HCI Mid Sems

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HCI : HCI is the study, planning and desigining with which human and computer works together to satisfy a
In an interaction with a computer the user
receives information that is output by the computer, and responds by providing
input to the computer – the user's output becomes the computer's input and vice
versa.

Sight may be used primarily in receiving information
from the computer, but it can also be used to provide information to the computer,
for example by fixating on a particular screen point when using an eyegaze system

Input in the human occurs mainly through the senses and output through the
motor control of the effectors
The senses in HCI are mainly - vision, hearing and touching. Smelling and tasting are not yet
exploited but can be in future in AR and VR use cases.
Effectors are limbs, eyes, fingers, head and vocal system.

Vision

- It is the primary source of information for the average person.
- It consists of two stages
  - Physical reception of the stimulus from the outside world.
  - Processing and interpretation of that stimulus

Human Eye

- Eye is a mechanism for receiving light and transforming it into electrical energy.
- Light is reflected from the objects in the real world and an image of these objects is created in the retina of our eyes.
- *Cornea and lens* of the eye focus the image of object on the back of the eye - *retina.*
- Cornea consists of two types of photo receptors -
  - Rods - highly sensitive to light and allow to see in low illumination. Situated towards the edge of retina.
  - Cones - three different types of cone, each sensitive to different wavelength of light(R G and B). This allows color vision. Concentrated on the fovea, a small area of the retina on which images are fixated.

Visual Perception

- Our ability to read or distinguish falls off inversely as the distance from our point of focus increases. This is due to the fact that the cones are packed more densely towards the center of our visual field

PERCEIVING SIZE AND DEPTH

- Visual Angle: angle between lines - top of the object to centre of eyes and bottom of object to center of eyes.
- If visual angle is small, we don't perceive the object at all. *Visual Acuity* is the ability of a person to perceive fine detail.
- Our perception of size of object, remains constant even if the visual angle changes. This is the *law of size constancy*, and it indicates that our perception of size relies on factors other than the visual angle.

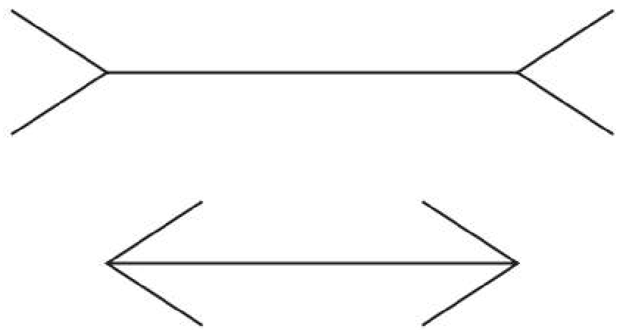
PERCEIVING BRIGHTNESS

- Brightness is a subjective response.
- It is dependent on *luminance*, which is the amount of light that is emitted by an object.
- *Contrast*, it is a function of the luminance of an object and the luminance of its background.
- Visual Acuity increases with increased luminance.

PERCEIVING COLOR

- Color is made up of
  - Hue - spectral wavelength
  - Intensity - intensity of brightness
  - Saturation - amount of whiteness.

AMBIGUITY or Limitation and capabilities of visual processing



|.6 The Muller–Lyer illusion – which line is longer?

- False case of law of size constancy.

Reading

Adults read approximately 250 words a minute. It is unlikely that words are scanned serially, character by character, since experiments have shown that words can be recognized as quickly as single characters. Instead, familiar words are recognized using word shape. This means that removing the word shape clues (for example, by capitalizing words) is detrimental to reading speed and accuracy

Hearing

- We can perceive the origin and the distance of source of sound, just by listening.

Human ear

- Hearing begins with vibrations in ear or sound waves.
- Sound consists of
  - Pitch
  - Loudness
  - Timbre
- 20hz to 15Khz. Human ear and distinguish change in frequency of 1.5hz at low frequencies.
- Auditory system performs sound filtering as well, allowing us to ignore background noise and concentrate of important information.

