Chapter 4
Input and Output
Keyboards

• A **keyboard** is an input device used to enter characters at the location marked by the insertion point or cursor
  – Can be built-in, wired, or wireless
  – Converted to ASCII/Unicode by OS
  – Typically contains:
    • Standard alphanumeric keys
    • Numeric keypad
    • Function keys
    • Delete and Backspace keys
    • Ctrl and Alt keys
    • Arrow keys
    • Special-purpose keys
Pointing Devices

• **Pointing devices** are used to:
  – Select and manipulate objects
  – Input data
  – Issue commands to the computer

• Common types of pointing devices:
  – Mouse
  – Pen/stylus
  – Devices that use touch input
Pens/Styluses

• A **stylus** is a pen-like device used to draw or write electronically on the screen
  – Also called digital pen, electronic pen, or pen
  – Pen input is being used for:
    • Photography, graphic design, animation
    • Industrial design, document processing, and healthcare applications
    • Navigating through a document
    • Issuing commands
    • Handwritten input and drawings
Digital Forms

• With **handwriting recognition**, written text can be converted to editable typed text.

• The use of digital forms is increasingly...
Touch Screens

• **Touch screens** are display devices that are touched with the finger to select commands or otherwise provide input to the computer
  – Common on portable computers, smartphones, and other mobile devices
  – Multi-touch screens can recognize input from more than one finger at a time
  – Some support both touch and pen input
  – Surface Hub (large multi-touch wall-mounted display)
  – Table PC (large computer either built into a table or designed to be used on a table)
Perceptual Computing

- Users control devices with 3D gestures, voice commands, and facial expressions
- Noncontact system
- Allows for full body input and input from a slight distance away or through a glass window

The Leap 3D System
Scanners, Readers, and Digital Cameras

• Some devices capture data initially in digital form
• Others capture data from source documents
  – Already exist in physical form (photographs, checks, invoices, or product labels)
  – Source data automation
    • Saves time
    • Increases accuracy
    • Utilizes scanning or reading devices
A **scanner** (optical scanner) is an input device that captures an image of an object in digital form

− Data is typically input as a single image

  • => Bitmapped/Raster Image Representations

− Can scan photos, documents, images, etc.

− Types of scanners

  • **Flatbed scanners** (scan flat objects one page at a time)
  
  • **Portable scanners** (scan objects while on the go)

  • 3D scanners (scan objects in 3D)

  • There are also task-specific scanners, such as receipt and business card scanners
Scanning Quality and Resolution

• Quality of scanned images indicated by optical resolution
  – Measured in number of dots per inch (dpi)
  – Can often be specified when image is scanned
  – Can be changed when scanned image is edited

• Higher resolution means better quality but larger file size
Digital Cameras

• **Digital cameras** take pictures and records them as digital images
  – Can be still cameras and/or video cameras
  – Integrated into portable computers, smartphones, and tablets

• Digital still cameras
  – Primary appeal is that images are immediately available
  – Camera quality is measured in megapixels
  – Typically use flash memory for storage
  – Slight delay when taking photos
Barcodes and Barcode Readers

- **Barcodes** are machine-readable optical codes that represent data as a set of bars
- **Barcode readers** are input devices that read barcodes
- Types of barcodes
  - Read by traditional barcode reader
    - Universal Product Code (UPC)
    - ISBN
    - Code 39
  - Read by mobile apps
    - QR Codes (two-dimensional; hold much more data)
    - Digital watermarks (icons)
Examples of Barcodes and Digital Watermark Icons
Radio Frequency ID (RFID)

• **Radio Frequency Identification (RFID)** is a technology that stores, reads, and transmits data located in RFID tags

• **RFID tags** contain tiny chips and radio antennas
  – Can be attached to objects
  – Read by **RFID readers**
    • Handheld, portal, and stationary
  – Tags only need to be within range of the reader, rather than in line of sight

• Used for a variety of applications
  – Tracking inventory and assets
  – Electronic toll collection
  – Tracking patients in hospitals
  – Ticketing applications
  – IDs (driver licenses, U.S. passports, etc.)
Near Field Communications (NFC)

