Human Computer Interaction

Chapter Two: Human and Computer in HCI

2014 E.C.

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Introduction

- Cognitive Psychology is defined as the scientific study of mental processes,
  - which includes attention, memory, problem solving, perception, thinking and language use of human.
- **Cognitive psychology** helps in HCI to understand capabilities and limitations of human beings. b/s it tells us
  - ✓ How humans perceive the world around them
  - ✓ How they store and process information and solve problems
  - ✓ And how they physically manipulate objects
- Human beings involves an intelligent information-processing system.
  - ✓ Includes **problem solving**, **learning**, and, consequently, **making mistakes**.

CON…

- **Model of human beings** as information processing unit.
- Contains three subsystems
  - ✓**The perceptual system:** handling sensory stimulus from the outside world
  - ✓**The motor system*:*** controls actions
  - ✓**The cognitive system*:*** provides the processing needed to connect the two

Information Input/output channels

- Input in the human occurs mainly through the **senses**
  - ✓Sight, hearing, touch, taste and smell
- Output in the human occurs mainly through the **motor control** of the effectors
  - ✓The fingers, eyes, vocal system
- Interaction of user and computer

  - That is the user's output becomes the computer's input and vice versa.

Human Memory

- There are three types of memory function:
  - Sensory memory
  - Long term memory
  - Short term memory
- **Sensory memory**
  - ✓ Buffers for stimuli received through senses(IEH.)
    - **Iconic** memory - visual stimuli(large amount of storage but, stores less than a second.)
    - **Echoic** memory - hearing stimuli
    - **Haptic** memory - tangible stimuli(touch)
  - ✓ Continuously overwritten

Con…

- **Short term memory**
  - Scratch -pad for temporary recall
- **Examples**

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- **Long-term memory (LTM)**
  - Information moves from STM to LTM through rehearsal/practice
  - Repository for all our knowledge
- Two types LTM structure
  - Episodic – serial memory of events
  - Semantic – structured memory of facts, concepts, skills

Con…

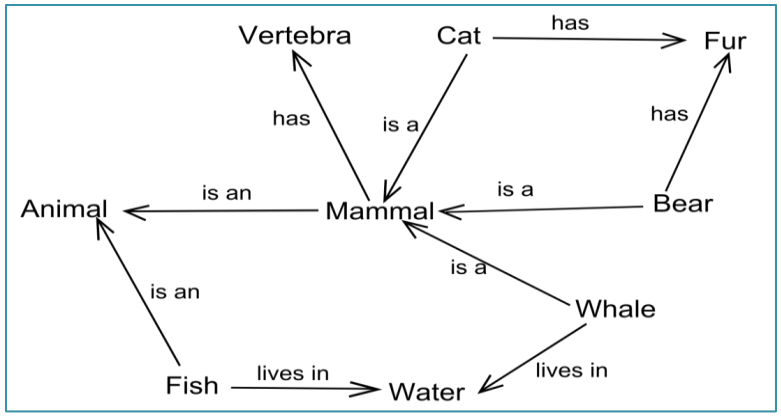
- **Episodic Memory Structure**
  - Serial memory of events and experiences
  - Supports inference i.e. We can reconstruct the actual events from this memory
  - Example - Your first day of college or graduation date of your first degree
  - Represents relationships between bits of information

Con…

- **Semantic Memory Structures**
  - Structured memory of facts, concepts, and skills
  - One way of representing this type of memory is using

Semantic Network Model

- Items are associated to each other in classes, and may inherit attributes from parent classes



Con…

- Three main activities related to long-term memory:
  - Storage or remembering of information,
  - Forgetting and
  - Retrieving information
- **Storage** of information
  - Rehearsal - information moves from STM to LTM
- **Forgetting** – what causes us lose information?
  - Two main theories of forgetting: decay and interference
    - Decay - If information is not retrieved and rehearsed, it will eventually be lost.
    - Interference - If we acquire new information it causes the loss of old information

Con…

- **Retrieval/Recovery**
  - **Do we really forget?**
  - Two types of information retrieval: **recall** & **Recognition**
    - **Recall /call to mind**
      - Information is reproduced from memory with out a hint E.g. trying to write a formula from your mind.
    - **Recognition**
      - Involves hint
      - Gives knowledge that it has been seen before
      - Less complex than recall
        - E.g. trying to find out the right formula from a group of similar formulas

Information processed and applied

- Most complex and separates humans from other is information processing systems
- **Thinking**
- **it can require different amounts of knowledge**
  - Performing a subtraction calculation vs. understanding
- Two categories of thinking considered: **Reasoning** & **Problem Solving**
  - In practice these are not different since the activity of solving a problem may well involve reasoning and vice versa.

