Human Computer Interaction

Chapter Two: Human in HCI

Content

- Information input/output
- Memory
- Reasoning, problem solving, skill and error
- Emotion
- Individual difference

The human

Information input/output in human

- **Visual**(vision-Eye), **auditory**(hearing-Ear), **haptic** (touch-Skin), **movement** (Gesture-mov't of hand or head to express idea)

Input in the human occurs mainly through the **senses organs Sight, hearing, touch, taste** and **smell** ***(first three are the most important to HCI.)***

Output in the human occurs through the **motor control** of the **effectors** the ***limbs***(hands), ***fingers***, ***head*** and ***vocal(speech***) system

Information stored in memory

- Sensory, Short-term, Long-term

Information processed and applied

- Reasoning, problem solving, skill, error

Emotion influences human capabilities Each person is different

Vision – visual Channel(Eye)

Vision is the primary source of information for the ***average person***.

Two stages in vision

- Physical reception of stimulus
- Processing and interpretation of stimulus

Interpreting the signal

Size and depth

- visual angle indicates how much of view object occupies (relates to size and distance from eye)
  - visual acuity is ability to perceive detail (limited)
  - familiar objects perceived as constant size (in spite of changes in visual angle when far away)
  - cues like overlapping help perception of size and depth

Interpreting the signal (cont)

Brightness

- subjective reaction to levels of light
- affected by luminance of object
- measured by just noticeable difference
- visual acuity increases with luminance as does flicke

Colour

- made up of hue, intensity, saturation
- cones sensitive to colour wavelengths
- blue acuity is lowest
- 8% males and 1% females colour blind

  Retina contains two **photoreceptor:**

  Rods for low light vision and ***cones*** for colour vision

Reading

Several stages:

- ~~visual pattern perceived~~
- decoded using internal representation of language
- interpreted using knowledge of syntax, semantics, pragmatics

- ❑ Reading involves saccades and fixations
- ❑ Perception occurs during fixations
- ❑ Word shape is important to recognition
- ❑ Negative contrast improves reading from computer screen

Hearing-Auditory channel(human Ear)

Provides information about environment with ***distances***, ***directions***, ***type***, etc.

Main source of information for the ***visually impaired people***

Uses of non-speech sounds include the following:

- **Attention –** warning sound and notification
- **Status information** - background sounds can be used to convey status information
- **Confirmation** - sound associated with an action ***to approve change***
- **Navigation** - using changing sound to indicate where the user is in a system

Physical apparatus

- **Outer ear** –protects inner and amplifies sound
- **Middle ear** –transmits sound waves as vibrations to inner ear
- **Inner ear** –chemical transmitters are released and cause impulses in auditory nerve

Sound elements

- **Pitch** – sound frequency
- **loudness** – amplitude
- **Timbre** – type or quality

Touch-Haptic channel(Skin or finger)

Touch tells us when we touch something hot or cold, and can therefore act as a warning

Provides important feedback about environment

May be key sense for someone who is ***visually*** and ***auditory impaired*** eg. braille

Stimulus received via receptors in the **skin**

- **Thermoreceptors** – heat and cold
- **Nociceptors** – intense pressure, and pain
- **Mechanoreceptors** – pressure (instant or continuous) - HCI

Some areas more sensitive than others e.g. fingers to sense braille and for typewriting

Another haptic perception is **Kinethesis**

- It is awareness of ***body position*** and ***limbs*** due to receptors in the joints

Movement

Time taken to respond to stimulus:

$$\text{reaction time} + \text{movement time}$$

Movement time dependent on age, fitness etc.

Reaction time - dependent on stimulus type:

- visual ~ 200ms
- auditory ~ 150 ms
- pain ~ 700ms

Increasing reaction time decreases accuracy in the unskilled operator but not in the skilled operator.

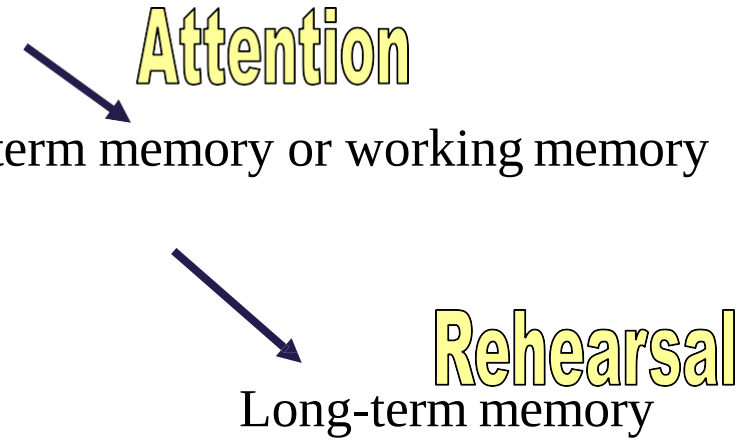
Movement

- Is about motor control and how the way we move affects our interaction with computer.
- So, targets as large as possible, distances as small as possible
- It also determine interface design to decide ***screen size*** and ***icons size***.
- Hitting a button in response to a question involves a number of processing stages.
- Each of these stages takes time, which can be roughly divided into **reaction time** and **movement time.**
- Speed and accuracy of movement are important considerations in the design of interactive systems

Memory

There are three types of memory function:

Sensory memories



Selection of stimuli governed by level of arousal.