Touching or Haptic Perception

Human Memory

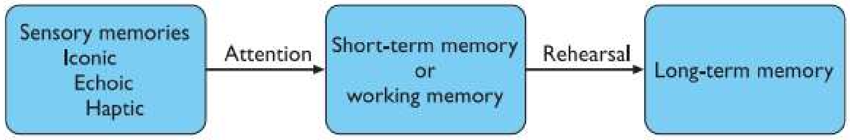


Figure 1.9 A model of the structure of memory

- Our day to day activities depend on memory. It allows us to repeat actions, to use language, and to use new information received via senses. It also gives us a sense of identity, by preserving information from our past experiences.
- There are three types of memories -
  - Sensory buffers
  - Short term memory or working memory
  - Long term memory

Sensory Memory

- It acts as a buffer for stimuli received through the senses.
- A sensory memory exists for each sensory channel: iconic memory for visual stimuli, echoic memory for aural stimuli and haptic memory for touch.
- These memories are constantly overwritten by new information coming in on these channels.
- Example : We still see the image created by fireworks even when they are not up now
  - We ask people to repeat what they said when we are busy doing something, but we realize we do know the question, or what they asked us in the first place.

Short Term Memory

- Used for temporary recall of memory. It stores information which is only required fleetingly.
- Example: When we do multiplications using distributive property, that is, 35*6 = 30*6 + 3*6. We evaluate these do sums independently and add them.
- In order to understand the sentence, we need to remember the initial part of the sentence.
- It has limited capacity.
- Closure effect : remember stuff in chunks
- Recency Effect: We tend to remember stuff in the ends than the one in middle.

Long Term Memory

- It stores factual information, experiential knowledge, procedural rules of behaviour.
- It stores everything that we know.
- It is different from short term memory -
  - It is huge, huge capacity if not unlimited.
  - Slow access time of approx. tenth of a second.
  - Forgetting occurs slow in access time.
- Two types of long term memory
  - Episodic
    - Stores past experiences in serial format.
  - Semantic
    - Structured record of facts, concepts and skill that we have acquired.
- Semantic memory is structed in some way to allow access to information representation of relationships between pieces of information and inference.

Thinking : Reasoning and Problem Solving

- ## Reasoning
  - It is the process by which we use the knowledge we have to draw conclusions or infer something new about the domain of interest.
    - Deductive Reasoning
    - Derives the logically necessary conclusions from the given premise.
    - *Deductive reasoning*

      Deductive reasoning derives the logically necessary conclusion from the given premises. For example,

      If it is Friday then she will go to work
      It is Friday
      Therefore she will go to work.

      It is important to note that this is the *logical* conclusion from the premises; it does not necessarily have to correspond to our notion of truth. So, for example,

      If it is raining then the ground is dry
      It is raining
      Therefore the ground is dry.
    - Deductive reasoning is therefore often misapplied. Given the premises

      Some people are babies
      Some babies cry

      many people will infer that 'Some people cry'. This is in fact an invalid deduction since we are not told that all babies are people. It is therefore logically possible that the babies who cry are those who are not people.

      It is at this point, where truth and validity clash, that human deduction is poorest.
    - Inductive Reasoning
    - It is generalizing from cases we have seen to infer information about cases we have not.
    - Example: We have seen elephants for trunks only. So we generalize that all elephants have trunks. But this can be proved false by producing an elephant without a trunk.
    - It is unreliable. But we use it constantly to learn about our environment.
    - Abductive Reasoning
    - It reasons from a fact to the action or state that caused it. This is the method we use to derive explanations for the events we observe.
    - Example: we know Sam drives fast when he drinks. Therefore we infer that if he is driving fast, he is drunk. This can be false, as there can be other reasons for driving fast too.
  - ## Problem Solving
  - If reasoning is a means of inferring new information from what is already known, problem solving is the process of finding a solution to an unfamiliar task, using the knowledge we have.
  - Human problem solving is characterized by the ability to adapt the information we have to deal with new situations.
  - Gestalt theory
    - Problem solving is both productive and reproductive, that is, it is based on insights and knowledge.
  - Problem Space Theory

Emotion

- Emotional response to situation affects how we perform.

- Positive emotions enable us to think more creatively, to solve complex problems, whereas negative emotion pushes us into narrow, focused thinking.

Individual Differences

- WE should remember that, although we share processes in common, humans are not all the same.
- These differences can be
  - Long term : sex, physical capabilities
  - Short term : effect of stress or fatigue.
- We should keep in mind these differences when making our designs. A decision can exclude a section of user population. For example, the current emphasis on visual interfaces excludes those who are visually impaired, unless the design also makes use of the other sensory channels.