Con

- **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 Reasoning**
  - Deduction: derive logically necessary conclusion from given premises. e.g. If it is Friday then she will go to work

    It is Friday, Therefore she will go to work.
- **Inductive Reasoning**
  - Induction - generalize from cases seen to cases unseen

    e.g. All elephants we have seen have trunks, therefore all elephants have trunks.

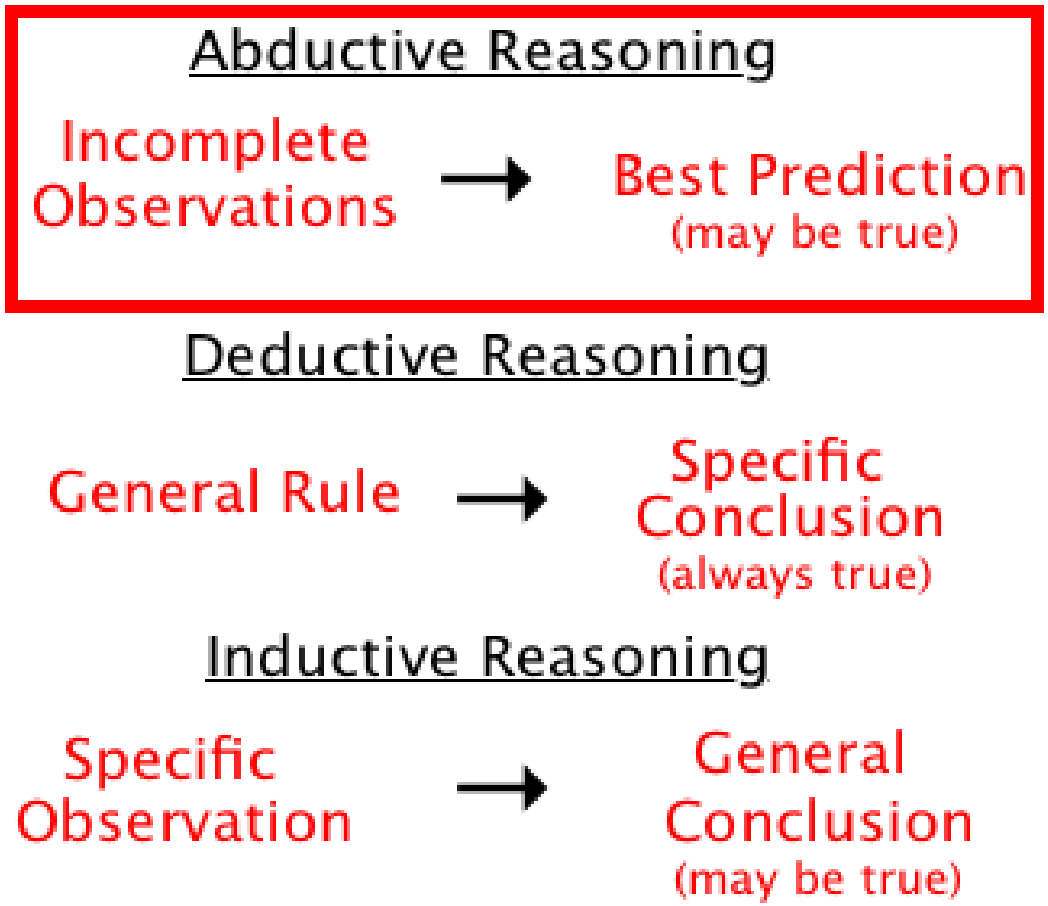
Con…

- **Abductive reasoning**
  - Reasoning from event to cause

    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/he is called to an emergency”
    - This can lead to problems in using interactive systems
      - If an event always follows an action, the user will infer that the event is caused by the action

Con…


Abductive Reasoning
Incomplete Observations
Best Prediction
(may be true)
Deductive Reasoning
General Rule
Specific Conclusion
(always true)
Inductive Reasoning
Specific Observation
General Conclusion
(may be true)

Problem solving

- Process of **finding solution to unfamiliar task** using knowledge we have.
- Several theories - different views on how people solve problems
- **Analogy**
  - Analogical mapping
    - Use knowledge of similar problem from similar domain
  - Analogical mapping difficult if domains are semantically different
- **Skill acquisition**
  - Information is structured more effectively
  - Example Chess players
    - Chess masters remember board configurations and good moves associated with them

