❖ **limited success as computer control and interaction devices**

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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

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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

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Head Tracking

❖ **head movement to convey control information to the computer**

  ❖ limited range of movements

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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)

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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

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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.

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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)\

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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

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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**

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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

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Recent Research Areas (cont.)

❖ **gesture, speech, and gazing**
  - ❖ two-handed gesturing by voice, and selection by gaze (CMU)
    - ❖ "Turn that block upside down."

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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

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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

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Capabilities and Limitations of I/O Devices

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"Degrees of Freedom"

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

- **temporal**
  - 1D
  -

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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

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Persistence

❖ **duration of the availability of the signal**

  ❖ transient

    ❖ fleeting

    ❖ overwritten by succeeding signals

  ❖ permanent

    ❖ stays available as long as needed

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Navigation

❖ **"movement" of the user within the interaction space**

  ❖ screen: pointing device

  ❖ sound, video: forward, rewind, pause

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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

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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

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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

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Additional Reading

❖ **Gaver, W.W. (1986). Auditory icons: Using sound in computer interfaces. Human-Computer Interaction, 2(2), 167-177.**

❖ **Pentland, A.P. (1996). Smart rooms. Scientific American, 274(4), 68-76. (April issue).**

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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**

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