Human-Computer Interaction (HCI) IT 5507

Chapter One: Introduction

Components of HCI

1. Human
2. Computer
3. Interaction

- The goal of HCI is to improve the interaction between users and computers by making computers more user friendly and receptive to the users' needs

Introduction

- Computers and related devices have to be designed with an understanding that people with specific tasks in mind

- System designers need to know how to think in terms of the eventual users' tasks and how to translate that knowledge into an executable system

HISTORY

WHAT IS HCI?

- The term *human–computer interaction* has been in widespread use since the early 1980s
- Systematic study of human performance in factories with an emphasis on manual tasks
- 2nd world War provided the impetus for studying the interaction between humans and machines
- This led to interest by researchers which forms Ergonomics Research Society in 1949

HISTORY

- Ergonomics – concerns primarily with the physical characteristics of machines and systems, and how these affect user performance
- It is an old discipline
- It is concerned with the management and manipulation of information within an organization
- Human Factors incorporate these issues, and more cognitive issues
- Ergonomics and Human Factors are often used interchangeably

HISTORY

- Ergonomics concerns user performance in the context of any system, whether computer, mechanical or manual
- As computer use became more widespread, an increasing number of researchers specialized in studying the interaction between people and computers
- The research *man– machine interaction became to human–computer interaction*

Introduction

- Information science and technology research concerns about HCI
- The introduction of technology has had a profound effect on the way that information can be stored, accessed and utilized and, consequently, a significant effect on the organization and work environment

- **HCI involves the design, implementation and evaluation of interactive systems in the context of the user's task and work**

Introduction

- HCI is not only a single user with a desktop computer
- User
  - Individual user
  - A group of users working together, or
  - A sequence of users in an organization, each dealing with some part of the task or process.
- The user is whoever is trying to get the job done using the technology

Introduction

- *Computer - ranging from* general desktop computer to a large-scale computer system, a process control system or an embedded system
- I*nteraction* - any communication between a user and computer
  - Direct interaction - a dialog with feedback and control throughout performance of the task
  - Indirect interaction - involve batch processing or intelligent sensors controlling the environment.

Introduction

- HCI is a multi-disciplinary subject.
- The ideal designer of an interactive system would have expertise in a range of topics:
  - **Psychology and cognitive science** concerns the user's perceptual, cognitive and problem-solving skills;
  - **Ergonomics** -user's physical capabilities
  - **Sociology** to help understand the wider context of the interaction
  - **Computer science and engineering** to be able to build the necessary technology;
  - **Business** to be able to market it
  - **Graphic design** to produce an effective interface presentation
  - **Technical writing** to produce the manuals, and so it goes on.

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Chapter Two: Understand Human

Why do we need to understand Humans

- Interacting with technology is cognitive
- Human information processing referred to as cognition
- Human cognition process is involved when interacting with system, like attention, perception and recognition, memory, learning, reasoning, problem solving and decision making
- Need to take into account cognitive processes involved and cognitive limitation of users
- Provides knowledge about what users can and cannot be expected to do
- Identifies and explains the nature and causes of problems users encounter
- Supply theories, modeling tools, guidance and methods that can lead to the design of better interactive products
- Must consider what are users good and bad at

Humans

- Human is the central character in HCI
- Human is the *user* for whom computer systems are designed to assist
- In order to design something for someone, we need to understand their capabilities and limitations
- Difficulties or, even, impossible or easy for humans capabilities
- How we can help them by encouraging these things

Humans

- Humans are limited in their capacity to process information
  - Information channel
  - Memory
  - Cognitive

- Information is received and responses given via a number of input and output channels
  - visual channel
  - auditory channel
  - haptic channel
  - movement.

Humans

- Information is stored in memory:
  - sensory memory
  - short-term (working) memory
  - long-term memory.
- Information is processed and applied:
  - reasoning
  - problem solving
  - skill acquisition
  - error.
- Emotion influences human capabilities
- Users share common capabilities but are individuals with differences, which should not be ignored

Human

- ***cognitive psychology: a***n approach to psychology that emphasizes internal mental processes
- Aspects of cognitive psychology
  - how humans perceive the world around them
  - how they store and process information and solve problems
  - how they physically manipulate objects
- A simplified *model* - the *Model Human Processor*
- It is a simplified view of the human processing involved in interacting with computer systems

Human

- The model comprises three subsystems:
  - the **perceptual system**: handling sensory stimulus from the outside world
  - the **motor system**: which controls actions
  - the **cognitive system**: which provides the processing needed to connect the two
- Each of these subsystems has its own **processor** and **memory**

Human

- Information is stored and processed, and information is passed out.

- Three components of Human Processing Model:

1. **input–output**,
2. **memory** and
3. **processing**.

INPUT–OUTPUT CHANNELS

- A person's interaction with the outside world occurs through information being received and sent: input and output
- In an interaction with a computer
  - Receives information that is output by the computer
  - Responds by providing input to the computer
    - The user's output becomes the computer's input and vice versa

INPUT–OUTPUT CHANNELS

- Input in the human occurs mainly through the senses and output through the motor control of the effectors.

- There are five major senses:

1. sight,
2. hearing,
3. touch,
4. taste and smell.
   - The first three are the most important to HCI

INPUT–OUTPUT CHANNELS

- Imagine using a personal computer (PC) with a mouse and a keyboard
- The application you are using has a graphical interface, with menus, icons and windows
- In your interaction with this system
  - You receive information primarily by **sight**, from what appears on the screen
  - However, you may also receive information by **hearing**
  - **Touch** plays a part too in that you will feel the keys moving, or the orientation of the mouse

Vision

- Human vision is a highly complex activity with a range of physical and perceptual limitations, yet it is the primary source of information for the average person

- We can roughly divide visual perception into two stages
  - The physical reception of the stimulus from the outside world
  - The processing and interpretation of that stimulus

Vision

- We need to understand both stages as both influence what can and cannot be perceived visually by a human being
  - which in turn directly affects the way that we design computer systems.

The human eye

- Vision begins with light.
- The eye is a mechanism for receiving light and transforming it into electrical energy
- Light is reflected from objects in the world and their image is focused upside down on the back of the eye
- The receptors in the eye transform it into electrical signals which are passed to the brain

Vision

- The *cornea* and *lens* at the front of the eye focus the light into a sharp image on the back of the eye, the *retina*.
- The retina is light sensitive and contains two types of *photoreceptor*: *rods* and *cones*.
- Read more about the components and their function from the text

Visual perception

- The information received by the visual apparatus must be filtered and passed to processing elements, so that we:
  - recognize coherent scenes
  - disambiguate relative distances
  - differentiate color

Visual perception

Perceiving size and depth

- Reflected light from the object forms an upside-down image on the retina.
- The size of that image is specified as a *visual angle*
- **Visual angle** is affected by both the size of the object and its distance from the eye.
  - If two objects are at the same distance, the larger one will have the larger visual angle
  - if two objects of the same size are placed at different distances from the eye, the furthest one will have the smaller visual angle.

Visual perception

- How does an object's visual angle affect our perception of its size?
- If the visual angle of an object is too small we will be unable to perceive it at all
  - *Visual* ***acuity*** is the ability of a person to perceive fine detail
- A number of measurements have been established to test visual acuity- standard eye tests

Visual perception

- Given that the visual angle of an object is reduced as it gets further away, we might expect that we would perceive the object as smaller
- In fact, our perception of an object's size remains constant even if its visual angle changes.
- So a person's height is perceived as constant even if they move further from you
- This is the ***law of size constancy***, and it indicates that our perception of size relies on factors other than the visual angle.
  - One of these factors is our perception of **depth**
    - **size and height** of the object in our field of view provides a cue to its distance
  - A third cue is **familiarity**: if we expect an object to be of a certain size then we can judge its distance accordingly

Visual perception

Perceiving brightness

- A second aspect of visual perception.
- Brightness is in fact a subjective reaction to levels of light.
- It is affected by *luminance* which is the amount of light emitted by an object.
- The luminance of an object is dependent on the amount of light falling on the object's surface and its reflective properties.
- Luminance is a physical characteristic and can be measured using a *photometer*.
- ***Contrast*** is related to luminance: it is a function of the luminance of an object and the luminance of its background.
- Visual acuity increases with increased luminance.