RECOGINITION IS EASIER THAN RECALL.

THE COMPUTER

Interaction is a process of information transfer. Often, the information we receive is in response to the information that we have recently imparted to them, and we may then respond to that.

Levels of Interaction

  - Initially batch processing was used - Information is entered into the computer in large mass - batch entry.
  - Initially punch cards were used.
  - Use cases : printing pay checks, or entering results from a questionnaire.
  - Interaction takes place over hours or days.
  - Slower paced interaction.
  - Nowadays desktop interaction is very fast and takes merely seconds.

Text Entry Devices

- ### Alphanumeric keyboard
  - #### QWERTY -
  - the layout of the letters and digits is fixed. The most popular with a lot of inertia now a days.
  - #### Alphabetic keyboards - Ease of learning
  - Easy to learn. Alphabets are in alphabetic order.
  - #### DVORAK Keyboard - Ergonomics of use
  - Designed to help people reach faster speeds.
  - Biased towards right handed people, in that 56% of key strokes are made by the right hand.
  - Layout is in such a way that majority of keystrokes are alternate handed.
  - Minimizes the number of keystrokes made by weaker fingers.
- ### Chord Keyboards
  - 4-5 keys are used. Letters are produced by pressing multiple keys at the same time.
  - Extremely Compact.
  - Small learning time but high social resistance.
  - One hand operation is possible.
- ### Phone pad and T9 entry
- ### Handwriting recognition
  - The computer can take input handwritten text.
  - This has some disadvantages -
    - Current tech is not so accurate in handwriting recognition.

        - Individual differences in handwriting are enormous.
- ### Speech Recognition
    - 97% recognition rates have been reported - which means one out of 30 words will be incorrect.
    - This is unacceptable.
    - Each user speaks differently, so the system needs to be trained and tuned to each new speaker.

Positioning Pointing and Drawing

Pointing devices allow the user to point, position and select items, either directly or by manipulating a pointer on the screen.

- Mouse
- Touchpad
- Trackball and thumbwheel
- Joystick and keyboard nipple
- Touch Sensitive Screen (touch Screens).
- Digitizing tablet
- Eyegaze : control the computer with your eyes.
- Cursor keys and discrete positioning

Display Devices

- The vast majority of interactive computer systems would be unthinkable with out some sort of display screen.

Bitmap displays:

Nearly all the displays use some sort of a bitmap to render images. That is the display is made up of vast numbers of colored dots or pixels in a rectangular grid.
Bits per pixel define how many colours can be rendered on the screen.
Total number of pixels : the ratio is usually 4:3
Density of pixels : this is measured in pixels per inch.

Cathode Ray tubes
Liquid Crystal Displays

For large screen displays, several small screens can be used. Either LCD or CRT are placed together in a video wall. These can display separate images, or a single image can be split into multiple small pieces.

Digital Paper

These are thin flexible materials that can be written to electronically, just like a computer screen, but which keep their contents even when removed from any electrical supply.

Devices for VR and 3D interaction

These require you to navigate and interact in a three-dimensional space. Sometimes these use the ordinary controls and displays of a desktop computer system, but there are also special devices used both to move and interact with 3D objects and to enable you to see a 3D environment.

- Cockpit and virtual controls
- 3D Mouse : The 3D mouse has a full six degrees of freedom as its position can be tracked (three degrees), and also its up/down angle (called pitch), its left/right orientation (called yaw) and the amount it is twisted about its own axis (called roll).
- DataGlove: uses optical fibres. Glove has optical fibres on joints and when the joint is bent, the leak from optical fibres is detected and this can be used to identify degree of bend. It also has ultrasonic sensors to determine the 3D positional information.
- VR helmets : 2 purposes - 1. They display the 3D world to each eye and 2) they allow the user's head moves to be tracked.

3D Displays : Just as the 3D images used in VR have led to new forms of input device, they also require more sophisticated outputs. Desktop VR is delivered using a standard computer screen and a 3D impression is produced by using effects such as shadows, occlusion (where one object covers another) and perspective. This can be very effective and you can even view 3D images over the world wide web using a VRML (virtual reality markup language) enabled browser.

