Chapter 1

Human–Computer Interaction (HCI)

is a discipline concerned with the study, design, construction and implementation of human centric interactive computer systems.

The Interdisciplinary Design Science of Human-Computer Interaction (HCI) combines knowledge and methods associated with professionals including:

- Psychologists (incl. Experimental, Educational, Social and Industrial Psychologists)
- Computer Scientists
- Instructional and Graphic Designers
- Technical Writers
- Human Factors and Ergonomics Experts
- Anthropologists and Sociologists

Usability goals & measures

Usability Goals

- **Effectiveness**
- **Efficiency**
- **Satisfaction**

Usability Measures

lead more directly to practical evaluation:

- **Time to learn.**
  How long does it take for typical members of the community to learn relevant task?
- **Speed of performance**
  How long does it take to perform relevant benchmarks?
- **Rate of errors by users**
  How many and what kinds of errors are made during benchmark tasks?
- **Retention over time**
  Frequency of use and ease of learning help make for better user retention.
- **Subjective satisfaction**
  Allow for user feedback via interviews, free-form comments and satisfaction scales.

Usability motivations

1. **Life-critical systems**
   Air traffic control, nuclear reactors, power utilities, police & fire dispatch systems, medical equipment
   - High costs, reliability and effectiveness are expected.
   - Length training periods are acceptable to provide error-free performance.
   - Subject satisfaction is less an issue due to well motivated users.
2. **Industrial and commercial uses**
   Banking, insurance, order entry, inventory management, reservation, billing, and point-of-sales systems
   - Ease of learning is important.
   - Speed of performance is important.
   - Subjective satisfaction is fairly important.

   Note// Speed and error rates are relative to cost.

3. **Office, home, and entertainment applications**
   Word processing, electronic mail, computer conferencing, and video game systems, educational packages, search engines, mobile device, etc.
   - Ease of learning, low error rates, and subjective satisfaction are paramount.
   - Infrequent use of some applications means interfaces must be intuitive and easy to use online help is important.
   - Competition cause the need for low cost
4. **Exploratory, creative, and collaborative systems**
   Web browsing, search engines, artist toolkits, architectural design, software development, music composition, and scientific modeling systems.
   Note// Collaborative work (enable more than one user to work together) EX:electronic meeting systems.
5. **Social-technical systems**
   Complex systems that involve many people over long time periods
   Voting, health support, identity verification, crime reporting.
   - Trust, privacy, responsibility, and security are **issues.**
   - Verifiable sources and status feedback are important.
   - Administrators need tools to detect unusual patterns of usage.

Cognitive and perceptual abilities

The human ability to interpret sensory input rapidly and to initiate complex actions makes modern computer systems possible.

Human cognitive processes:

- Long-term and semantic memory
- Short-term and working memory.
- Problem solving and reasoning.
- Decision making and risk assessment.
- Language communication and comprehension
- Search, imagery, and sensory memory
- Learning, skill development, knowledge acquisition, and concept attainment

Personality differences

Carl Jung's theories of personality types.

1. **Extroversion versus introversion.**
   - **Extroverts** focus on external stimuli.
   - **Introverts** rely on their inner ideas and work alone contentedly.
2. **Sensing versus intuition.**
   - **Sensing** types are attracted to established routines.
   - **Intuitive** types like solving new problems.
3. **Perceptive versus judging.**
   - **Perceptive** types like to learn about new situations but may have trouble making decisions.
   - **Judging** types like to make a careful plan and will seek to carry through the plan
4. **Feeling versus thinking.**
   - **Feeling** types are aware of other people's feelings.
   - **Thinking** types are unemotional and like to put things in logical order.