Visual perception

Perceiving color

- Color is usually regarded as being made up of three components: ***hue***, ***intensity*** and ***saturation***.
- **Hue** is determined by the spectral wavelength of the light.
  - Blues have short wavelengths, greens medium and reds long.
  - Approximately 150 different hues can be discriminated by the average person.

Visual perception

- **Intensity** is the brightness of the color, and **saturation** is the amount of whiteness in the color.
  - By varying these two, we can perceive in the region of 7 million different colors.
  - However, the number of colors that can be identified by an individual without training is far fewer (in the region of 10)
- The eye perceives color because the cones are sensitive to light of different wavelengths.
- There are three different types of cone, each sensitive to a different color (blue, green and red).
- Color vision is best in the fovea, and worst at the periphery.
- Finally, we should remember that around 8% of males and 1% of females suffer from color blindness, most commonly being unable to discriminate between red and green.

Visual perception

The capabilities and limitations of visual processing

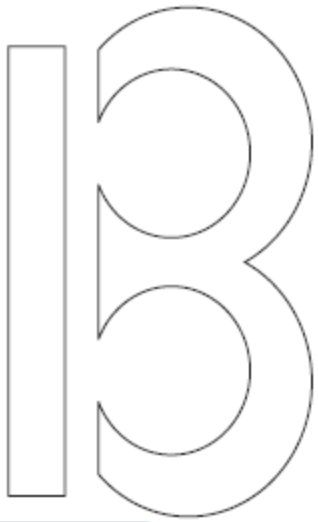
- Visual processing involves the transformation and interpretation of a complete image, from the light that is thrown onto the retina.
- As said before, our expectations affect the way an image is perceived.
  - For example, if we know that an object is a particular size, we will perceive it as that size no matter how far it is from us.

Visual perception

- Visual processing compensates for the movement of the image on the retina which occurs as we move around and as the object which we see moves.
- Although the retinal image is moving, the image that we perceive is stable.
- Similarly, color and brightness of objects are perceived as constant, in spite of changes in luminance.

Visual perception

- This ability to interpret and exploit our expectations can be used to resolve ambiguity.
- For example, consider the image below:



Hearing

- The sense of hearing is often considered secondary to sight, but we tend to underestimate the amount of information that we receive through our ears.

- By hearing you can also tell ***where*** the sounds are coming from, and estimate **how far** away they are.

Hearing

The human ear

- Just as vision begins with light, hearing begins with vibrations in the air or *sound waves*.
- The ear receives these vibrations and transmits them, through various stages, to the auditory nerves.
- The ear comprises three sections, commonly known as the *outer ear*, *middle ear* and *inner ear*.
  - Read about these

Hearing

Processing sound

- Sound is changes or vibrations in air pressure
- It has a number of characteristics which we can differentiate

- *Pitch* is the frequency of the sound. A low frequency produces a low pitch, a high frequency, a high pitch

- *Loudness* is proportional to the amplitude of the sound; the frequency remains constant

Touch

- The third and last of the senses that we will consider is touch or *haptic perception*.
- Touch provides us with vital information about our environment.
- The skin contains three types of sensory receptor: *thermo-receptors* respond to heat and cold, *nociceptors* respond to intense pressure, heat and pain, and *mechano-receptors* respond to pressure.
- It is the last of these that we are concerned with in relation to human–computer interaction.

Touch

- There are two kinds of mechanoreceptor, which respond to different types of pressure.
- ***Rapidly adapting mechanoreceptors*** respond to immediate pressure as the skin is indented.
- These receptors also react more quickly with increased pressure.
- However, they stop responding if continuous pressure is applied.
- ***Slowly adapting mechanoreceptors*** respond to continuously applied pressure.

Touch

- Although the whole of the body contains such receptors, some areas have greater sensitivity or acuity than others.

HUMAN MEMORY

- Much of our everyday activity relies on memory.
- As well as storing all our factual knowledge, our memory contains our knowledge of actions or procedures.
- It is generally agreed that there are three types of memory or memory function:
  - *sensory buffers*
  - *short-term memory* or *working memory*
  - *long-term memory*

HUMAN MEMORY

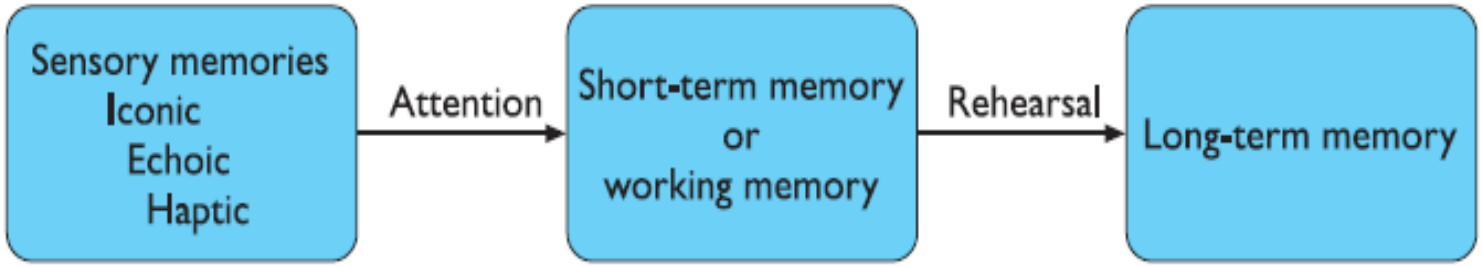


Figure 1.9 A model of the structure of memory

Sensory memory

- The sensory memories act as buffers for stimuli received through the senses.
- A sensory memory exists for each sensory channel:
  - *iconic memory* for visual stimuli
  - *echoic memory* for aural stimuli
  - *haptic memory* for touch.
- These memories are constantly overwritten by new information coming in on these channels.

HUMAN MEMORY

Short-term memory

- Short-term memory or working memory acts as a 'scratch-pad' for temporary recall of information.
- It is used to store information which is only required quickly.
  - For example, calculate the multiplication 35×6 in your head.
  - The chances are that you will have done this calculation in stages, perhaps 5×6 and then 30 , 6x3 and added the results; To perform calculations such as this we need to store the intermediate stages for use later.
- Or consider reading.
  - In order to comprehend this sentence you need to hold in your mind the beginning of the sentence as you read the rest.
- Both of these tasks use short-term memory.
- Our minds have a tendency to flush short-term memory in order to get on with the next job

HUMAN MEMORY

Long-term memory

- Here we store factual information, experiential knowledge, procedural rules of behavior – in fact, everything that we 'know'.
- It differs from short-term memory in a number of significant ways.
  - First, it has a huge, if not unlimited, capacity.
  - Secondly, it has a relatively slow access time of approximately a tenth of a second.
  - Thirdly, forgetting occurs more slowly in long-term memory, if at all.

HUMAN MEMORY

Long-term memory structure

- There are two types of long-term memory:
  - *episodic memory*
  - *semantic memory*.
- Episodic memory represents our memory of events and experiences in a serial form
  - It is from this memory that we can reconstruct the actual events that took place at a given point in our lives
- Semantic memory, on the other hand, is a structured record of facts, concepts and skills that we have acquired
- The information in semantic memory is derived from that in our episodic memory, such that we can learn new facts or concepts from our experiences.