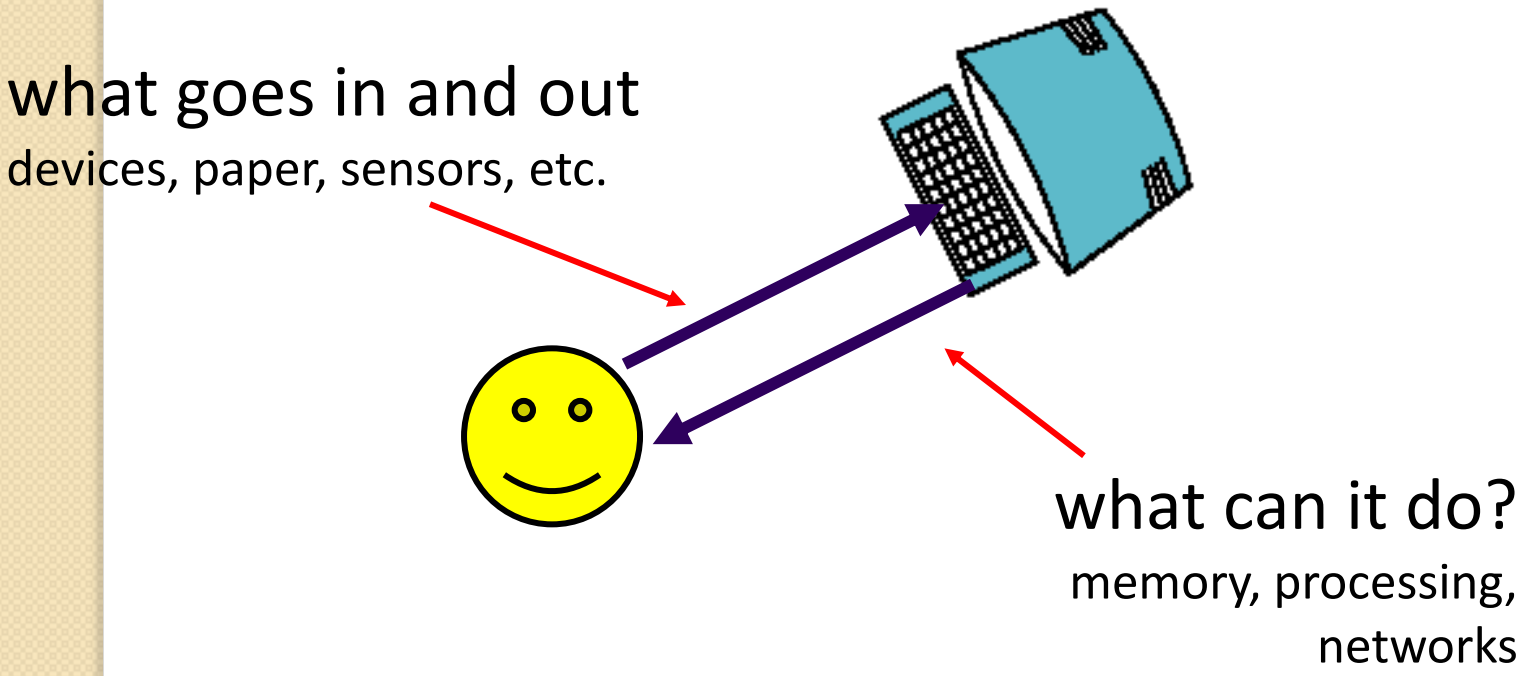
Emotion influences human capabilities

- Emotion is our interpretation of a physiological response to a stimuli
- The biological response to physical stimuli is called Affect
- Affect influences how we respond to situations
  - Positive → creative problem solving
  - Negative → narrow thinking

  "Negative affect can make it harder to do even easy tasks; positive affect can make it easier to do difficult tasks" (Donald Norman)
- Emotion clearly involves both cognitive and physical responses to stimuli
- Implications for interface design
  - Stress will increase the difficulty of problem solving
  - Relaxed users will be more forgiving (tolerant) of shortcoming in design