Memory

❑ Sensory memory

Buffers for stimuli received through senses

- **iconic** memory - visual stimuli
- **echoic** memory – aural (hearing) stimuli
- **haptic** memory - tactile (touch) stimuli

Information is passed from sensory memory into short-term memory by ***attention***

❑ Short-term Memory (STM)

Is also called ***working memory***

Short-term memory has a limited capacity

❑ Long-term memory (LTM)

Repository for all our knowledge, experiences, and factual information

- slow access
- slow decay(forgetting), if any
- huge or unlimited capacity

Long-term memory is intended for the ***long-term storage of information***.

Information is placed there from working memory through **rehearsal**.

Processing (Thinking, Reasoning and Problem Solving)

- How information is *processed* and *manipulated*
- These are ***most complex*** and which *separates* humans from other information-processing systems, both artificial and natural
- Humans are able to use information to ***reason*** and ***solve problems*** and ***think*** about things

Thinking

- ***How is information processed and Manipulated?***
- Humans are able to think about things of which we have no experience, and solve problems which we have never seen before.
- Thinking can require different amounts of knowledge
- Some thinking activities are very directed and the knowledge required is constrained.
- Others require vast amounts of knowledge from different domains.
  - Performing a subtraction calculation vs. understanding newspaper headlines
- Two categories of thinking considered: **Reasoning** & **Problem Solving**

Reasoning

❖ Reasoning is the process by which we use the knowledge to draw conclusions or infer something new about the domain of interest

There are a number of different types of reasoning

❖***Deductive***, ***Inductive*** *and* ***Abductive***

1. Deductive Reasoning

Deduction: derive logically necessary conclusion from given premises (base).

e.g. If it is Friday then she will go to work

It is Friday

Therefore she will go to work.

A type of logic in which one goes from a general statement to a specific instance.

Example *All men are mortal*. (major premise)

Socrates is a man. (minor premise)

Therefore, Socrates is mortal. (conclusion)

Reasoning

2. Inductive Reasoning

Induction - is generalizing from cases we have **seen** to infer information about cases we have **not seen**

e.g. all elephants we have seen have trunks,
therefore all elephants have trunks. (positive Evidence)

3. Abductive reasoning

reasoning from ***fact of event*** to cause certain action

e.g. Sam drives fast when drunk.
If I see Sam driving fast, assume drunk.

Unreliable: can lead to false explanations –

E.g. The reason for driving fast may because “she is called to an emergency”

Problem solving

- Problem solving is the process of finding a solution to an unfamiliar task, using the knowledge we have.
- Reasoning is a means of infer new information from what is already known

Individual differences

Everyone has no similar capabilities and limitations, therefore we can't make generalizations

- long term differences
  - sex, physical and intellectual abilities
- short term differences
  - effect of stress or fatigue
- Still others change through time
  - age

These differences should be taken into account in our designs.

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.

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 limitations 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, modelling tools, guidance and methods that can lead to the design of better interactive products.
- Must consider what are users good and bad at?

Human Considerations in Design

The User's Knowledge and Experience:

- **Computer Literacy -** Highly technical(experienced), moderate, or none
- **System Experience -** High, moderate, or low knowledge of a particular system and its methods of interaction
- **Systems Use -** Frequent or infrequent use of other systems in doing job
- **Education -**High school, college, or advanced degree
- **Typing Skill -** Expert (135 WPM), skilled (90 WPM), good (55 WPM), average (40 WPM), or "hunt and peck" (10 WPM).
- **Native Language or Culture-** English, another, or several

Human Considerations in Design

Psychological Characteristics:

- **Attitude-** Positive, neutral, or negative feeling toward system
- **Motivation** - Low, moderate, or high due to interest or fear
- **Patience** - Patience or impatience in accomplishing goal
- **Expectations**- Kinds and reasonableness
- **Stress Level** - High, some, or no
- **Age** - Young middle aged or elderly
- **Gender** - Male or Female
- **Handness** - Left, right or ambidextrous (ablety to use the right and left hands equally well.)
- **Disabilities** - Blind, defective vision, deafness, motor handicap

Chapter Three: Computer in HCI

Contents

- Input device
- Output device
- Virtual reality
- Physical interaction
- Paper
- Memory
- Processing

The Computer

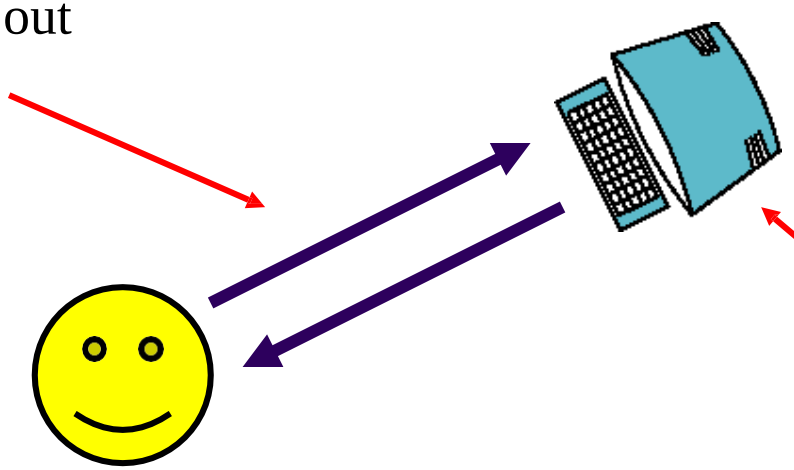
A computer system is made up of various elements each of these elements affects the ~~interaction~~