HUMAN MEMORY

- Semantic memory is structured in some way to allow access to information, representation of relationships between pieces of information, and inference.
- One model for the way in which semantic memory is structured is as a **network**.
  - Items are associated to each other in classes, and may inherit attributes from parent classes.
- This model is known as a *semantic network*

THINKING: REASONING AND PROBLEM SOLVING

Reasoning

- *Reasoning* is the process by which we use the knowledge we have to draw conclusions or infer something new about the domain of interest.
- There are a number of different types of reasoning: *deductive*, *inductive* and *abdicative*.

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Chapter Three: The Computer

Computer

- Computer run interactive programs will process in the order of 1000 million instruction per second
- It is limited by its design

Three issues affect computers interfaces

1. Effects of finite processor speed
2. Limitation on interactive performance
3. Network Computing

Effects of finite processor speed

- Speed of processing can seriously affect the user interface
- These effects must be taken into account when designing an interactive system
- There are two sorts of faults due to processing speed

1. Slow
2. Fast

- Ex. cursor tracking in character based text editors
- Unfortunately, the system is behind in responding to the user, and so has a few more cursor left keys to process-the cursor then overshoots
- There is typically no way for the user to tell whether the buffer is empty or not except by interacting very slowly with the system and observing the cursor has moved after every key press

Limitation on interactive performance

1. Computation bound
2. Storage channel bound
3. Graphics bound
4. Network capacity

Limitation on interactive performance

- Computation bound is rare for an interactive program but possible for example when using find/replace in a large document
- The system should be designed so that long delays are not in the middle of interaction and so that the user gets some idea of how the job is progressing

Limitation on interactive performance

- Storage channel bound the speed of memory access can interfere with interactive performance
- Graphics bound: for many modern interfaces, this is the most common bottleneck
- It is easy to underestimate the time taken to perform what appear to be simple interface operations
- 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

Networked Computing

- Computer systems in use today are much more powerful than they were a few years ago, which means that the standard computer on the desktop is quite capable of high performance interaction without recourse to outside help
- However, it is often the case that we use computers not in their standalone mode of operation, but linked together in networks

Computer

- The most sophisticated machines are worthless unless they can be used properly by man
- A computer system comprises various elements, each of which affects the user of the system
- Computer elements

1. Input devices ex. text entry, drawing, selection
2. Output devices ex. large and situated displays, 3D
3. Memory
4. Processing

Overview

- Virtual reality systems and 3D visualization which have special interaction and display devices
- Various devices in the physical world
  - Physical controls and dedicated displays
  - sound, smell and haptic feedback
  - sensors for movement, temperature, bio-signs

Overview

- Paper output and input: the paperless office and the less-paper office:
  - different types of printers and their characteristics, character styles and fonts
  - scanners and optical character recognition.
- Memory:
  - short-term memory: RAM
  - long-term memory: magnetic and optical disks
  - capacity limitations related to document and video storage
  - access methods as they limit or help the user.
- Processing:
  - the effects when systems run too slow or too fast, the myth of the infinitely fast machine
  - limitations on processing speed
  - networks and their impact on system performance.

Overview

A typical computer system

- There are variants on these basic devices.
- Some of this variation is driven by different hardware configurations: desktop use, laptop computers, PDAs (personal digital assistants).
- Partly the diversity of devices reflects the fact that there are many different types of data, and many different types of user, each with their own unique requirements.

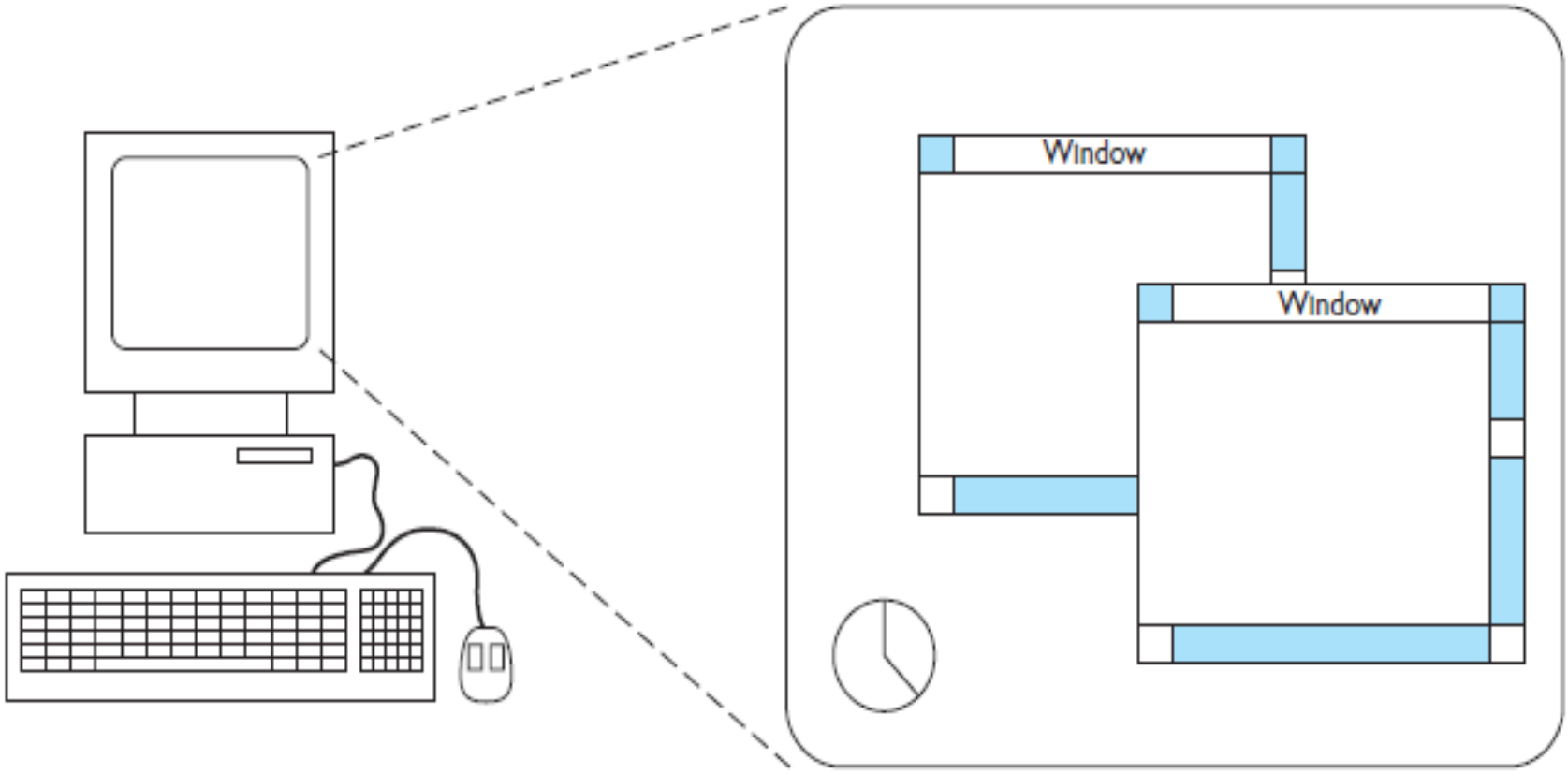


Figure 2.1 A typical computer system

TEXT ENTRY DEVICES

- Entering text is one of our main activities when using the computer.
- The most obvious means of text entry is the plain keyboard,
- There are several variations on this: (different keyboard layouts)
  - ‘chord’ keyboards that use combinations of fingers to enter letters
  - Phone key pads
  - Handwriting and speech recognition