Touch feel and smell

- Not commonly used in computer applications, but are useful in VR scenarios, such as the use in medial domains to 'practice' surgical procedures, the feel of an instrument moving through different types of tissue.
- The devices used to emulate these procedures have force feedback, giving different amounts of resistance depending on the state of virtual operation.
- Such devices that influence our physical senses are called haptic devices.

- There is evidence that smell is one of the strongest cues to memory. Some arcade games also generate smells, for example, burning rubber as your racing car skids on the track. These examples both use a fixed smell in a particular location.

Physical Controls

- A desktop computer system has to serve many functions and so has generic keys and controls that can be used for a variety of purposes. In contrast, these dedicated control panels have been designed for a particular device and for a single use. This is why they differ so much.
- Microwave has flat control panel with soft buttons - whilst cooking, hands may be greasy or have food on them. Smooth controls have no gaps where food can accumulate and clog buttons. This keeps it hygienic. Same is the case for modern day washing machines.

Environment and BioSensing

- Usage of sensors
- Like the ones in washrooms with infrared sensors on the basin. The switch in cars which turns on the light automatically when the door is opened.
- There are lot of sensors around us that monitoring our behavior and actions.
- There are many different sensors available to measure virtually anything: temperature, movement (ultrasound, infrared, etc.), location (GPS, global positioning, in mobile devices), weight (pressure sensors).

Memory

The details of computer memory are not in themselves of direct interest to the user interface designer. However, the limitations in capacity and access methods are important constraints on the sort of interface that can be designed.

RAM and short term memory

- Volatile
- Fast access
- Limited memory

Disks and Long term memory

- For most computer users the LTM consists of disks, possibly with small tapes for backup.
- Two types - magnetic and optical. With disks there are two access times to consider, the time taken to find the

right track on the disk, and the time to read the track. The former dominates random reads, and is typically of the order of 10 ms for hard disks.
- Similarly, although 256 Mbytes of RAM are enough to hold most (but not all) sin gle programs, windowed systems will run several applications simultaneously, soon using up many megabytes. Operating systems handle this by paging unused bits of programs out of RAM onto disk, or even swapping the entire program onto disk. This makes little difference to the logical functioning of the program, but has a significant effect on interaction.
- The delays due to swapping are a symptom of the von Neumann bottleneck between disk and main memory. There is plenty of information in the memory, but it is not where it is wanted, in the machine's RAM. The path between them is limited by the transfer rate of the disk and is too slow

Compression

- In fact, things are not quite so bad, since compression techniques can be used to reduce the amount of storage required for text, bitmaps and video. All of these things are highly redundant.
- Text can easily be reduced by a factor of five and bitmaps often compress to 1% of their original size.
- For video, in addition to compressing each frame, we can take advantage of the fact that successive frames are often similar. We can compute the difference between successive frames and then store only this – compressed, of course.

PROCESSING and NETWORKS

- Computers that run interactive programs will process in the order of 100 million instructions per second. It sounds a lot and yet, like memory, it can soon be used up.
- For activities involving the user's hand–eye coordination, delays of even a fraction of a second can be disastrous.

Effect of finite speed processor

- Speed of processing can seriously affect the user interface. These effects must be taken into account when designing an interactive system.
- . In order to avoid faults of the first kind, the system buffers the user input; that is, it remembers keypresses and mouse buttons and movement. Unfortunately, this leads to problems of its own. One example of this sort of problem is cursor tracking, which happens in character-based text editors. The user is trying to move backwards on the same line to correct an error, and so presses the cursor-left key. The cursor moves and when it is over the correct position, the user releases the key. Unfortunately, the system is behind in responding to the user, and so has a few more cursor-left keys.
- A similar problem, icon wars, occurs on window systems. The user clicks the mouse on a menu or icon, and nothing happens; for some reason the machine is busy or slow. So the user clicks again, tries something else – then, suddenly, all the buffered mouse clicks are interpreted and the screen becomes a blur of flashing windows and menus.

Limitations on interactive performance

- Computation Bound
    - For a very long process try to give an indication of duration before it starts; and during processing an indication of the stage that the process has reached is helpful. This can be achieved by having a counter or slowly filling bar on the screen that indicates the amount done, or by changing the cursor to indicate that processing is occurring. Many systems notice after they have been computing for some time and then say 'this may take some time: continue (Y/N)?'.
- Storage Channel bound
    - As we discussed in the previous section, the speed of memory access can interfere with interactive performance.
- Graphics Bound

    - Most computers include a special-purpose graphics card to handle many of the most common graphics operations. This is optimized for graphics operations and allows the main processor to do other work such as manipulating documents and other user data.
- Network Capacity
    - Most computers are linked by networks. At the simplest this can mean using shared files on a remote machine. When accessing such files it can be the speed of the network rather than that of the memory which limits performance.