- input devices – text entry and pointing
- output devices – screen (small and large), digital paper
- virtual reality – special interaction and display devices
- physical interaction – e.g. sound, haptic, bio-sensing
- paper – as output (print) and input (scan)
- memory – RAM & permanent media, capacity & access
- processing – speed of processing, networks

Interacting with computers

to understand human–*computer* interaction
… need to understand computers!

what goes in and out
devices, paper,
sensors, etc.



what can it do?
memory, processing,
networks

A ‘typical’ computersystem

~~screen, or monitor, on which there are windows~~

keyboard

mouse/trackpad

Variations

- desktop
- laptop
- PDA

the devices dictate the styles of interaction that the system supports

If we use different devices, then the interface will support a different style of interaction

Text entry devices

- keyboards (QWERTY et al.)
- chord keyboards,
- phone pads
- handwriting,
- speech

Text entry devices :-keyboards

- **QWERTY**

  Standardised layout

Textentrydevices :-keyboards

Alphabetic

- keys arranged in alphabetic order
- not faster for trained typists
- not faster for beginners either!

Text entry devices :-keyboards

- **Chord keyboards**
  - only a few keys, letters typed as combination of key presses
  - Compact size – ideal for portable applications
  - Fast - once you have trained

Textentrydevices :-keyboards

Phone pad

use numeric keys with multiple presses

2 – a b c 6 - m n o

3 - d e f 7 - p q r s

4 - g h i 8 - t u v

5 - j k l 9 - w x y z

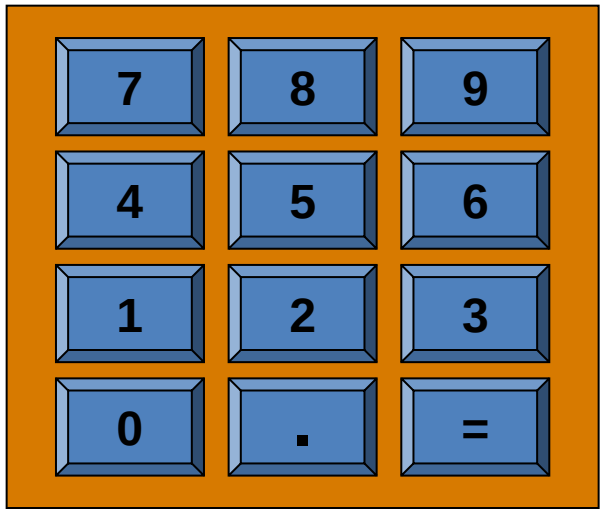
hello = 4433555[pause]555666

Textentrydevices :-keyboards

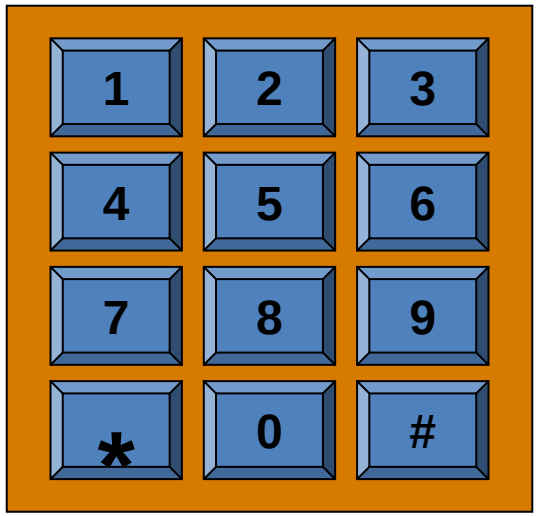
Numeric keypads

for entering numbers quickly:

- calculator,
- telephones
- ATM Machine



calculator



telephones

ATM machine

Text entry devices:

Handwriting Recognition

- Text can be input into the computer, using a pen and a digesting tablet and the computer taking this form of input and converting it to text
  - natural interaction by human hand
- Usually, used in
  - PDAs, and
  - tablet computers

Speech recognition

- One talk to computer, the speech recognition system convert the sound into text

Positioning, pointing and drawing

- mouse,
- touchpad
- trackballs,
- joysticks etc.
- touch screens,
- Tablets
- Eyegaze
- cursors

Positioning, pointing and drawing

- **The Mouse**
  - Handheld pointing device
  - Very common & easy to use
- **Touchpad**
  - small touch sensitive tablets
  - ‘stroke’ to move mouse pointer
  - used mainly in laptop computers
- **Touch-sensitive screen**
  - Detect the presence of finger or stylus on the screen.
  - works by interrupting matrix of light beams, capacitance changes or ultrasonic reflections
  - *direct* pointing device

display devices

- bitmap screens (CRT & LCD)- resolution and color
- large & situated displays- like **plasma**, **video walls**, **Projected**
- digital paper- ***programmable sheets of paper***

Memory

Short-term Memory – RAM=primary Memory

- ✓RAM- volatile
- ✓ROM- *non-volatile*
- ✓Registers -store intermediate result of CPU

Long-term Memory – Secondary Memory

- ✓HDD
- ✓CD Disk
- ✓Flash memory …….

Virtual reality and 3D interaction

Virtual Reality (VR):- is the use of computer technologies to create simulated environment.

Virtual reality systems present a 3D virtual world

Many PC games are themselves virtual.