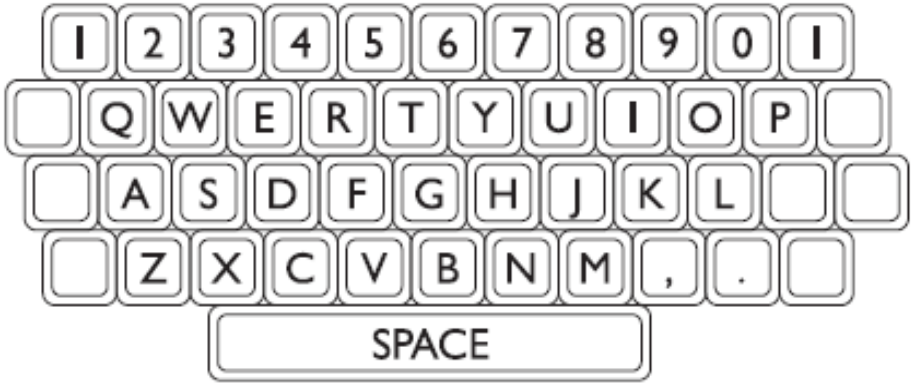
TEXT ENTRY DEVICES

The alphanumeric keyboard

- The keyboard is still one of the most common input devices in use today
- Standardized layout, known by the first six letters of the top row of alphabetical keys, QWERTY.
- There are alternative designs which have some advantages over the QWERTY layout
  - But these have not been able to overcome the vast technological inertia of the QWERTY keyboard.
- The alternatives are of two forms
  - 26 key layouts and chord keyboards
- A 26 key layout rearranges the order of the alphabetic keys, putting the most commonly used letters under the strongest fingers, or adopting simpler practices.

TEXT ENTRY DEVICES

- *The QWERTY keyboard*



- *Ease of learning – alphabetic keyboard*
  - Letters arranged alphabetically across the keyboard.
  - It might be expected that such a layout would make it quicker for untrained typists to use, but this is not the case

TEXT ENTRY DEVICES

- *Presentations on*:
  - DVORAK keyboard
  - Chord keyboards
- Phone pad and T9 entry
  - A phone only has digits 0–9, not a full alphanumeric keyboard.
  - To overcome this for text input the numeric keys are usually pressed several times

TEXT ENTRY DEVICES

Handwriting recognition

- If we were able to write as we would when we use paper, it is an intuitive and simple way of interacting with the computer
  - But, **current technology is still fairly inaccurate** and so makes a significant number of mistakes in recognizing letters, though it has improved rapidly.
  - Moreover, **individual differences in handwriting** are enormous, and make the recognition process even more difficult.

TEXT ENTRY DEVICES

- The most significant information in handwriting is the stroke information
  - the way in which the letter is drawn
- So, online recognition is far easier than reading handwritten text on paper
- Pen-based systems that use handwriting recognition are actively marketed in the mobile computing market, especially for smaller pocket organizers
  - Such machines are typically used for taking notes and jotting down and sketching ideas, as well as acting as a diary, address book and organizer
- Using handwriting recognition has many advantages over using a keyboard.
  - A pen-based system can be small and yet still accurate and easy to use, whereas small keys become very tiring, or even impossible, to use accurately
  - pen-based approach does not have to be altered when we move from jotting down text to sketching diagrams

TEXT ENTRY DEVICES

Speech recognition

- Promising area of text entry, but it has been promising for a number of years and is still only used in very limited situations.
- Complex design issues and many problems.
- Despite its problems, speech technology has found markets in the following:
  - Telephone information systems
  - Access for the disabled
  - In hands-occupied situations (like military)
  - And for those suffering repetitive strain injury (RSI)
    - injury to muscles and tendons caused by continuous repetitive use of particular muscles

POSITIONING, POINTING AND DRAWING

- Central to most modern computing systems is the ability to point at something on the screen and thereby manipulate it.
- The **mouse** is still most common for desktop computers
- But is facing challenges as laptop and handheld computing increase their market share: **touchpad**

The mouse

- For ball based mouse, rotation is detected by small rollers that are in contact with the ball, and these adjust the values of movement of cursor.

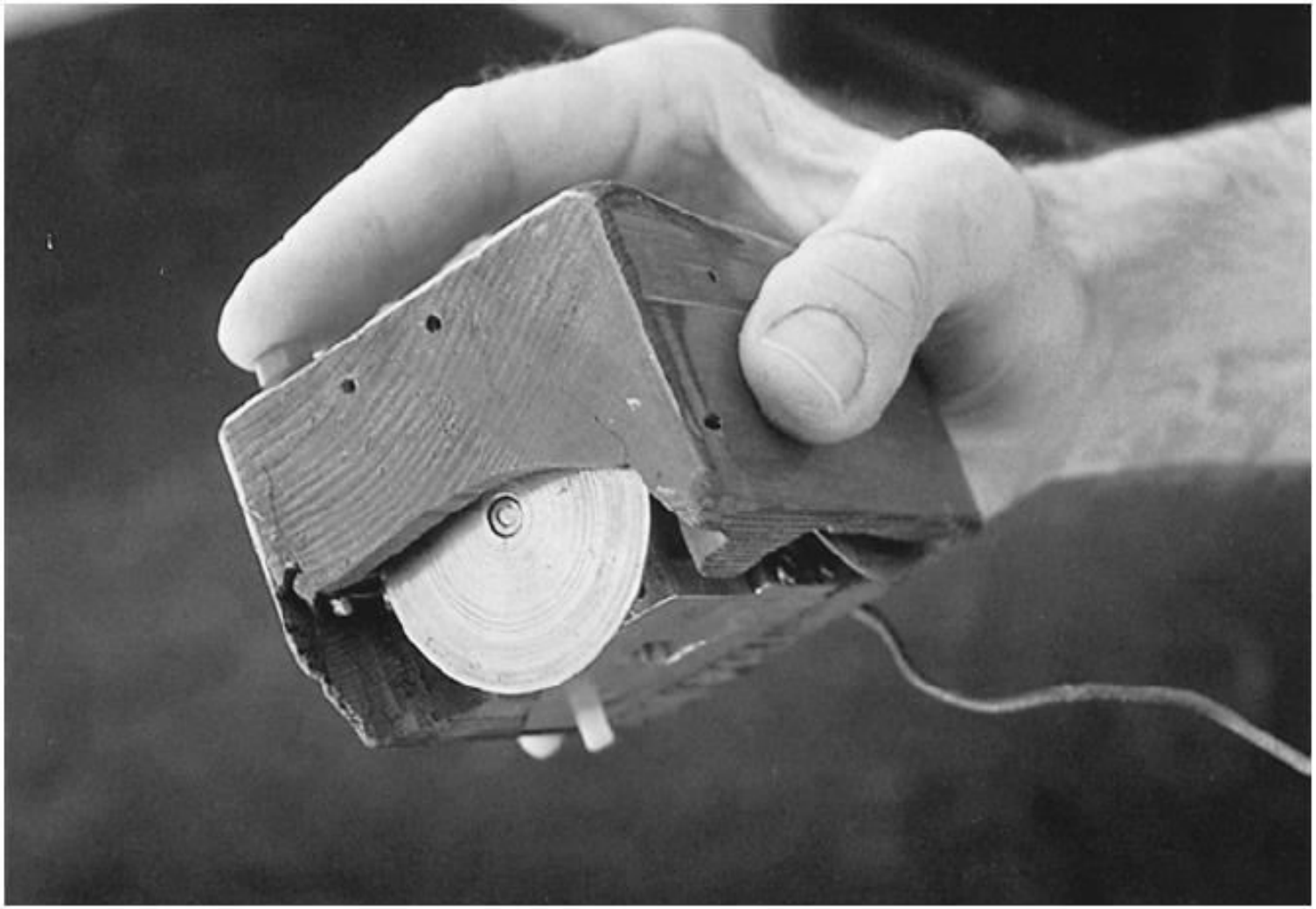


Figure 2.6 The first mouse. Photograph courtesy of Douglas Engelbart and Bootstrap Institute

POSITIONING, POINTING AND DRAWING

Optical mice

- Work differently from mechanical mice
  - A light-emitting diode emits a weak red light from the base of the mouse,
  - this is then reflected off a special pad with a metallic grid-like pattern, upon which the mouse has to sit, and the fluctuations in reflected intensity as the mouse is moved over the gridlines are recorded by a sensor in the base of the mouse and translated into relative x, y motion.