Interaction

Execution Evaluation Cycle - Norman's Model

- The user formulates a plan of action, which is then executed at the computer interface. When the plan, or part of the plan, has been executed, the user observes the computer interface to evaluate the result of the executed plan, and to determine further actions.
- There are seven stages in Norma's model -
    - Establishing the goal
    - Forming the intention
    - Specifying the action sequence
    - Executing the action
    - Perceiving the system state
    - Interpreting the system state
    - Evaluating the system state with respect to the goal and intentions
- Each stage is an activity of the user. Each stage is, of course, an activity of the user. First the user forms a goal. This is the user's notion of what needs to be done and is framed in terms of the domain, in the task language. It is liable to be imprecise and therefore needs to be translated into the more specific intention, and the actual actions that will reach the goal, before it can be executed by the user. The user perceives the new state of the system, after execution of the action sequence, and interprets it in terms of his expectations. If the system state reflects the user's goal then the computer has done what he wanted and the interaction has been successful; otherwise the user must formulate a new goal and repeat the cycle.

Some interfaces cause problems to the user due to -

- Gulf of execution

  The gulf of execution is the difference between the user's formulation of the actions to reach the goal and the actions allowed by the system.
- Gulf of Evaluation

  The gulf of evaluation is the distance between the physical presentation of the system state and the expectation of the user.

The user and the system do not use the same terms to describe the domain and goals – remember that we called the language of the system the core language and the language of the user the task language.

Interaction Framework

- It has 4 components
    - User
    - System
    - Input
    - Output

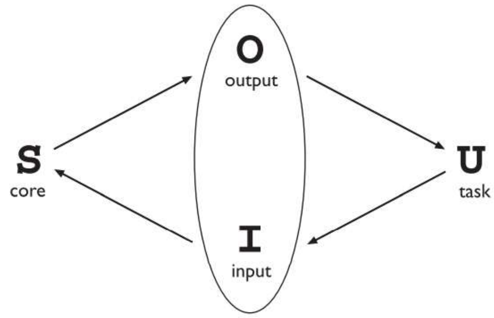


Figure 3.1 The general interaction framework

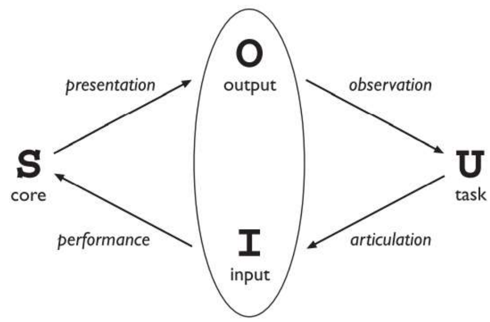
- 

Figure 3.2 Translations between components

- User give input .
- Input is translated into the core language as operations to be performed by the system.
- System transforms itself as described by the operations.
- Execution phase is complete, evaluation begins.
- System is now in a new state and this must be communicated to user as output.
- The current values of system attributes are rendered as concepts or features of the Output.

The User's formulation of the desired task to achieve some goal needs to be articulated in the input language.

Ergonomics

Eregonomics (or human factors) is traditionally the study of the physical characteristics of the interaction: how the controls are designed, the physical environment in which the interaction takes place, and the layout and physical qualities of the screen
A primary focus is on user performance and how the interface enhances or detracts from this.

Arrangement of Controls and displays

- functional controls and displays are organized so that those that are functionally related are placed together.
- sequential controls and displays are organized to reflect the order of their use in a typical interaction (this may be especially appropriate in domains where a particular task sequence is enforced, such as aviation).
- frequency controls and displays are organized according to how frequently they are used, with the most commonly used controls being the most easily accessible.
- In addition to the organization of the controls and displays in relation to each other, the entire system interface must be arranged appropriately in relation to the user's position. So, for example, the user should be able to reach all controls necessary and view all displays without excessive body movement. Critical displays should be at eye level. Lighting should be arranged to avoid glare and reflection distorting displays. Controls should be spaced to provide adequate room for the user to manoeuvre

Health Issues

- Physical Position
  - Users should be able to reach all controls comfortably and see all displays. Users should not be expected to stand for long periods and it sitting should be provided with back support.