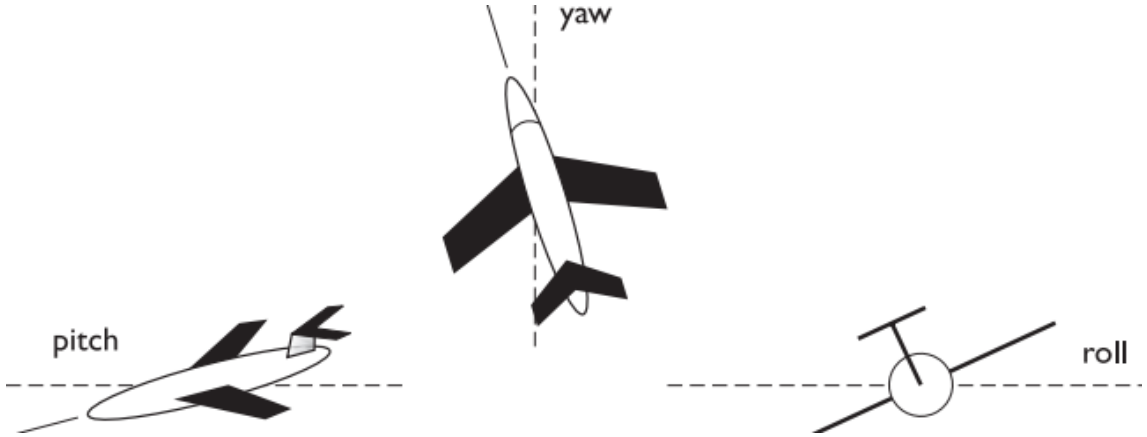
The 3D mouse: has 6 degrees of freedom/movement:

x, y, z

up/down angle (**pitch**),

its left/right orientation (**yaw**) and

the amount twists about its own axis (**roll**)



Virtual reality and 3D interaction

- **Data glove**
  - fibre optics used to detect finger position and bending
- **VR helmets**
  - detect head motion and possibly eye gaze (controlled looking)

(i)they display the 3D world to each eye and
(ii) they allow the user's head position to be tracked.

Paper: printing and scanning

Printing

- computer systems have made it easier to produce paper documents
- Printers take electronic documents and put them on paper
- It is so easy to run off many copies of a letter (or book),
- All printing technologies build the image on the paper as a series of dots
  - dot-matrix printers, ink-jet and bubble-jet printers, laser printer

Scanning

- scanners reverse printing process by converting paper printed doc to the bitmap image

Processing

- The size of processor and memory affects the processing speed of computer
- Effects of finite processor speed
  - speed of processing can seriously affect the user interface
- two sorts of **faults** due to processing speed: those when it is ***too slow***, and those when it is ***too fast!***

Chapter Four: Interaction

Contents

- Introduction
- Models of interaction
- Ergonomics
- Interaction styles
- The context of the interactions paradigms

What is Interaction?

communication

user  system

- 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 number of ways in which the user can communicate with the system, batch input, direct manipulation etc.

Models Of Interaction

- Two common interaction models -
  - **Donald Norman's model**
  - **Abowd and Beale framework**

Some terms in Interaction

- the purpose of an interactive system is to aid a user in accomplishing goals from some application domain.
  - **Domain-** area of expertise and knowledge in some real-world activity eg. graphic design, Networking, electricity
  - **Tasks** are operations/actions to manipulate the concepts of a domain.
  - A **goal** is the desired output from a performed task.

Donald Norman's execution–evaluation cycle

- ***Most influential model of interaction*** due to **closeness** to our intuitive understanding of the interaction b/n human & computer
- describe the interaction in terms of the **goals** and **actions** of the user
- The Donald Norman's interaction cycle divided into two major phases:

  Execution and

  Evaluation which are further subdivided into **seven stages**

Norman's execution–evaluation cycle…

The stages in Norman's model of interaction are as follows:

1. **Establishing the goal**. user's notion of what needs to be done
2. **Forming the intention-** defining more specific objective
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 execution–evaluation cycle…

Eg. switching on a light- Imagine you need more light

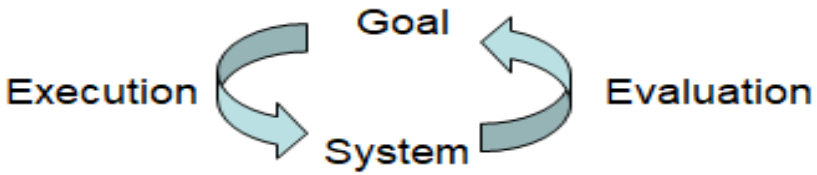
1) **Goal**:- to get more light
2) **Intention**:- to switch on the ***desk lamp***
3) **Actions sequence**:- you or someone else closer will press the lamp switch
4) **Execution**:- lamp switch pressed
5) **Perceiving**:- user observes the result (light is on or not)
6) **Interpreting**:- interpret this, 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
7) **Evaluating**:- is there enough light? If so, the cycle is complete. If not, you may formulate a new intention

Norman's execution–evaluation cycle…

Eg2. Deleting a unwanted folder

1) **Goal**:- to delete the folder in D drive
2) **Intention**:- to delete folder using ***short cut***
3) **Actions sequence**:- navigate to folder location, select folder
4) **Execution**:- press **CTRL+Delete** keys
5) **Perceiving**:- user observes the result (folder is deleted or not)
6) **Interpreting**:- if folder is deleted, Short cut is efficient, otherwise, folder needs other deleting methods.
7) **Evaluating**:- if folder deleted successfully, the goal accomplished, otherwise formulate new intention and repeat the cycle.