Cultural and international diversity

- Characters, numerals, special characters
- Left-to-right versus right-to-left versus vertical input and reading
- Date and time formats
- Numeric and currency formats
- Weights and measures
- Telephone numbers and addresses
- Names and titles (Mr., Ms., Mme.)
- Social-security, national identification, and passport numbers
- Capitalization and punctuation
- Sorting sequences
- Icons, buttons, colors
- Pluralization, grammar, spelling
- Etiquette, policies, tone, formality, metaphors

Universal Usability

1. **Users with Disabilities**
   The flexibility of desktop, web, and mobile devices makes it possible for designers to provide special services to users who have disabilities.
2. **Older Adult Users**
   Understanding the human factors of aging can help designers to create user interfaces that facilitate access by older adult users.
3. **Younger users**
   They are often frustrated with the use of technology and are endangered by threats surrounding privacy, alienation, pornography, unhelpful peers, and malevolent strangers.
   // Another lively community of users is children, whose uses emphasize entertainment and education. When they become teenagers, they may become highly proficient users who often help their parents or other adults.

Goals for our profession

- Potential research topics
- Providing tools, techniques, and knowledge for system implementers
- Raising the computer consciousness of the general public

- **Short Questions:**
- 1. What is Human-computer Interaction?
- 2. List down the three usability goals.
- 3. Write a note on life critical systems with examples.
- 5.Write short notes on Collaborative Applications.
- 6. Describe shortly about Socio technical systems.
- 7. List any six human cognitive processes.
- 8. What are the three goals of HCI?

- **Long Answer Questions:**
- 9. What are usability goals? State the measures of usability goals.
- 10. Describe the Jung's classifications of personality types.
- 11. List the user-interface design considerations for internationalization?
- 12. Discuss the various deign considerations for older adult users and children.

- Specific and practical **guidelines** that prescribe good practices and caution against dangers.
- Middle-level **principles** to analyze and compare design alternatives.
- High-level **theories** and models that describe objects and actions with consistent terminology so that comprehensible explanations can be made to support communication and teaching.

Guidelines

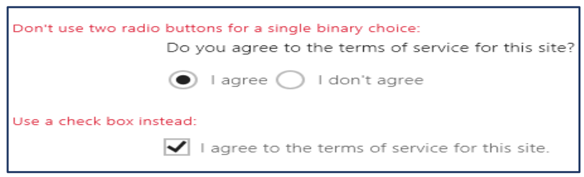
helps by developing a shared language and then promoting **consistency** among multiple designers in terminology usage, **appearance**, and **action sequences**.

Note// It records best practices derived from practical experience or empirical studies, with appropriate examples and counter examples.

Critics: Too specific, incomplete, hard to apply, and sometimes wrong

Guidelines for Navigating the interface

- Standardize task sequences.
- Use thumbnails to preview large images.
- Ensure that embedded links are descriptive.
- Use unique and descriptive headings.
- Use check boxes for binary choices.

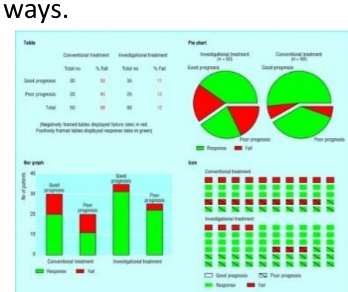


Accessibility guidelines

- **Text alternatives**. Provide text alternatives for any non-text content such as large print, braille, speech, symbols, or simpler language.
- **Time-based media**. Provide alternatives for time-based media
- **Distinguishable**. Make it easier for users to see and hear content
- **Predictable**. Make web pages appear and operate in predictable ways.

Organizing the display

- Consistency of data display
- Efficient information assimilation by the user
- Minimal memory load on the user
- Compatibility of data display with data entry
- Flexibility for user control of data display



Getting the user's attention

- **Intensity**. Use two levels only, with limited use of high intensity to draw attention. (bold)
- **Marking**. Underline the item, enclose it in a box, point to it with an arrow, or use an indicator such as an asterisk, bullet, dash, plus sign, or X.
- **Size**. Use up to four sizes, with larger sizes attracting more attention.
- **Choice of fonts**. Use up to three fonts.
- **Inverse video**. Use inverse coloring.
- **Blinking**. Use blinking displays (2-4 Hz) or blinking color changes with great care and in limited areas.
- **Color**. Use up to four standard colors, with additional colors reserved for occasional use.
- **Audio**. Use soft tones for regular positive feedback and harsh sounds for rare emergency conditions.