- Temperature
  - Experimental studies show that performance deteriorates at high or low temperatures, with users being unable to concentrate efficiently.
- Lighting
  - Adequate lighting should be provided to allow users to see the computer screen without discomfort or eyestrain. The light source should also be positioned to avoid glare affecting the display.
- Noise
  - Excessive noise can be harmful to health, causing the user pain, and in acute cases, loss of hearing. Noise levels should be maintained at a comfortable level in the work environment.
- Time
  - The time users spend using the system should also be controlled. As we saw in the previous chapter, it has been suggested that excessive use of CRT displays can be harmful to users, particularly pregnant women.

Color

- The colors used should also correspond to common conventions and user expectations. Red, green and yellow are colors frequently associated with stop, go and standby respectively. . These conventions should not be violated without very good cause.
- However, we should remember that color conventions are culturally determined. For example, red is associated with danger and warnings in most western cultures, but in China it symbolizes happiness and good fortune. The color of mourning is black in some cultures and white in others

Interaction Styles

- CLI
- Menus
- Natural Language
- Form fills
- WIMP interface
  - Windows, Icons, Menus and pointers
  - It is the default interface for most of the systems today.
  - Example: Windows, MacOS etc.
- 3 Dimensional interfaces
  - The simplest technique is where ordinary WIMP elements, buttons, scroll bars, etc., are given a 3D appearance using shading, giving the appearance of being sculpted out of stone.
  - there are virtual reality and information visualization systems where the user can move about within a simulated 3D world.

Elements of the WIMP Interface

- these elements of the WIMP interfaces are called widgets, and they com prise the toolkit for interaction between user and system.
- Windows
- These are areas of the screen that behave as if they were independent terminals in their own right.
- A window consists of text and graphics and can be moved or resized.
- More than one window can be on a screen at once, allowing separate tasks to be visible at the same time.
- Icons
- Windows can be closed and lost for ever, or they can be shrunk to some very reduced representation. A small picture is used to represent a closed window, and this representation is known as an icon. By allowing icons, many windows can be available on the screen at the same time.
- Shrinking a window to its icon is known as iconifying the window.
- Icons can take many forms: they can be realistic representations of the objects that they stand for, or they can

be highly stylized.

- Pointers
- The pointer is an important component of the WIMP interface, since the interaction style required by WIMP relies very much on pointing and selecting things such as icons.
- Menus
- A menu presents a choice of operations or services that can be performed by the system at a given time.
- Button
- Buttons are individual and isolated regions within a display that can be selected by the user to invoke specific operations.
- 'Pushing' the button invokes a command, the meaning of which is usually indicated by a textual label or a small icon. Buttons can also be used to toggle between two states.
- Toolbars
- Many systems have a collection of small buttons, each with icons, placed at the top or side of the window and offering commonly used functions.
- Dialog boxes
- Dialog boxes are information windows used by the system to bring the user's attention to some important information, possibly an error or a warning used to prevent a possible error.

CONTEXT OF INTERACTION

Often systems are chosen and introduced by managers rather than the users themselves. In some cases the manager's perception of the job may be based upon observation of results and not on actual activity. The system introduced may therefore impose a way of working that is unsatisfactory to the users. If this happens there may be three results:

1. the system will be rejected,
2. the users will be resentful and unmotivated,
3. the user will adapt the intended interaction to his own requirements.

This indicates the importance of involving actual users in the design process

On the other hand, the introduction of new technology may prove to be a motivation to users, particularly if it is well designed, integrated with the user's current work, and challenging.

Providing adequate feedback is an important source of motiva tion for users. If no feedback is given during a session, the user may become bored, unmotivated or, worse, unsure of whether the actions performed have been successful.

Experience, engagement and fun

Paradigms

The designer of an interactive system, then, is posed with two open questions:

1. How can an interactive system be developed to ensure its usability?
2. How can the usability of an interactive system be demonstrated or measured?