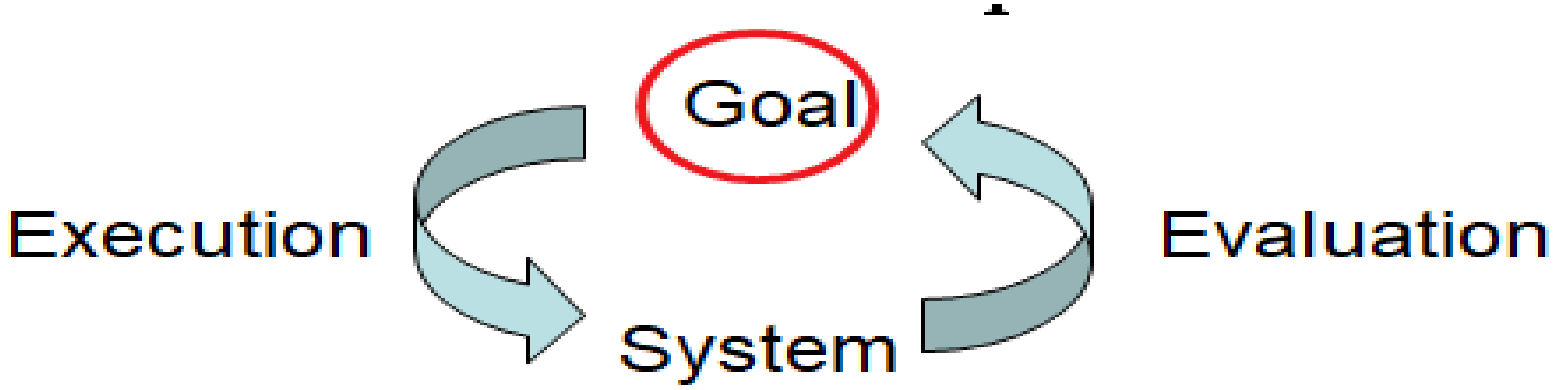
Execution/evaluation loop



The plan formulated by the user is executed by the computer. When finished, the user evaluates the results and determines the further actions.

- ❑ User establishes the goal
- ❑ Formulates intention
- ❑ Specifies actions at interface
- ❑ Executes action
- ❑ Perceives system state
- ❑ Interprets system state
- ❑ Evaluates system state with respect to goal

Execution/evaluation loop



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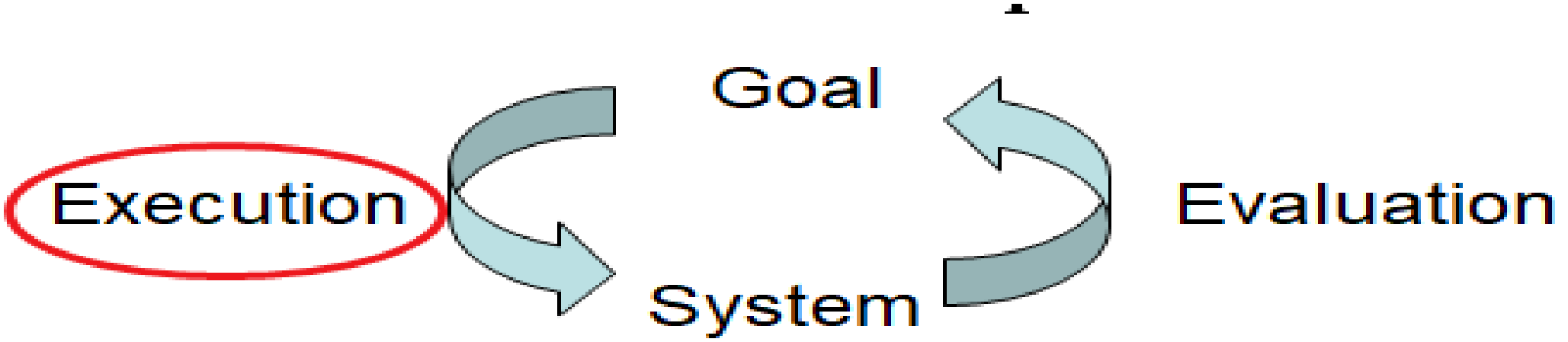

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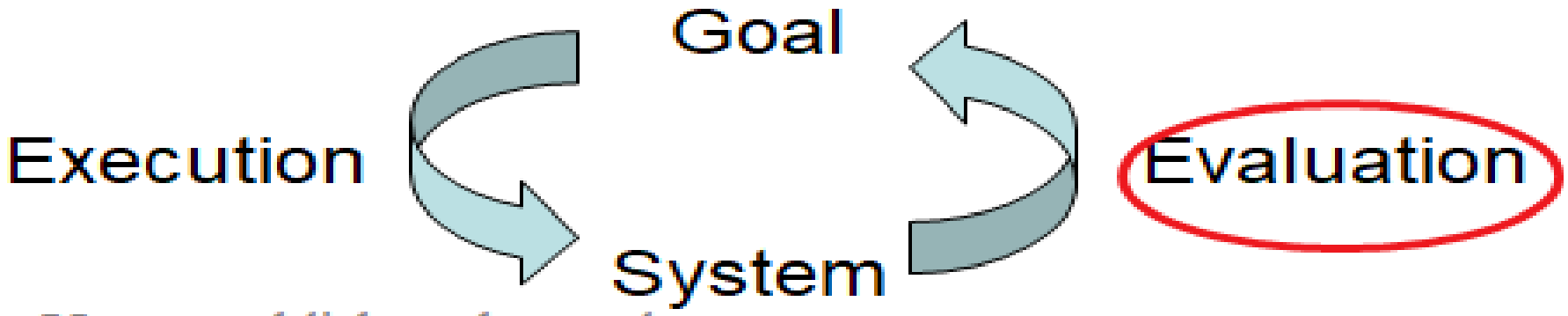