Principles

- More fundamental, widely applicable, and enduring than guidelines
- Need more clarification/interpretation.
- Fundamental principles
  - Determine user's skill levels.
  - Identify the tasks.

Determine user's skill levels

- **Novice or first-time users**. True novice users—for example, grandparents sending their first e-mail to a grandchild—are assumed to know little of the task or interface concepts. By contrast, first-time users are often professionals who know the task concepts well but have shallow knowledge of the interface concepts.
- **Knowledgeable intermittent users**. Many people are knowledgeable but intermittent users of a variety of systems (for example, corporate managers using word processors to create templates for travel reimbursements).
- **Expert frequent users**. thoroughly familiar with the task and interface concepts.

Identify the tasks

- // After carefully drawing the user profile, the developers must identify the tasks to be carried out.
- // Every designer would agree that the set of tasks must be determined before design can proceed, but too often, the task analysis is done informally or incompletely.
- High-level task actions can be decomposed into multiple middle-level task actions, which can be further refined into atomic actions that users execute with a single command, menu selection, or other action.

Interaction styles

1. Direct Manipulation
2. Menu selection
3. Form fill-in
4. Command language
5. Natural language

Advantages	Disadvantages
Direct manipulation	
Visually presents task concepts	May be hard to program
Allows easy learning	May require graphics display and pointing devices
Allows easy retention	
Allows errors to be avoided	
Encourages exploration	
Affords high subjective satisfaction	
Menu selection	
Shortens learning	Presents danger of many menus
Reduces keystrokes	May slow frequent users
Structures decision making	Consumes screen space
Permits use of dialog-management tools	Requires rapid display rate
Allows easy support of error handling	
Form fill-in	
Simplifies data entry	Consumes screen space
Requires modest training	
Gives convenient assistance	
Permits use of form-management tools	
Command language	
Flexible	Poor error handling
Appeals to "power" users	Requires substantial training and memorization
Supports user initiative	
Allows convenient creation of user-defined macros	
Natural language	
Relieves burden of learning syntax	Requires clarification dialog
	May not show context
	May require more keystrokes
	Unpredictable

Schneiderman's 8 golden rules of interface design

1. Strive for consistency
2. Cater to universal usability
3. Offer informative feedback
4. Design dialogs to yield closure
5. Prevent errors
6. Permit easy reversal of actions
7. Support internal locus of control
8. Reduce short term memory load

Theories

- Beyond the specifics of **guidelines**
- **Principles** are used to develop reliable, broadly useful theories
- **Theories** – descriptive, explanatory prescriptive or predictive
- Theories concern: motor, perceptual, or cognitive skills

More on theories

- **Descriptive theories**
  - provide consistent terminology(Object, Action)
- **Explanatory theories:**
  - Observing behavior
  - Describing sequence of activities
  - Conceiving of designs
  - Comparing high-level concepts of designs
- **Prescriptive theories:**
  - Giving designers clear guidance for choices
- **Predictive theories:**
  - Enable designers to compare proposed designs for execution time or error rates

Theories are according to Perceptual, Cognitive, & Motor Skills

- **Motor skill performance theories**
  predicting key stroking or pointing times.
- **Perceptual theories**
  predicting reading times for free text, lists, formatted displays, and other visual or auditory tasks.
- **Cognitive theories**
  involving short term, working, and long-term memory, are central to problem solving and play a key role in understanding productivity as a function of response time.