One approach to answering these questions is by means of example, in which suc cessful interactive systems are commonly believed to enhance usability and, therefore, serve as paradigms for the development of future products

- Paradigms for interaction
- Time sharing
- In which a single computer could support multiple users. Previously, the human (or more accurately, the

programmer) was restricted to batch sessions, in which complete jobs were submitted on punched cards or paper tape to an operator who would then run them individually on the computer.
- Time-sharing systems of the 1960s made programming a truly interactive.
- Video Display Units
- Introduction of sketchpads.
- Sketchpad demonstrated two important ideas. First, computers could be used for more than just data processing. They could extend the user's ability to abstract away from some levels of detail, visualizing and manipulating different representations of the same information.
- Programming toolkits
- To use computers to teach humans.
- producing computing equipment that aided human problem solving ability was in providing the right toolkit.
- Personal Computing
- This meant making computers and computing power accessible to novice people - with less or no knowledge about computer.
- LOGO language for children to make graphics using natural language.
- Personal computing was all about providing individuals with enough computing power so that they were liberated from dumb terminals which operated on a time-sharing system.
- Windows and WIMP
- Humans can pursue more than one task at a time.
- WIMP for interaction mechanisms
- Metaphor
- In developing the LOGO language to teach children, Papert used the metaphor of a turtle dragging its tail in the dirt. Children could quickly identify with the real-world phenomenon and that instant familiarity gave them an understanding of how they could create pictures. Metaphors are used quite successfully to teach new concepts in terms of ones which are already understood.
- It is no surprise that this general teaching mechanism has been successful in introducing computer novices to relatively foreign interaction techniques.
- Tremendous commercial successes in computing have arisen directly from a judicious choice of metaphor.
- Direct Manipulation
- In CLI, to get information about past interactions, we have to ask for it and also know the command needed to ask for it.
- Direct Manipulation provides rapid feedback, coined by Ben Shneiderman.
- Feature -
    - Visibility of objects of interest
    - Incremental action at the interface with rapid feedback of all actions
    - Reversibility of all actions, so that users are encouraged to explore without penalties.
- Computer separated cooperative work
- Another development in computing in the 1960s was the establishment of the first computer networks which allowed communication between separate machines.
- Personal computing was all about providing individuals with enough computing power so that they were liberated from dumb terminals which operated on a time-sharing system.
- the emergence of collaboration between individuals via the computer – called computer-supported cooperative work, or CSCW.
- CSCW systems are built to allow interaction between humans via the computer and so the needs of the many must be represented in the one product.
- WWW
- The web is built on top of the internet, and offers an easy to use, predominantly graphical interface to information, hiding the underlying complexities of transmission protocols, addresses and remote access to data.
- The internet (see Section 2.9) is simply a collection of computers, each linked by any sort of data connection, whether it be slow telephone line and modem or high-bandwidth optical connection. The computers of the internet all communic ate using common data transmission protocols (TCP/IP) and addressing systems (IP

addresses and domain names).

- Ubiquitous Computing
- Computing power is underlying and people don't need to know where it is happening.
- Ubiquitous means appearing everywhere.
- Computers come in various sizes depending on the task they are needed for.
- Computer : people ratio is reducing.
- 'permeate our physical environment so much that we do not notice the computers anymore'
- Sensor based and context aware interaction
- Sensors are everywhere around us
    - Basins
    - Cars
    - Camera
- Previous interactive computation has focussed on the user explicitly telling the computer exactly what to do and the computer doing what it is told. In context-aware computing the interaction is more implicit. The computer, or more accurately the sensor-enhanced environment, is using heuristics and other semi-intelligent means to predict what would be useful for the user.

We have seen that the history of computing is full of examples of creative insight into how the interaction between humans and computers can be enhanced. While we expect never to replace the input of creativity in interactive system design, we still want to maximize the benefit of one good idea by repeating its benefit in many other designs. The problem with these paradigms is that they are rarely well defined. It is not always clear how they support a user in accomplishing some tasks.
As a result, it is entirely possible that repeated use of some paradigm will not result in the design of a more usable system. The derivation of principles and theoretical models for interaction has often arisen out of a need to explain why a paradigm is successful and when it might not be. Principles can provide the repeatability that paradigms in themselves cannot provide. However, in defining these principles, it is all too easy to provide general and abstract definitions that are not very helpful to the designer. Therefore, the future of interactive system design relies on a complementary approach. The creativity that gives rise to new paradigms should be strengthened by the development of a theory that provides principles to support the paradigm in its repeated application.