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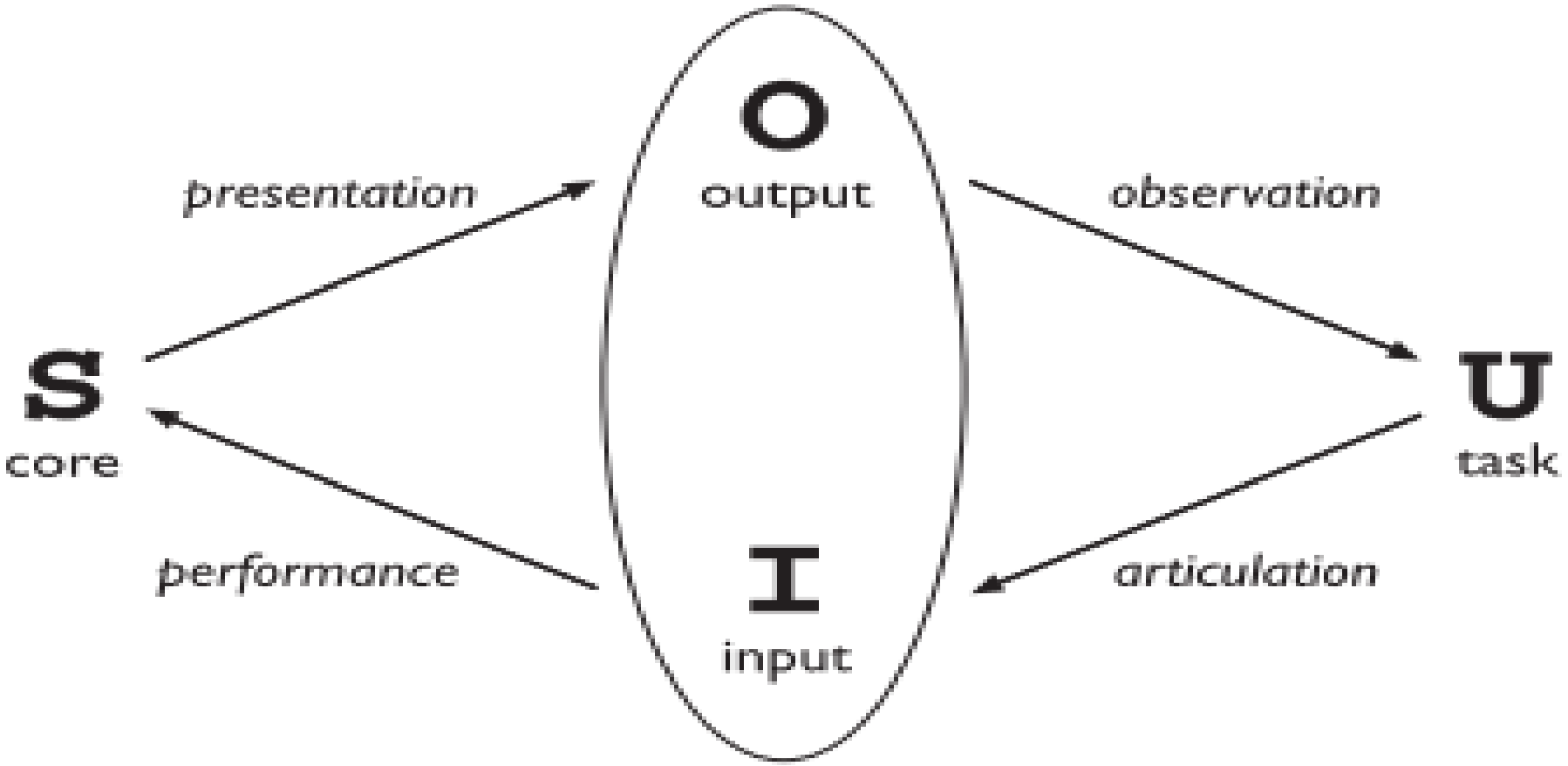
Models Of Interaction

- Norman demonstrated two problems caused by interfaces :
  - ***Gulfs of execution:-*** *is* the difference between the **user's** formulation of the **actions** to reach the goal and the **actions** allowed by the **system**.
  - ***Gulfs of evaluation***:- is the distance between the ***physical presentation of the system state*** and ***user expectation***
- User and system do not use the same terms to describe the domain and goals
  - language of the system (***core language***) and the language of the user (***task language***.)

Abowd and Beale framework

- Provides more realistic description of interaction by including the system explicitly, and breaks it into **four main components**
  - *System*, *User*, *Input* and *Output*
- Each component has its own language
  - *User*'s **task language**
  - *System*'s **core language**
  - *Input* and *Output's* **Interface(input/output) language**
- Interface sits between the *User* and the *System*
- four steps in the interactive cycle, each involves 4 translation from one component to another: articulation, performance, presentation and observation.