- **Near Field Communications (NFC)** is a short-range wireless communication standard based on RFID
  - Used to transfer information between smartphones or between a smartphone and an NFC-enable reader
  - Used for contactless mobile payments
    - Credit card or smartphone containing the NFC technology needs to be within an inch or so of the NFC-enabled payment terminal
      - More appropriate than conventional RFID for mobile payments
Optical Mark Readers (OMR) and Optical Character Recognition (OCR)

• Optical mark readers (OMRs) input data from optical forms to score or tally exams, questionnaires, ballots

• **Optical character recognition (OCR)** recognizes text characters and converts them to electronic form as text, not images
  – Identifies each character and convert it to editable text
  – Used to process turnaround documents like monthly bills
  – Read by OCR devices
  – Optical characters are designed to be read by OCR devices but can still be read by humans
Biometric Readers

- **Biometric readers** are used to input biometric data such as an individual’s fingerprint or voice
  - Can be stand-alone readers or built into another piece of hardware
  - Most often used for access control, to authorize electronic payments, and to log on to secure Web sites
Augmented Reality

- Overlays computer generated images on top of real-time images
- Today, most often with smartphones using camera input, location info, and other data
- Displays appropriate information related to images captured by the smartphone

A smartphone AR app pointing at a business district.
Audio Input

• Audio input
  – The process of entering audio data into the computer
  – => Digitized (bit depth x sampling rate)

• Voice input
  – Inputting spoken words and converting them to digital form via microphone or headset
  – Used in conjunction with sound recorder software
  – **Speech recognition systems** enable the device being used to recognize voice input as spoken words
    • Detects Phonemes
    • Can be used for dictation as well to as to issue commands to the device
  – Usually incorporated into smartphones, GPS systems, and other mobile devices
Music Input Systems

- Music input systems input music into a computer or other device
  - Existing music can be input using CDs or a Web download
  - For original compositions, microphones, keyboard controllers, and guitar controllers can be used to input music
  - Inputted music can be edited, saved, played, etc.
Display Devices

• **Display devices** present output visually on some type of screen
  – **Monitors** are display devices typically used with a desktop computer
  – **Display screens** are built into a variety of devices
    • Notebook and other portable computers
    • Smartphones and mobile devices
    • Handheld gaming devices, home entertainment devices, kitchen appliances
    • Digital photo frames, e-book readers, smart watches
    • Digital signage systems, digital billboards
Display Device Characteristics

• Color vs. monochrome displays
  – Images are formed using \textit{pixels}
  – Most displays today are color displays

• CRT vs. flat-panel displays
  – Cathode ray tube (CRT) displays: large, bulky, and heavy
  – Flat-panel displays: take up less desk space; use less power
Size, Aspect Ratio, and Screen Resolution

• Size and aspect ratio
  – Device size measured diagonally from corner to corner
  – Wide variety of sizes available
  – Most are wide-screen displays (16:9 aspect ratio)

• Screen resolution
  – The number of pixels used on a display determines its resolution
  – Affects the amount of information that can be displayed on the screen at one time
  – Can be changed to match users’ preference
What is 720P

- 720p => 720 horizontal scan lines
  - P is for Progressive (non-interlaced)
  - 720 vertical pixels
- Typically 1280 × 720 px
  - 16:9 aspect ratio (AR)
  - HD ready but 1080p is now most common HD
  - Requires ~1/2 bandwidth than 1080p
  - 720p is 1280 x 720 < 1 million pixels
  - 1080p is 1920 x 1080 > 2 million pixels
Video Adapters, Interfaces, and Ports

• Video cards determine the graphic capabilities of a computer
• VGA, DVI, and HDMI are the three most common interfaces to connect monitors to a computer
• Ports exposed in the system unit cases connect monitors to computers
  – Newer option is to use USB ports
Wired, Wireless, and High-Definition Displays

• Wired vs. wireless displays
  – Wired display are physically connected to the system via a cable
  – Wireless displays connect using a wireless network connection (Wi-Fi, Bluetooth)

• High-definition displays
  – Most common HD format is 1080p
  – **Ultra HD (4K)** uses about four times as many pixels as 1080p displays
Flat Panel Display Technologies