Design-by-Levels

- **The conceptual level** is the user's "**mental model**" of the interactive system.
- **The semantic level** user's input and by the computer's output display.
- **The syntactic level** defines how the user actions that convey semantics are assembled into complete sentences that instruct the computer to perform certain tasks.
- **The lexical level** deals with device dependencies and with the precise mechanisms by which users specify the syntax.

Consistency

- An important goal for designers is a **consistent** user interface.
- Consistency for objects and actions/commands
- Consistent use of color, layout, icons fonts, button sizes etc.
- If terminology for objects and actions is orderly and describable by few rules, users will be able to learn and retain them easily.

This example illustrates consistency and two kinds of inconsistency (A illustrates lack of consistency, and B shows consistency except for a single violation):

Consistent	Inconsistent A	Inconsistent B
delete/insert table	delete/insert table	delete/insert table
delete/insert column	remove/add column	remove/insert column
delete/insert row	destroy/create row	delete/insert row
delete/insert border	erase/draw border	delete/insert border

Short Questions:

- 1. What are guidelines?
- 2. Mention the five high level goals for organizing data display?
- 3. List few design guidelines for getting user's attention
- 4. Define principles. State the two fundamental principles of interaction design.
- 5. List the five types of interaction styles.
- 6. What are theories?
- 7. Briefly describe explanatory theories.
- 8. What is consistency? Give example.

Long Questions:

9. Describe the guidelines for navigating the interfaces.

10. Write a brief description of accessibility guidelines.

11. Explain the three types of users based on their skill levels.

12. Describe the eight golden rules of interface design.

13. What are theories ? Explain Consistency theory.

14. Describe the four levels of interface design models.

Chapter 3

Good interfaces => Satisfied user

- Competence in performing tasks
- Ease in learning originally and in assimilating advanced features
- Confidence in the capacity to retain mastery over time
- Enjoyment in using the interface
- Eagerness to show off the interface to novices
- Desire to explore more powerful aspects

Direct-manipulation interfaces => Good interfaces

- Visible objects
- Rapid, reversible, incremental actions
- Pointing actions

Newer concepts extend direct manipulation Include

- Collaborative interfaces
- Touchable interfaces
- Virtual reality
- Augmented reality
- Teleoperation

Examples of Direct-Manipulation Systems

- ### Spatial Data Management System

  In geographic applications, it seems natural to give a spatial representation in the form of a map that provides a familiar model of reality.

  - **Xeroc PARC's Information Visualizer**
  - **ArcGIS™** by ESRI™
  - **GoogleMaps™** and the more powerful **Google Earth™**

- ### Video Games

  Most exciting, well-engineered, and commercially successful example of direct-manipulation systems → Video Games

  Note// Pong is the first video game.

  Nintendo Wii, Sony PlayStation, and Microsoft Xbox continue to evolve

  - 3D, stereo sound, multiplayer, wireless controllers
  - Commands are physical actions whose results are immediately shown on screen
  - No syntax to remember → no syntax error messages
  - Games continuously display a score → feedback encourages mastery

  Video Games Examples

  - SimCity – good example of direct manipulation / urban planning
  - Second Life – social virtual world
  - Spore – evolving creatures
  - Myst – puzzle; well received
  - DOOM and Quake controversial
  - World of Warcraft – massive multiplayer game
  - Guitar Hero video game

- ### Computer Aided Design

  Most **computer-aided design (CAD)** systems for automobiles, electronic circuitry, aircraft, or mechanical engineering use principles of direct manipulation.

  - Autodesk Inventor
  - AutoCAD®

  Related applications are for **computer-aided manufacturing (CAM)** and process control. Honeywell's Experion® Process Knowledge System provides the manager of an oil refinery, paper mill, or power utility plant with a colored schematic view of the plant.

  - Honeywell's Experion®

Principles of Direct Manipulation

1. Continuous representations of objects and actions of interest with meaningful visual metaphors.
   - Novices learn, masters quick, intermittent users retain, can see actions further goals
2. Physical actions or presses of labeled buttons, instead of complex syntax.
   - Easy to learn, fewer errors, users feel in control
3. Rapid, incremental, reversible actions whose effects on the objects are visible immediately.