Abowd and Beale framework …



Translations between components

Abowd and Beale framework …

- There are four steps in the interactive cycle, involves translation from one component to another
- **Input** and **Output** together form the **Interface.**
- *User* begins interactive cycle with the formulation of a goal and a **task** to achieve that goal
  - **Articulation** - User's formulation of the desired task to achieve some goal needs using **input language**
  - **Performance** - the interface translates the input language into stimuli for the system (**core language**)
  - **Presentation** - the system presents the results in the **output language**
  - **Observation** - the interface translates the output language into personal understanding

What is Interface?

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.

Interaction takes place at the Interface,

Ergonomics

Study of the physical characteristics of interaction

Ergonomics

- Is the study of the physical characteristics of interaction
  - how the controls are designed,
  - the physical environment in which the interaction takes place, and
  - the layout and physical qualities of the screen
- Also known as **human factors** – but this can also be used to mean much of HCI!
- Ergonomics good at defining standards and guidelines for designing systems

Ergonomics -examples

- **arrangement of controls and displays**

  e.g. controls grouped according to function or frequency of use, or sequentially to allow rapid access

- **surrounding environment**

  e.g. seating arrangements adaptable to cope with all sizes of user

- **health issues:** possible consequences of our designs on the health and safety of users.

  e.g. physical position, environmental conditions (temperature, humidity), lighting, noise,

- **use of colour**

  e.g. use of red for warning, green for okay,
  awareness of colour-blindness. Blue should not be used to display critical information etc.

Red, green and yellow are colors frequently associated with stop, go and standby respectively.
The color of mourning is **black** in some cultures and **white** in others.

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.

Common interactionstyles

- command line interface
- menus
- natural language
- question/answer and query dialogue
- form-fills and spreadsheets
- WIMP
- point and click three–dimensional interfaces

Context

Interaction affected by social and organizational context

other people

- desire to impress, competition, fear of failure

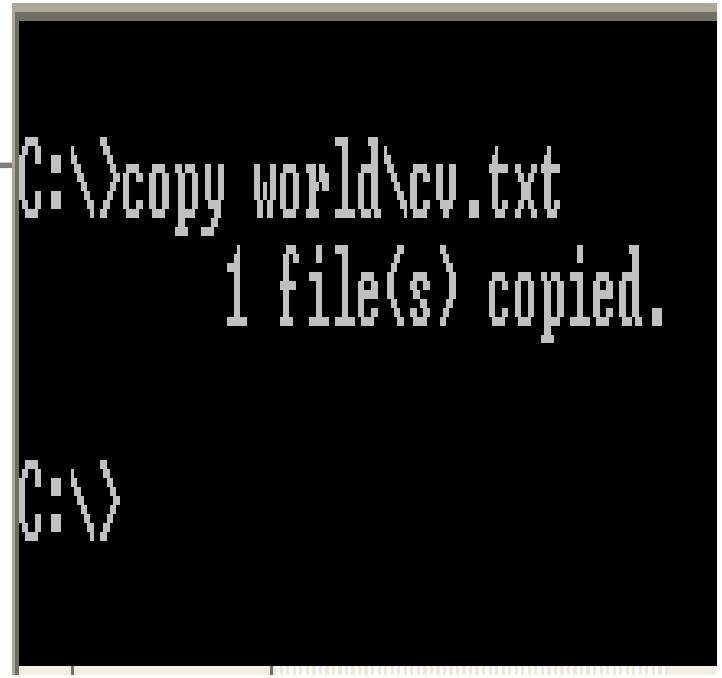
motivation

- fear, allegiance, ambition, self-satisfaction

inadequate systems

- cause frustration and lack of motivation

Command Line Interface



Advantages

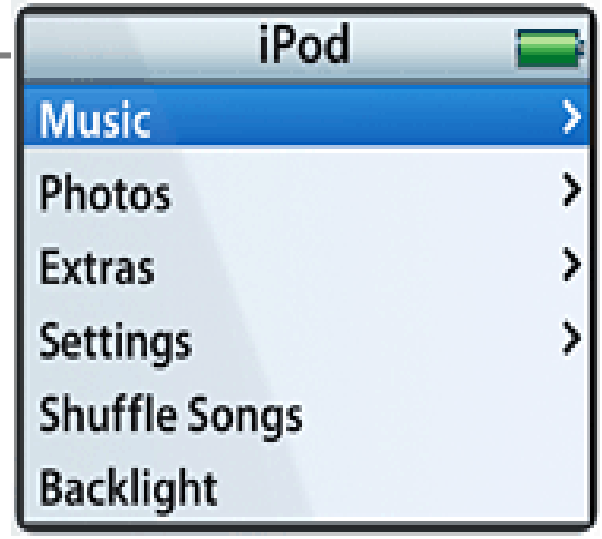
- Very flexible with the use of “switches” (options)
- Good for “expert” users - can quickly access commands
- Uses the fewest system resources

Disadvantages

- Requires the user to learn “complex” commands or language
- “Hidden” features i.e. if the command is unknown we cannot make use of that feature
- Not very good for novice users