POSITIONING, POINTING AND DRAWING

Other inputs devices include:

- Touchpad
  - Touchpads are touch-sensitive tablets
  - They are operated by stroking a finger over their surface, rather like using a simulated trackball.
- Trackball and thumbwheel
- Joystick and keyboard nipple
- Touch-sensitive screens (touchscreens)
- Stylus and light pen

POSITIONING, POINTING AND DRAWING

Eyegaze systems

- Allow you to control the computer by simply looking at it!
- Some systems require you to wear special glasses or a small head-mounted box, others are built into the screen or sit as a small box below the screen.
  - A low-power laser is shone into the eye and is reflected off the retina.
  - The reflection changes as the angle of the eye alters, and by tracking the reflected beam the eyegaze system can determine the direction in which the eye is looking.
  - The system needs to be adjusted, typically by staring at a series of dots on the screen, but thereafter can be used to move the screen cursor or for other more specialized uses.

POSITIONING, POINTING AND DRAWING

- Used in:
  - Military applications
  - For disabled users
  - For workers in environments where it is impossible for them to use their hands
- The rarity of the eyegaze is due partly to its newness and partly to its expense, and it is usually found only in certain domain-specific applications.

DISPLAY DEVICES

- Interactive computer systems would be unthinkable without some sort of display screen
  - But many such systems do exist, though usually in specialized applications only

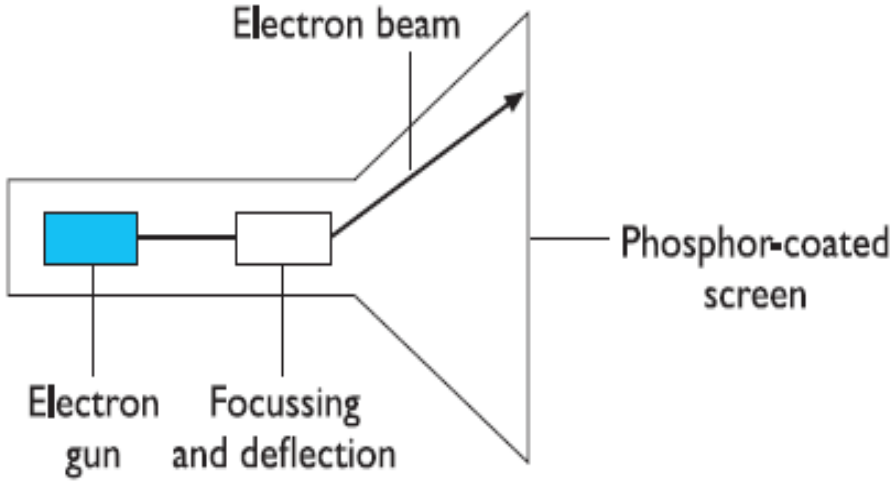
Bitmap displays – resolution and color

- All computer displays are based on some sort of bitmap.
- That is the display is made of vast numbers of colored dots or pixels in a rectangular grid.
- These pixels may be limited to black and white, in grayscale, or full color.

DISPLAY DEVICES

Technologies

- *Cathode ray tube*
  - the television-like computer screen



DISPLAY DEVICES

- *Liquid crystal display*
  - light, flat plastic screens
  - utilize liquid crystal technology and are smaller, lighter and consume far less power than traditional CRTs
  - no radiation problems associated with them
- Large displays and situated displays
- Digital paper
  - A new form of ‘display’ that is still in its infancy
  - 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 VIRTUAL REALITY AND 3D INTERACTION

Positioning in 3D space

- Virtual reality systems present a 3D virtual world
- Individual presentation on:
  - *Cockpit and virtual controls*
  - *The 3D mouse*
  - *Dataglove*
  - *Virtual reality helmets*
  - *Whole-body tracking*
  - 3D displays

Other Outputs

Sound output

- Often designed to be used in conjunction with screen displays

PAPER: PRINTING AND SCANNING

- Printing
- Scanning

MEMORY

RAM and short-term memory (STM)

- At the lowest level of computer memory are the registers on the computer chip
  - But these have little impact on the user, only affect the general speed of the computer.
- Most currently active information is held in silicon-chip *random access memory* (*RAM*).
- Different forms of RAM differ as to their precise access times, power consumption and characteristics

MEMORY

Disks and long-term memory (LTM)

- two main kinds of technology used in disks: *magnetic disks* and *optical disks*.

Table 2.1 Typical capacities of different storage media

	STM small/fast	LTM large/slower
Media:	RAM	Hard disk
Capacity:	256 Mbytes	100 Gbytes
Access time:	10 ns	7 ms
Transfer rate:	100 Mbyte/s	30 Mbyte/s

MEMORY

Related Issues

- Compression
- Storage format and standards
- Methods of access

Interaction

Levels of interaction – batch processing

- Years ago, information was entered into the computer in a large mass – **batch data entry**
- Minimal interaction with the machine: the user would simply dump a pile of punched cards onto a reader, press the start button, and then return a few hours later.
- With batch processing the interactions take place over hours or days
- Ex. pay check, questionnaire processing

Interaction

- In contrast the **typical desktop computer system** has interactions taking seconds or fractions of a second (or with slow web pages sometimes minutes!).
- The field of Human–Computer Interaction largely grew due to this change in interactive pace.

Richer interaction – everywhere, every-when

- Information appliances are putting internet access or dedicated systems onto the fridge, microwave and washing machine.
- We carry with us WAP phones and smartcards, have security systems that monitor us and web cams that show our homes to the world.

PROCESSING AND NETWORKS

- Computers that run interactive programs will process in the order of 100 million instructions per second.
- Speed of processing can seriously affect the user interface.
- There are two sorts of faults due to processing speed: those when it is too slow, and those when it is too fast!
  - to strange effects at the interface.

PROCESSING AND NETWORKS

- Problems related with fast processing, for instance, is when the user can not be able to read and understand the output of the system.
  - In displaying a demo for example, if a demo pass in a blur over the screen with nothing remaining on the screen long enough to read.
    - Many high-resolution monitors suffer from a similar problem when they display text.
  - Another example is the rate of cursor flashing

PROCESSING AND NETWORKS

Networked computing

- It is often the case that we use computers not in their standalone mode of operation, but linked together in networks.
- As well as fixed networks it is now normal to use a high bandwidth modem or wireless local area network (LAN) to connect into the internet and world wide web from home or hotel room anywhere in the world.
- As more and more people buy computers principally to connect to the internet the idea of the *network computer* has arisen – a small computer with no disks whose sole purpose is to connect up to networks.

PROCESSING AND NETWORKS

- Such networked systems have an effect on interactivity
  - Networks sometimes operate over large distances, and the transmission of information may take some time, which affects the response time of the system and hence the nature of the interactivity.