3D Interfaces

- "Pure" 3D interfaces have strong utility in some contexts.
  Examples medical, product design, scientific visualization
- Other situations, more constrained 2D interfaces may be preferable to simplify interactions.
  Examples 3D bar charts, air-traffic control, digital libraries
- "Enhanced" **interfaces**, better than reality, can help reduce the limitations of the real-world,
  Examples providing simultaneous views, flying, x-ray vision

Note// Closer the interfaces to the real world, will be easier to use.

For some computer-based tasks—such as **medical imagery**, architectural drawing, **computer-assisted design**, **chemical-structure modeling**, and **scientific simulations**—pure 3D representations are clearly helpful and have become major industries.

Note// Successful applications of 3D representations are game environments.

Features for effective 3D

- Use occlusion, shadows, perspective, etc. carefully.
- Minimize the number of navigation steps for users to accomplish their tasks.
- Keep text readable.
- Avoid unnecessary visual clutter, distraction, contrast shifts, and reflections.
- Simplify user movement.
- Prevent errors.
- Simplify object movement.
- Organize groups of items in aligned structures to allow rapid visual search.
- Enable users to construct visual groups to support spatial recall.

Teleoperation

Teleoperation (or remote operation) indicates operation of a system or machine at a distance.

Derives from two concepts

- direct manipulation in personal computers
- process control in complex environments

Physical operation is remote controlled.

- Surgery, power plants, chemical plants, military ops, computer supported collaborative work

Complicating factors in the architecture of remote environments

- Time delays
  - transmission delays
  - operation delays
- Incomplete feedback
- Feedback from multiple sources
- Unanticipated interferences

Teleoperation - Applications

- **Telemedicine**
  Medical care delivered over communication links
- **Telepathology**
  A pathologist examines tissue samples or body fluids under a remotely located microscope.
- **Virtual Colonoscopy**
  Allows the patient to undergo a CT scan as opposed to a more invasive procedure.
- **Robotic surgery**
  An alternative to conventional surgery that enables a smaller incision and more accurate and precise surgical movements.

Teleoperation – military application

- Commonly used by the military and by civilian space projects
- Operations using unmanned aircraft
- Teleoperated missile firing aircraft
- Agile and flexible mobile robot
- Harsh environments such as undersea, space exploration

Direct Manipulation – Benefits and Drawbacks

Benefits:

1. Control/display compatibility
2. Less syntax reduces error rates
3. Errors are more preventable
4. Faster Learning and higher retention
5. Encourages exploration

Drawbacks:

1. Increased system resources
2. Some action may be cumbersome
3. Macro techniques are often weak
4. History and other tracing may be difficult
5. Visually impaired users may have more difficulty

Chapter 4

Virtual Reality (VR)

Virtual Reality is a high-end user-computer interface that involves real-time simulation and interaction through multiple sensory channels.

Note// Virtual reality can break physical laws and allow users to act as though they were somewhere else

Four Key Elements in Experiencing Virtual Reality:

1. **Virtual World**
   An imaginary space, often (but not necessarily) manifested through a medium.
2. **Immersion**
   Having a sense of presence within an environment; this can be purely a mental state, or can be accomplished through physical means
   - Mental **immersion** : A state of being deeply engaged, with a suspension of disbelief
   - Physical **immersion** : Bodily entering a medium
3. **Sensory feedback**
   Visual/aural/haptic feedback to participants, based on some aspects of their physical positions
4. **Interactivity**
   In a virtual reality experience, participants are able to move around and change their viewpoint, generally through movements of their head.

Significance of Virtual reality in Flight Simulators

Flight simulation designers work hard to create the most realistic experience for fighter and airline pilots(train the pilots how to deal with airplanes).

Note// The cockpit displays and controls are taken from the same production line that creates the real ones.