Menu Driven Interface

Advantages

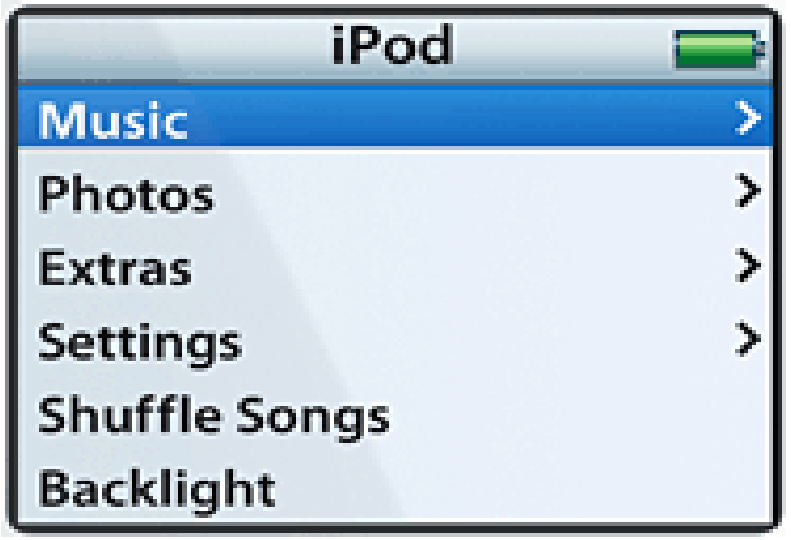


- No need to learn complex commands/language
- Easier for a novice to learn/use
- Ideal when there are a limited number of options (efficient)

Disadvantages

- Can be frustrating for experienced users i.e. the command they want to use is buried 5 levels deep.
- User interface may be limitedby screen space and number of options available.

Menu Driven Interfaces



Menu Driven Applications

- ATM
- Mobile Phone
- MP3 Player
- Video recorder
- Household Devices
- Digital/Cable TV

Form-fills

Form-fills

- Primarily for data entry or data retrieval
- Screen like paper form.
- Data put in relevant place
- Requires good design

Query interfaces

Query interfaces

- Question/answer interfaces
  - user asked series of questions
  - suitable for novice users
  - often used in information systems
- Query languages (e.g. SQL)
  - used to retrieve information from database
  - requires understanding of database structure and language syntax, hence requires some expertise

Graphical User Interface

Advantages

- Most suitable interface for inexperienced or novice users
- Many generic packages for a GUI will share common features

Disadvantages

- GUIs use more system resources than other types of interface

Natural Language Interface

Advantages

- No training required
- Can be quicker than keyboard entry
- Hands-free
- Can be used by the disabled

Disadvantages

- Emerging technology – still contains “bugs”
- Difficulty in dealing with homonyms
- Difficult to recognise all the different ways of saying things (and regional dialects)
- Artificial languages are often more precise

User interface (UI)

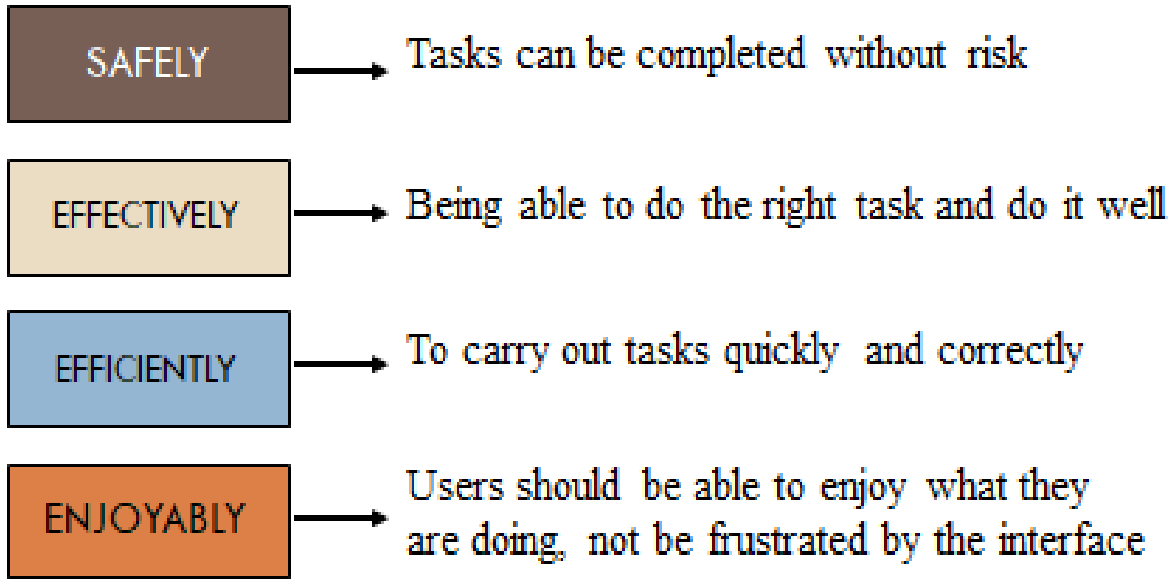
User interface: User interfaces mediate the interaction (**dialog**) between humans and computers.

The User Interface today is often one of the most critical factors regarding the success or failure of a computer system

Good UI design:

- Increases efficiency
- Improves productivity
- Reduces errors
- Reduces training
- Improves acceptance

Generally Users should be able to use an interface:



Principles of User interface design

- Simple and natural dialogue
  - Speak the user's language
  - Minimize user's memory load
  - Provide feedback
  - Provide clearly marked exits
  - Provide shortcuts
  - Deal with errors in a positive manner
  - Provide help

Summary

~~Quality of system depends on how it is represented and used by user~~

Therefore, enormous amount of attention has been paid to better designs of HCI.

Virtual reality can be the common interface in future

Natural and Neural Interfaces are the future of Human-Computer input interfaces