Human-Computer Interaction (HCI) IT 5507

Chapter Four: The Interaction

RECAP

- HCI is a design, implementation and evaluation of interactive systems in the context of user's task and work
- Computer – pc to main frame computer embedded system
- User – single user, a group of user or a sequence of user
- Interaction- direct or indirect communication b/n user and computer

RECAP

- Human
  - Input and out put channels include visual, auditor , haptic and movement
  - Memory – sensory, short term and long term
  - Processing – reasoning, problem solving and skill acquisition ex. deductive and inductive reasoning
- Human Processor model – perceptual system, motor system, cognitive system
- Computer
  - Input- output devices
  - Memory – SHORT TERM, LONG TERM MEMORY
  - Processing

What is Interaction

- Interaction involves at least two participants: the user and the system.
- *Interaction is* communication between user and system
- Both are complex, and are very different from each other
- Interaction refers to a dialogue generated by the command and data, input to the computer and the display, output of the computer and the sensory perceptual input to the human and motor response output of the human
- There are a number of ways in which the user can communicate with the system
  - From batch input to highly interactive input devices

What is Interface

- Interaction takes place at the Interface
- The interface must therefore effectively translate between them to allow the interaction to be successful
- Interface is made up of a set of hardware devices and software tools from the computer side and a system of sensory, motor and cognitive processes from the human side
- This translation can fail at a number of points and for a number of reasons

What is Interface

User Interface

Parts of the computer that the user contacts with

Interaction

Usually involve a dialogue with feedback & control throughout performing a task(e..g. user invokes “print” command and then interface replies with a dialog box)

HCI Goals

- Develop Improve use
- Safety- protecting users and data
- Utility- high and low utility
- Effectiveness – desired goal
- Efficiency – less time
- Usability – easy to learn and use
- Appeal to the system – impression and long term satisfaction

Basic Goal of HCI

- Usability – easy to learn and use, safe to use, effective, efficient, enjoyable to use

MS- vs HCI Goals

Goals	Achieved	Example
Safety		Warning for exit
Utility		A lot of functions is provided
Effectiveness		A science student can edit equations
Efficiency		Default template
Usability		Icon facilitate ease of learning
Appeal		Interface is attractive

Models of Interaction

- There are models of interaction that enable us to identify and evaluate components of the interaction
  - At the physical, social and organizational issues that provide the context for it.
- The use of models of interaction can help us to understand exactly what is going on in the interaction and identify the likely root of difficulties
  - 1. Survey
  - 2. Normans
  - 3. Interactive

Norman's Model

1. Survey to the different styles of interaction that are used and consider how well they support the user
2. Norman's *execution–evaluation cycle is* the most influential model of interaction

The terms of interaction

- Traditionally, the purpose of an interactive system is to aid a user in accomplishing *goals* from some application *domain*
  - **Domain** defines an area of expertise and knowledge in some real-world activity
  - ***Tasks*** are operations to manipulate the concepts of a domain
  - A ***goal*** is the desired output from a performed task
  - An ***intention*** is a specific action required to meet the goal

Norman's Model

- ***Task analysis*** involves the identification of the problem space for the user of an interactive system in terms of the **domain**, **goals**, **intentions** and **tasks**
- The *System* and *User* are each described by means of a language that can express concepts relevant in the domain of the application.
- The *System*'s language refer to as the *core language*
  - The core language describes computational attributes of the domain relevant to the *System* state
- The *User*'s language refer to as the *task language*
  - The task language describes psychological attributes of the domain relevant to the *User* state

Norman's Model

The execution–evaluation cycle

- 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

Norman's Model

- The interactive cycle can be divided into two major phases.
  - **execution** and **evaluation**.
- These can then be subdivided into further stages, seven in all.
  1. Establishing the goal
  2. Forming the intention
  3. Specifying the action sequence
  4. Executing the action
  5. Perceiving the system state
  6. Interpreting the system state
  7. Evaluating the system state with respect to the goals and intentions

Norman's Model

- Norman uses a simple example of switching on a light to illustrate this cycle
- Imagine you are sitting reading as evening falls
  - You need more light- **goal**
  - **Form an intention** to switch on the desk lamp, and you **specify the actions required**, to reach over and press the lamp switch
    - or– you may ask a person closer to switch on the light for you
- Your goal is the same(more light) but the intention and actions are different

Norman's Model

- When you have **executed the action** you **perceive the result**
  - either the light is on or it isn't and you interpret this, based on your knowledge of the world.
  - For example, if the light does not come on you may interpret this as indicating the bulb has blown or the lamp is not plugged into the mains, and you will formulate new goals to deal with this.
- If the light does come on, you **will evaluate the new state according to the original goals**
  - is there now enough light? If so, the cycle is complete.
  - If not, you may formulate a new intention to switch on the main ceiling light as well

Norman's Model

- Norman uses this model of interaction to demonstrate why some interfaces cause **problems** to their users
  - ***gulfs of execution*** and the ***gulfs of evaluation***
- Gulf of execution: difference between the user's formulation of the actions to reach the goal and the actions allowed by the system
  - If the actions allowed by the system correspond to those intended by the user, the interaction will be effective
- The interface should therefore aim to reduce this gulf

Norman's Model

- Gulf of evaluation is the distance between the physical presentation of the system state and the expectation of the user
- If the user can readily evaluate the presentation in terms of his goal, the gulf of evaluation is small
- The more effort that is required on the part of the user to interpret the presentation, the less effective the interaction

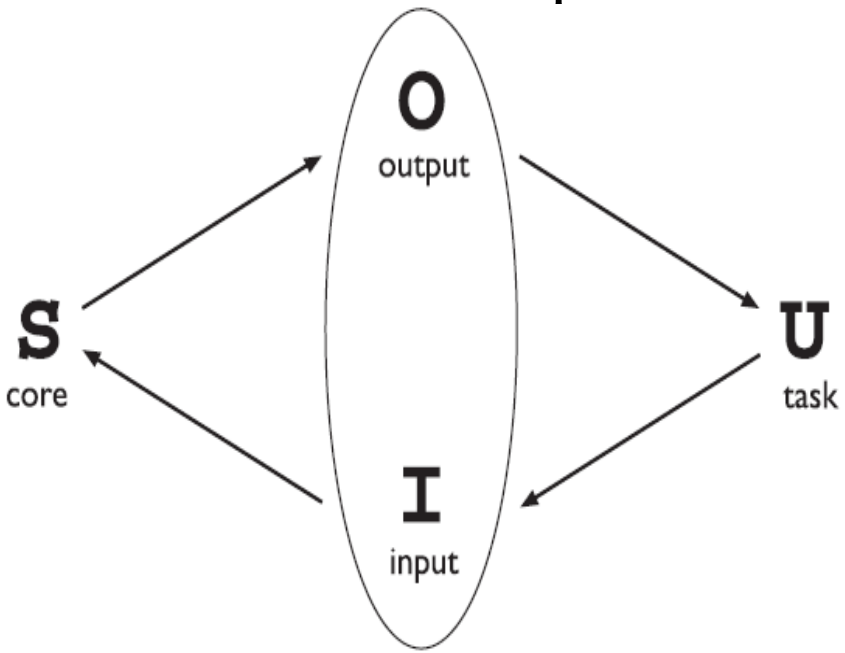
Norman's Model

- Norman's model only considers the system as far as the interface
- It concentrates wholly on the user's view of the interaction
- It does not attempt to deal with the system's communication through the interface

Interaction framework

3. **The interaction framework**

- The interaction framework attempts a more realistic description of interaction by including the system explicitly, and breaks it into four main components.