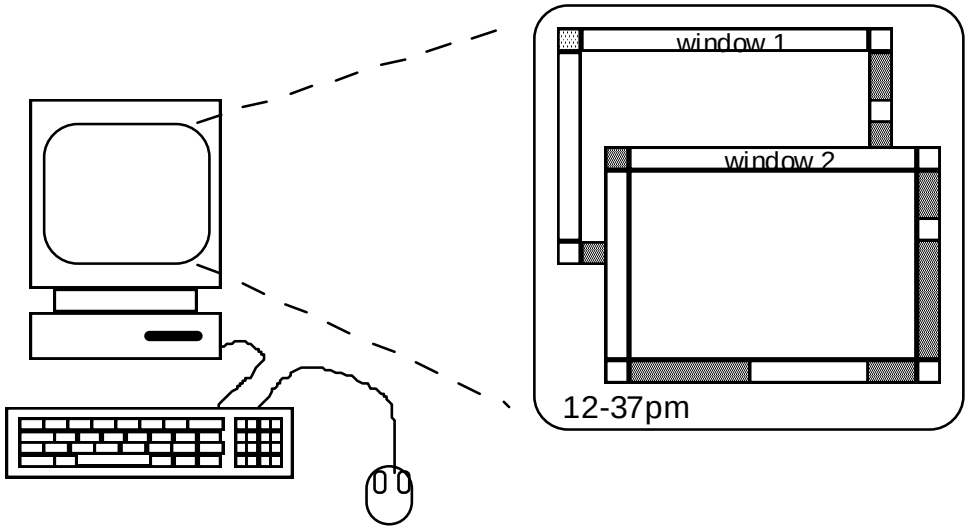
The Computer

- A computer system comprises various elements
  - Input devices, output devices , memory, processing devices, …
- To understand human–computer interaction we need to understand computers!



Introduction

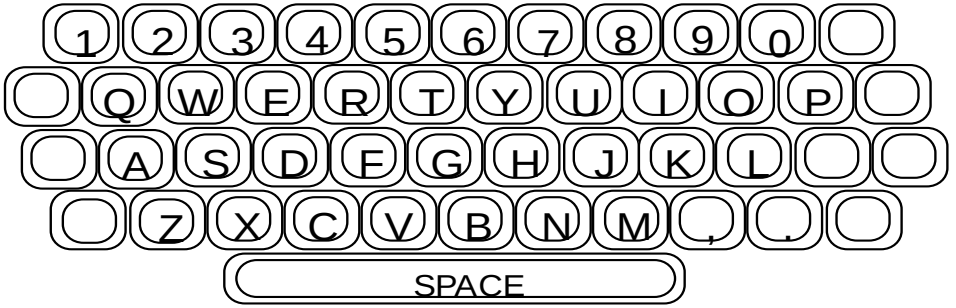
- **A 'typical' computer system**
  - Screen, or monitor, on which there are windows
  - Keyboard
  - Mouse/track pad
  - Variations
    - Desktop
    - Laptop
    - PDA



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

Text entry devices

- **Keyboards**
  - Most common text input device
  - Layout
    - QWERTY, Alphabetic, Dvorak



- **QWERTY**
  - **Standardised layout but …**
    - Minor differences between UK and USA keyboards
    - Non-alphanumeric keys are placed differently e.g. **£** Vs **$**
  - QWERTY arrangement not optimal for typing – layout to prevent typewriters jamming!
  - Alternative designs allow faster typing

Text entry devices: Keyboards…

- **Alphabetic**
  - Keys arranged in alphabetic order
  - Not faster for trained typists
  - Not faster for beginners either!
- **Dvorak**
  - Common letters under dominant fingers
  - Biased towards right hand

Text entry devices: Keyboards…

- **Special keyboards**
  - Designs to reduce fatigue for repetitive strain injury (RSI)
    - For one handed use
    - e.g. the Maltron left-handed keyboard

  - **Chord keyboards**
    - Only a few keys - four or five
    - letters typed as combination of key presses
    - Compact size – ideal for portable applications
    - Short learning time – key presses reflect letter shape
    - Fast - once you have trained but fatigue after extended use

Text entry devices: Keyboards…

- **Special keyboards…**
  - Phone pad and T9 entry (text on 9 keys)
    - Use numeric keys with multiple presses