The elaborate technology may cost $100 million but even so, it is lot cheaper, safer, and more useful for training than the $400 million jet that it simulates.

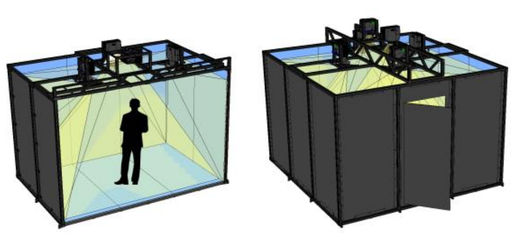
Types of VR Systems

- Immersive VR (Artificial Reality)
- Telepresence
- Augmented reality
- Desktop reality

Artificial reality and CAVE

CAVE™ **(Cave Automatic Virtual Environment)**, a room with several walls of high-resolution rear projected displays with three-dimensional audio.

Note// It Can offer satisfying experiences for several people at a time.



مثال للتوضيح

Telepresence

The telepresence aspect of virtual reality break the physical limitations of space and allows users to act as though they are somewhere else.

Telepresence is a computer-generated environment consisting of interactive simulations and computer graphics in which a human experiences presence in a remote location.

Augmented reality AR

Enables users to see the real world with an overlay of additional information.

Examples

- while users are looking at the walls of a building, their semitransparent eyeglasses may show the location of electrical wires and studwork.
- Medical applications, such as allowing surgeons to look at a patient while they see an overlay of an x-ray or sonogram to help locate a cancer tumor.

Desktop Virtual Reality

Desktop or fish tank virtual environments (both references are to standard "looking-at" displays) are becoming more common, because they avoid the physically distressing symptoms and require only standard equipment.

Note// Desktop virtual reality uses a computer monitor for virtual reality applications.

Technologies for Successful virtual environments

1. **Visual Display**
   The normal size (12 to 17 inches diagonally). large-screen (17- to 30-inch) displays can cover a 20- to 30-degree.
   // Visual Display is a display device designed to electronically display images, text, or video
   head-mounted displays block other images, so the effect is more dramatic, and head motion produces new images, so the users can get the impression of 360-degrce coverage.
   boom-mounted display that senses the users' positions without requiring them to wear heavy goggles.
2. **Head-position sensing**
   Head-mounted displays can provide differing views depending on head position. Look to the right, and you see a forest; look to the left, and the forest gives way to a city.
3. **Hand-position sensing**
   DataGlove™ is an innovative invention that continues to be refined, with improvements being made to its comfort, accuracy, and sampling rate.
4. **Force feedback & Haptics**
   performing experiments in chemistry laboratories or for handling nuclear materials provide force feedback that gives users a good sense of when they grasp an object or bump into one.
5. **Sound input and output**
   Sound output adds realism to bouncing balls, beating hearts, or dropping vases, as videogame designers found out long ago.
6. **Other sensations**
   - The tilting and vibration of flight simulators
   - Tilting and Vibrating Virtual Roller Coaster
7. **Collaborative Virtual Environments**
   Such environments allow two people at remote sites to work together, possibly designing an object, while seeing each other's actions and the object of interest

Chapter 5

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

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

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 (speech to text

- **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.

Continuous-speech recognition

Challenges:

- Difficulty in recognizing boundaries between spoken words
- Normal speech patterns blur boundaries
- Diverse accents o Variable speaking rates
- Disruptive background noise
- Challenging emotional intonation

Applications of CSR systems:

- Enable users to dictate letters and compose reports verbally for automatic transcription.
- Enable automatic scanning and retrieval from radio or television programs, court proceedings, lectures, or telephone calls for specific words or topics.

Examples:

- **IBM ViaVoice®** speech-dictation system
- **Dragon®** - NaturallySpeaking™ Medical system

Voice Information System

Interactive Voice Response (IVR) – can provide good customer service at low cost.