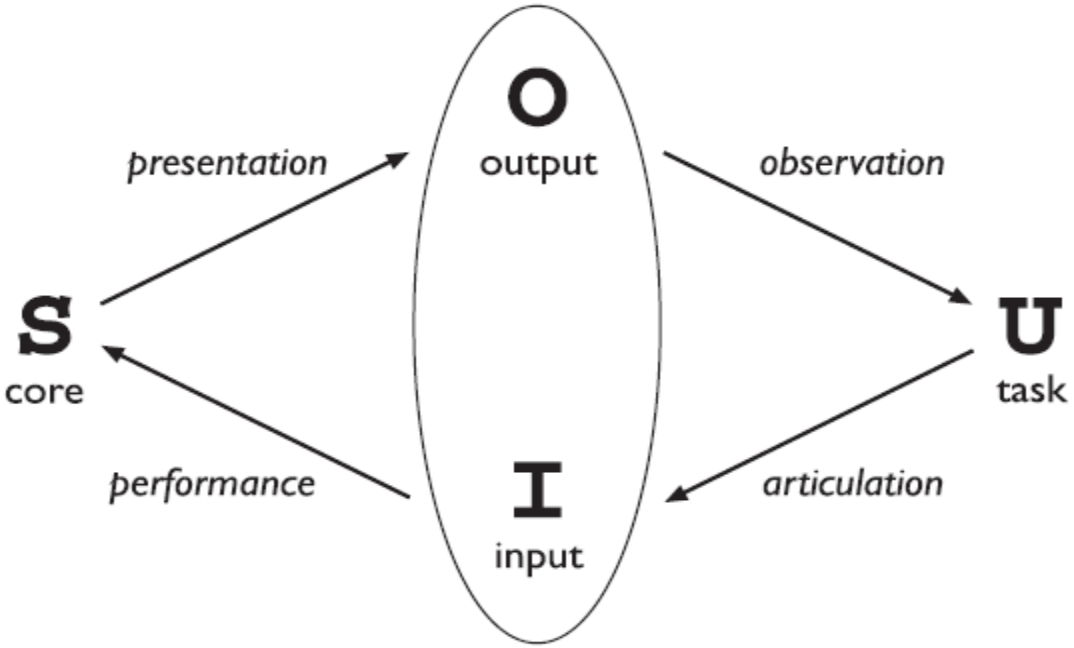
The general interaction framework

Interaction framework

- The nodes represent the four major components in an interactive system
  - the ***System***, the ***User***, the ***Input*** and the ***Output***
- Each component has its own language
  - *User*'s task language
  - *System*'s core language,
  - languages for both the *Input* and *Output* components
- *Input* and *Output* together form the *Interface*

Interaction framework

- As the interface sits between the *User* and the *System*, there are four steps in the interactive cycle, each corresponding to a translation from one component to another.



Translations between components

Interaction framework

- The *User* begins the interactive cycle with the formulation of a goal and a task to achieve that goal.
- The only way the user can manipulate the machine is through the *Input*, and so the task must be articulated within the input language.
- The input language is translated into the core language as operations to be performed by the *System*.

Interaction framework

- The *System* then transforms itself as described by the operations; the execution phase of the cycle is complete and the evaluation phase now begins.
- The *System* is in a new state, which must now be communicated to the *User*.
- The current values of system attributes are rendered as concepts or features of the *Output*.
- There are four main translations involved in the interaction:
  - articulation, performance, presentation and observation.

ERGONOMICS

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

ERGONOMICS

Arrangement of controls and displays

- Sets of controls and parts of the display should be grouped logically to allow rapid access by the user
- This issue becomes vital when we turn to safety-critical applications such as plant control, aviation and air traffic control.
  - In each of these contexts, users are under pressure and are faced with a huge range of displays and controls.
  - Here it is crucial that the physical layout of these be appropriate

ERGONOMICS

- For example, on one particular electronic newsreader, used by one of the authors, the command key to read articles from a newsgroup (y) is directly beside the command key to unsubscribe from a newsgroup (u) on the keyboard.
- This poor design frequently leads to inadvertent removal of newsgroups.

ERGONOMICS

- It is important to group controls together logically
- Possible organizations include the following:
  - **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.

ERGONOMICS

- 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.
  - for example, the user should be able to reach all controls necessary and view all displays without excessive body movement.

ERGONOMICS

The physical environment of the interaction

- Ergonomics is concerned with the design of the work environment itself
  - Where will the system be used?
  - By whom will it be used?
  - Will users be sitting, standing or moving about?

ERGONOMICS

Health issues

- Following are factors in the physical environment that directly affect the quality of the interaction and the user's performance
  - **Physical position:**
    - users should be able to reach all controls comfortably and see all displays
  - **Temperature:**
    - Experimental studies show that performance deteriorates at high or low temperatures, with users being unable to concentrate efficiently

ERGONOMICS

- **Lighting**
  - adequate lighting should be provided to allow users to see the computer screen without discomfort or eyestrain
- **Noise**
  - 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
    - It has been suggested that excessive use of CRT displays can be harmful to users,

ERGONOMICS

Ergonomics and HCI

- Ergonomics is distinct from HCI but sits alongside it
- Ergonomic factors are in general well established and understood and are therefore used as the basis for standardizing hardware designs

INTERACTION STYLES

- Interaction can be seen as a dialog between the computer and the user
- The choice of interface style can have a profound effect on the nature of this dialog
- The most common interface styles are
  - command line interface
  - menus
  - natural language
  - question/answer and query dialog
  - form-fills and spreadsheets
  - **WIMP(Windows, Icons, Menus and Pointer)**
  - point and click
  - three-dimensional interfaces

INTERACTION STYLES

Command line interface

- The first interactive dialog style to be commonly used
- provides a means of expressing instructions to the computer directly, using function keys, single characters, abbreviations or whole-word commands.
- In some systems the command line is the only way of communicating with the system, especially for remote access using *telnet*
- More commonly today it is supplementary to menu-based interfaces, providing accelerated access to the system's functionality for experienced user.

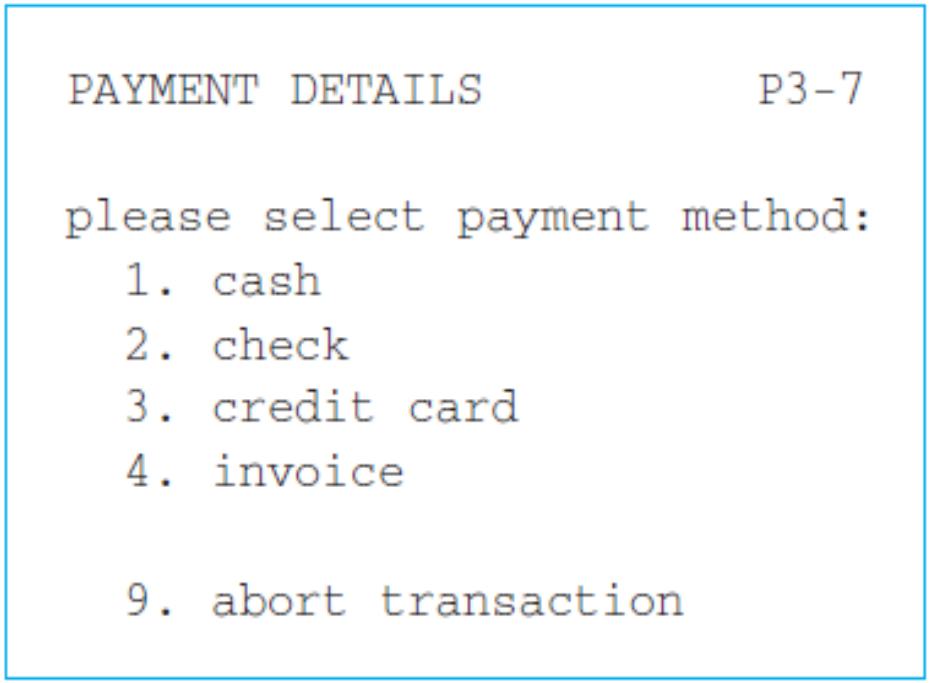
INTERACTION STYLES

- Command line interfaces are powerful
  - they offer direct access to system functionality
    - as opposed to the hierarchical nature of menus
  - can be combined to apply a number of tools to the same data
- Commands must be remembered
  - They are therefore better for expert users than for novices.
- This problem can be alleviated a little by using consistent and meaningful commands and abbreviations
- The commands used should be terms within the vocabulary of the user rather than the technician
- Unfortunately, commands are often obscure and vary across systems, causing confusion to the user and increasing the overhead of learning