      2 - a b c 6 - m n o

      3 - d e f 7 - p q r s

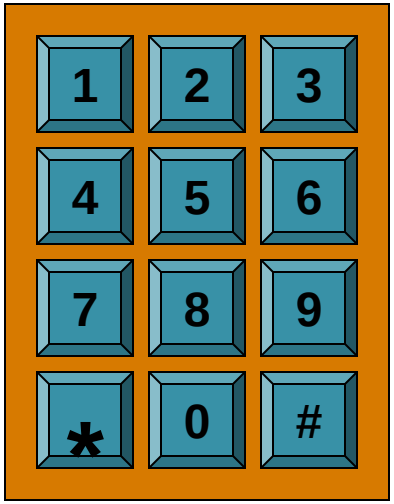
      4 - g h i 8 - t u v

      5 - j k l 9 - w x y z

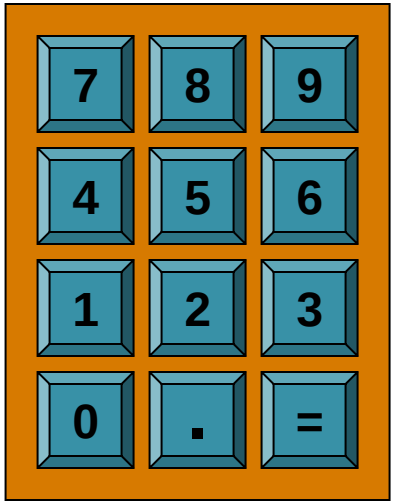
      hello = 4433555[pause]555666
    - T9 predictive entry
      - Type as if single key for each letter
      - Use dictionary to ‘guess’ the right word
      - Hello = 43556 …
      - But 26 => menu ‘am’ or ‘an’

Text entry devices: Keyboards…

- **Special keyboards…**
- **Numeric keypads**
  - For entering numbers quickly:
    - calculator, PC keyboard
  - For telephones not the same!!
  - ATM like phone



telephone



calculator

ATM

Text entry devices

- **Handwriting Recognition**
  - Text can be input into the computer, using a pen
  - Natural interaction
  - Technical problems:
    - interpreting individual letters
- **Speech recognition**
  - Most successful when:
    - Limited vocabulary systems
  - Problems with
    - External noise interfering
    - Imprecision of pronunciation
    - Large vocabularies
    - Different Speakers

Positioning, pointing and drawing

- **The Mouse -** How does it work? Two methods for detecting motion
  - Mechanical
    - Contains a metal or rubber ball on its under side
    - Rolling of the ball in any direction will cause movement of the pointer on-screen in the same direction
    - Can be used on almost any flat surface
  - Optical
    - Light emitting diode on underside of mouse
    - May use special grid-like pad or just on desk
    - Less susceptible to dust and dirt
    - Detects fluctuating alterations in reflected light intensity to calculate relative motion in (x, z) plane

Positioning, pointing and drawing…

- **Touchpad**
  - Small touch sensitive tablets
  - ‘Stroke’ to move mouse pointer
  - Used mainly in laptop computers
- **Joystick**
  - Indirect - pressure of stick determines velocity of movement
  - Buttons for selection - on top or on front like a trigger
  - Often used for computer games - aircraft controls and 3D navigation

Positioning, pointing and drawing…

Touch-sensitive screen

- **Advantages:**
  - Fast, and requires no specialised pointer
  - Good for menu selection
  - Suitable for use in hostile environment: clean and safe from damage.
- **Disadvantages:**
  - Finger can mark screen
  - Imprecise (finger is a fairly blunt instrument!)
    - Difficult to select small regions or perform accurate drawing

Display Devices

- **Bitmap displays -** (CRT & LCD)
  - Screen is vast number of coloured dots
  - **Resolution** … used (inconsistently) for
    - Number of pixels on screen (width x height)
      - e.g. 1024 x 768, 240x400
  - **Bit depth**
  - Bit depth specifies the number of bits used for each colour component
- Monochrome screens - one bit per pixel - black/white only
- More bits per pixel give rise to more color
  - e.g. 8 bit $2^8 = 256$,

    32 bit $2^{32} = 4294967296$

Display Devices

4 bit.png
16 colors
13 KB (-87%)

2 bit.png
4 colors
6 KB (-94%)

1 bit.png
2 colors
4 KB (-96%)

Display Devices

32 bit.png
4,294,967,296 colors
98 KB

8 bit.png
256 colors
37 KB (-62%)

Memory

- **Short-term memory – RAM**
  - Random access memory (RAM)
    - On silicon chips
- **Long-term Memory – Disks**
  - **Magnetic disks**: magnetic media E.g. floppy disks, hard disks
  - **Optical disks -** use lasers to read and sometimes write E.g. CD-ROM, DVD
  - **Solid State Memory -** uses integrated circuit assemblies. used in PDAs, cameras etc. e.g. a USB flash drive

Approaches to HCI

Describes HCI design approaches that may be applied to user interface designs to develop user-friendly, efficient design.