Note// Voice Information technologies are used in Personal Voicemail systems.

Telephone based speech systems enable storing and forwarding of spoken messages with user commands entered with keyboards. (eg: Whatsapp)

Small handheld voice **note-takers** available in the market.

Audio books have been successful – allow users to control the pace, while conveying the curator’s enthusiasm or author’s emotions.

Speech generation

Inexpensive, compact and reliable systems using digitized speech segments have been used in Automobile Navigation System, Internet services, Utility Control rooms and Children's games.

Applications for Blind

- **Text-to-speech** utilities like the built-in **Microsoft Windows Narrator**.
- **Screen readers** like **Freedom Scientific's JAWS** – allows users with visual impairments to productively navigate between windows, select applications, browse graphical interfaces and read text

Speech Synthesis

Algorithms are used to generate the sound (speech synthesis) and the intonation may sound robot-like.

Web-based voice applications

Standards for voice tagging of web pages (**VoiceXML™**and **Speech Application Language Tags**, or **SALT**) For example, cell-phone users could access web information through combinations of visual displays and speech-generation output.

Displays – Small and Large

The display has become the primary source of feedback to the user from the computer

The display has many important characteristics, 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**

Usage characteristics distinguish displays:

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

Display technology

1. **Raster-scan cathode-ray tube (CRT)**
   electron beam sweeping out lines of dots to form letters.
   // refresh rates 30 to 70 per second.
2. **Liquid-crystal displays (LCDs)**
   voltage changes influence the polarization of tiny capsules of liquid crystals.
   //Thin film, light weight, low electricity consumption
3. **Plasma Displays**
   rows of horizontal wires are slightly separated from vertical wires by small glass-enclosed capsules of neon-based gases.
   // Flat profile, consume more electricity
4. **Light-emitting diodes (LEDs)**
   certain diodes emit light when a voltage is applied.
   arrays of these small diodes can be assembled to display characters.
   // Used in large public displays, curved displays
   // Matrices of some miniature LEDs are also used in some head-mounted displays.
5. **Organic Light-emitting diodes (OLEDs)**
   Durable & energy efficient
   Laid on flexible plastic or metallic foil
   // Used with **wearable** or **rollable** displays

6. **Electronic ink technology**
   Paper-like resolution
   Tiny capsules with negatively charged black particles and positively charged white particles can be selectively made visible.
7. **Tiny Projectors** – **Microvision Pico projectors**
   Project color images on the wall from mobile devices
8. **Braille displays**
   for the blind users

Large Displays

- **Informational wall displays**
  Effective in Control rooms. Details can be retrieved on individual consoles
  Applications:
  - Military command and control operations
  - Utility Management
  - Emergency response
  - Allows teams of collaborating scientists and decision makers
- **Interactive wall displays**
  Large touch sensitive screen on which a computer screen is projected
  Digital white board System:
  - SMART Board® from SMART technologies Inc.
  - Colored pens and digital eraser simulate a traditional white board
  - Facilitates Screen recording and software keyboard
- **Multiple desktop displays**
  Discontinuities in the overall display space. And it Can be of different size and resolution.
  // Users to stand or rotate their heads or bodies to attend all displays
  Useful for personal creative applications
  Example:
  - Flash application might require a timeline, a stage, graphic component editors, a scripting language editor, a directory browser and a preview window, all open at the same

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.

Chapter 6

Information Visualization

"A Picture is worth a thousand words"

Information visualization can be defined as the use of interactive visual representations of abstract data to amplify cognition.

Information visualization provides compact graphical presentations and user interfaces for interactively manipulating large numbers of items, possibly extracted from far larger datasets.

Note// The **abstract characteristic** of the data is what distinguishes **information visualization** from **scientific visualization**.