INTERACTION STYLES

Menus

- In a menu-driven interface, the set of options available to the user is displayed on the screen, and selected using the mouse, or numeric or alphabetic keys
- Since the options are visible they are less demanding of the user, relying on recognition rather than recall
- However, menu options still need to be meaningful and logically grouped to aid recognition



Menu-driven interface

INTERACTION STYLES

Natural language

- Perhaps the most attractive means of communicating with computers, at least at first glance, is by natural language
- Natural language understanding, both of speech and written input, is the subject of much interest and research
- Unfortunately, however, the ambiguity of natural language makes it very difficult for a machine to understand

INTERACTION STYLES

- It seems unlikely that a general natural language interface will be available for some time
- Language is by nature vague and imprecise: this gives it its flexibility and allows creativity in expression.
  - Computers, on the other hand, require precise instructions

INTERACTION STYLES

Question/answer and query dialog

- *Question and answer dialog* is a simple mechanism for providing input to an application in a specific domain
- The user is asked a series of questions (mainly with yes/no responses, multiple choice, or codes) and so is led through the interaction step by step
  - Example: web questionnaires.

INTERACTION STYLES

- These interfaces are easy to learn and use, but are limited in functionality and power.
  - As such, they are appropriate for restricted domains (particularly information systems) and for novice or casual users
- *Query languages*, on the other hand, are used to construct queries to retrieve information from a database
- They use natural-language-style phrases, but in fact require specific syntax, as well as knowledge of the database structure.

INTERACTION STYLES

Form-fills and spreadsheets

- *Form-filling interfaces* are used primarily for data entry but can also be useful in data retrieval applications
- The user is presented with a display resembling a paper form, with slots to fill in
- Often the form display is based upon an actual form with which the user is familiar, which makes the interface easier to use.

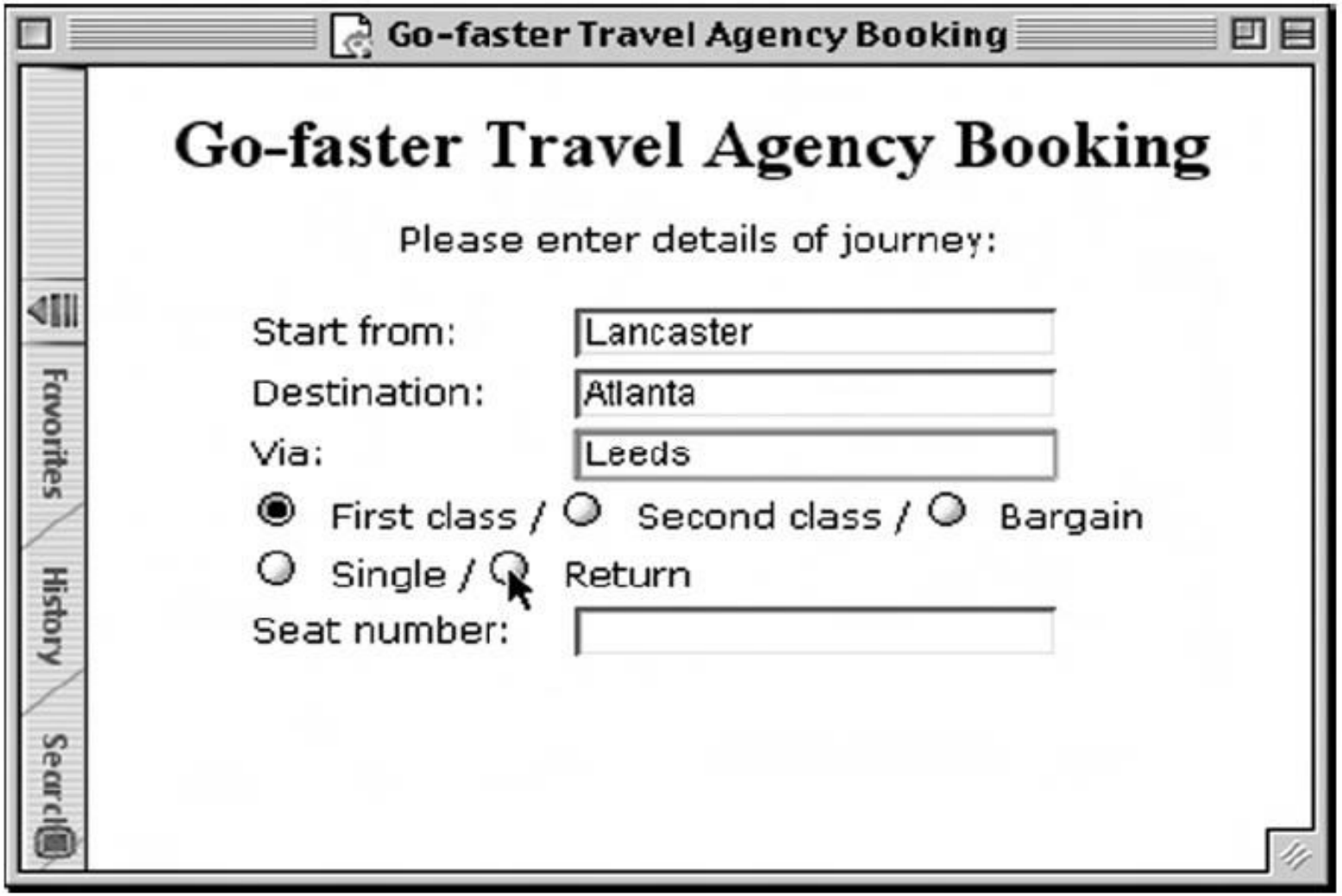


Figure 3.9 A typical form-filling interface. Screen shot frame reprinted by permission from Microsoft Corporation

INTERACTION STYLES

- *Spreadsheets* are a sophisticated variation of form filling.
- The spreadsheet comprises a grid of cells, each of which can contain a value or a formula.
  - The formula can involve the values of other cells (for example, the total of all cells in this column)

INTERACTION STYLES

The WIMP interface

- **w**indows, **i**cons, **m**enus and **p**ointers
- often simply called windowing systems
- the default interface style for the majority of interactive computer systems in use today
  - especially in the PC and desktop workstation arena
- Examples of WIMP interfaces include Microsoft Windows for IBM PC compatibles, MacOS for Apple Macintosh compatibles and various X Windows-based systems for UNIX…

INTERACTION STYLES

Point-and-click interfaces

- In most multimedia systems and in web browsers, virtually all actions take only a single click of the mouse button
- closely related to the WIMP style
  - however, the philosophy is simpler and more closely tied to ideas of *hypertext*.
- popularized by world wide web pages

INTERACTION STYLES

Three-dimensional interfaces

- There is an increasing use of three-dimensional effects in user interfaces
- The most obvious example is virtual reality
- 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
- A more complex technique uses interfaces with 3D workspaces.
  - there are virtual reality and information visualization systems where the user can move about within a simulated 3D world