- **Liquid crystal displays (LCDs)** use charged liquid crystals between sheets of glass or plastic
  - Requires backlighting
- **Light emitting diode (LED)** displays use LCD panels and LED backlighting
- **Organic light emitting diode (OLED)** displays use layers of organic material
  - Emit visible light so do not require backlighting
  - More energy efficient
  - Are thinner and have a wider viewing angle
  - Incorporated into many digital cameras, smartphones, TVs, and other consumer devices
Electronic Paper (E-Paper) Displays

• **Electronic paper (e-paper)** displays use electronic ink (e-ink)
  – Used for e-readers and other devices
  – Easier to read in direct sunlight
  – Content can change wireless
  – Only uses power to change images, not maintain an image
  – Can be monochrome or color
Other Types of Flat Panel Displays

- **Interferometric Modulator (IMOD) displays**
  - Essentially a complex mirror that uses external light to display images
  - Designed initially for mobile phones and portable devices
  - Images are bright and clear, even in sunlight

- **Plasma displays** use layers of gas between two plates of glass
  - Being replaced by LCDs
Wearable and Touch Displays

- Wearable displays project images from a mobile device to a display screen
  - Smart glasses
- Touch and gesture capabilities
  - Kiosks
  - Portable gaming devices
  - Smartphones
  - Tablets
AR Holographic Displays

Wearable Holographic Displays

• Project images on top of what the person wearing the display is already seeing

• Microsoft HoloLens
  – Essentially a head-mounted computer
  – Does not need to connect to a smartphone or computer to function
Data and Multimedia Projectors

- **Data projectors** (multimedia projectors) display output from a computer to a wall or projection screen
  - Found in classrooms and conference rooms
  - Can be wireless or integrated into devices
  - Some contain an iPod dock
- Pico projectors are pocket-size and connect to mobile and portable devices
- Keyboard projectors project virtual keyboards
- 3D projectors can project images used with 3D glasses or holograms
Printers

- **Printers** produce hard copy
  - Impact printers (dot-matrix)
    - Print mechanism strikes an inked ribbon to transfer ink to the paper
    - Used to produce multipart forms
  - Non-impact printers (ink-jet/laser)
    - Use liquid ink or toner
    - Produce higher quality images
    - Much quieter than impact printers
  - Can be color or black-and-white printers
Laser Printers

• **Laser printers** use toner powder and technology similar to that of a photocopier to produce images on paper

• The standard for business documents
  – Print one entire page at a time
  – Generally faster and have better quality output than ink-jet printers

• Use toner cartridges; toner is transferred to the paper and fused with heat

• Color printers use four toner cartridges
Ink-Jet Printers

• **Ink-jet printers** spray droplets of ink to produce images on paper
  – Use ink cartridges
  – Usually print in color
  – Often the choice for home use
  – Relatively inexpensive with good-quality output
  – Print more slowly than laser printers
  – Potential applications for the future
    • Dispensing liquid metal, computer chips, “printing” human tissue, silk and protein ink, etc.
Printer Characteristics

• Print resolution
  – Measured in dpi (dots per inch) or images per minute (IPM)
  – More dots per inch results in higher quality output
  – 300 dpi for general purpose printing; 1,200 dpi for photographs; 2,400 dpi for professional applications

• Print speed
  – Measured in pages per minute (PPM)
  – Range from about 15 to 65 ppm
• Personal vs. network printers
  – Personal printers connect directly to a single computer
  – Network printers connect directly to a home or an office network; some can perform cloud printing
  – Cloud printing (over Internet often with Web interface)
• Connection options
  – USB connection, wired network, Wi-Fi, Internet
• **Multifunction devices (MFDs) or all-in-ones**
  – Copy, fax, scan, print
3D Printers

- **3D printers** form output in layers to build a 3D version of the desired output
  - Can print using plastic, metal, ceramic, wood, glass, sugar, etc.
  - Additive manufacturing
  - Print customized objects on demand
    - Personal products
    - Medical products
    - Prototypes or custom parts
  - Can contain moving parts
  - Issues such as 3D-printed weapons
Audio Output

- Audio output includes voice, music, and other audible sounds
  - Common audio output devices
    - **Computer speakers**
    - **Headphones, headsets, and earbuds**
Summary

- Keyboards
- Pointing and Touch Devices
- Scanners, Readers, and Digital Cameras
- Audio Input
- Display Devices
- Printers
- Audio Output
- Haptics (critically missing from text)
  - any form of interaction involving touch