- **Information visualization**: categorical variables and the discovery of patterns, trends, clusters, outliers, and gaps
- **Scientific visualization**: continuous variables, volumes and surfaces

Sometimes called **Visual Data Mining** (**VDM**), it uses the enormous visual bandwidth and the remarkable human perceptual system to enable users to make discoveries, make decisions, or propose explanations about patterns, groups of items, or individual items.

Visual-information-seeking mantra:

- Overview first, zoom and filter, then details on demand.
- Overview first, zoom and filter, then details on demand.
- Overview first, zoom and filter, then details on demand.

Data Type by Task Taxonomy

Data Types	
1D Linear	Document Lens, Seesoft™, Information Mural, TextArc
2D Map	Geographic information systems, ESRI ArcInfo™, ThemeView™, newspaper layout, self-organizing maps
3D World	Desktops, WebBook™, VRML™, Web3D™, architecture, computer-assisted design, medicine, molecules
Multidimensional	Parallel coordinates, scattergram matrices, hierarchical clustering, Spotfire®, Tableau®, GGobi®, DataDesk®, TableLens®, InfoZoom®
Temporal	DataMontage, Palantir, Project Managers, LifeLines, TimeSearcher
Tree	Outliners, degree-of-interest trees, cone/cam trees, hyperbolic trees, SpaceTree, treemaps
Network	NetMap™, netViz™, Pajek, JUNG, UCINet, NetDraw, TouchGraph, SocialAction, NodeXL

Tasks	
Overview	Gain an overview of the entire collection
Zoom	Zoom in on items of interest
Filter	Filter out uninteresting items
Details-on-demand	Select an item or group and get details when needed
Relate	View relationships among items
History	Keep a history of actions to support undo, replay, and progressive refinement
Extract	Allow extraction of subcollections and of the query parameters

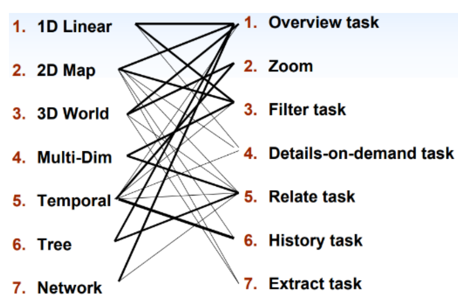
Data Types

1. **1D Linear Data**
   - source code, text, dictionaries, lists
   - show attributes of items
2. **2D Map Data**
   - Planar data, maps, floor plans, news layouts
   - may or may not be rectangular
   - find adjacent items, regions, paths
   - perform 7 basic tasks
3. **3D World Data**
   - Real world objects, 3D relationships
   - Must cope with orientation when viewing
   - Uses: medical imaging, architectural walkthroughs
4. **Multidimensional Data**
   - Items with n attributes, EEG brain waves (freq x time x channel)
   - Usually looking for patterns

5. **Temporal Data**
    - Time Series, Data, EKGs, Stock Market, Weather
    - Have start/end times items may overlap
    - compare periodical data
6. **Tree Data**
    - outliners, degree-of-interest trees, cone/cam trees, hyperbolic trees, SpaceTree, treemaps.
7. **Network Data**
    - Answers questions about paths
    - view complex relationships, such as social networks of terrorists.

The seven basic tasks

1. **Overview task**
   users can gain an overview of the entire collection
2. **Zoom task**
   users can zoom in on items of interest
3. **Filter task**
   users can filter out uninteresting items
4. **Details-on-demand task**
   users can select an item or group to get details
5. **Relate task**
   users can relate items or groups within the collection
6. **History task**
   users can keep a history of actions to support undo, replay, and progressive refinement
7. **Extract task**
   users can allow extraction of sub-collections and of the query parameters



Challenges for Information Visualization

- Importing and cleaning data : preprocessing
- Combining visual representations with textual labels
- Finding related information (and integrating it)
- Viewing large volumes of data
- Integrating data mining (letting statistical analysis see subtle trends)
- Integrating with analytical reasoning techniques
- Collaborating with others
- Achieving universal usability with visualization tools
- Evaluation