- four approaches include the
- **Anthropomorphic Approach,**
- **Cognitive Approach,**
- **Predictive Modelling Approach, and**
- **Empirical Approach**.

Anthropomorphic Approach

- Involves designing a user interface to possess human-like qualities.
- For instance, an interface may be designed to communicate with users in a human-to-human manner, as if the computer empathizes with the user.
- Interface error messaging in often written this way, such as, “We’re sorry, but that page cannot be found.”
- Another example is the use of avatar in computer-based automation, as can be found in automated telephony systems.
- For example, when a voice-response system cannot understand what the user has spoken, after several attempts it may reply in an apologetic tone, “I’m sorry, I can’t understand you.”

Con…

Affordances

- Human affordances are perceivable potential actions that a person can do with an object.
- In terms of HCI, icons, folders, and buttons afford mouse-clicking, scrollbars afford sliding a button to view information off-screen, and drop-down menus show the user a list of options from which to choose.
- Similarly, pleasant sounds are used to indicate when a task has completed, signalling that the user may continue with the next step in a process. Examples of this are notifications of calendar events, new emails, and the completion of a file transfer.

Constraints

- Constraints complement affordances by indicating the limitations of user actions. An unpleasant sound (sometimes followed by an error message) indicate that the user cannot carry out a particular action.
- Affordances and constraints can be designed to non-verbally guide user behaviours through an interface and prevent user errors in a complex interface.

Cognitive Approach

- The cognitive approach to HCI considers the abilities of the human brain and sensory-perception in order to develop a user interface that will support the end user.

Metaphoric Design

- Using metaphors can be an effective way to communicate an abstract concept or procedure to users
- Computers use a “desktop” metaphor to represent data as document files, folders, and applications.
- A benefit of using metaphors in design is that users who can relate to the metaphor are able to learn to use a new system very quickly.

Con…

- For example, Macintosh computers use the icon of a trashcan on the desktop, while (windows OS) PCs have a recycle bin.

Attention and Workload Models

- To provide good usability, it is important to consider the user's attention span, which may be based on the environment of use, and the perceived mental workload involved in completing a task.
- Typically, users can focus well on one-task-at-a-time. For example, when designing a web-based form to collect information from a user, it is best to contextually collect information separately from other information.
- The form may be divided into "Contact Information" and "Billing Information", rather than mixing the two and confusing users.
- If all the data were collected on a single form that makes the user scroll the page to complete, the user may become overwhelmed by the amount of work that needs to be done to complete the form, and he may abandon the website.

Con…

- Workload can be measured by the amount of information being communicated to each sensory system at a given moment.
- Overloading the user's memory is another common problem on websites.
- For example, when there are too many options to choose from, a user may feel overwhelmed by the decision they have to make, become frustrated, and leave the website without completing their goal.

Human Information Processing Model(HIP)

- HIP describes the flow of information from the world, into the human mind, and back into the world.
- When a human pays attention to something, the information first gets encoded based on the sensory system that channeled the information.
- Next, the information moves into Working Memory, formerly known as Short-Term memory.

Con…

- Working STM can hold a limited amount of information (up to 30 seconds).
- Repeating or rehearsing information may increase this duration.
- After Working Memory, the information may go into LTM or simply be forgotten.
- Long-Term Memory is believed to be unlimited, relatively permanent memory storage.
- After information has been stored in long-term memory, humans can retrieve that information via recall or recognition.
- The accuracy of information recall is based on the environmental conditions and the way that information was initially encoded by the senses.

The empirical approach

- The empirical approach to HCI is useful for examining and comparing the usability of multiple conceptual designs.
- This testing may be done during pre-production by counterbalancing design concepts and conducting usability testing on each design concept

Human Task Performance Measures

- In addition to a qualitative assessment for conceptual design, measuring users' task performance is important for determining usability.
- User performance can be assessed absolutely, i.e., the user accomplishes or fails to complete a task, as well as relatively, based on pre-established criteria .
- The time and number of errors may be compared to the desired standard.

Predictive Modelling Approach

- GOMS is a method for examining the individual components of a user experience in terms of the time it takes a user to most efficiently complete a goal.
- GOMS is an acronym that stands for Goals, Operators, Methods, and Selection Rules.
- Goals are defined as what the user desires to accomplish on the website.
- Operators are the atomic-level actions that the user performs to reach a goal, such as motor actions, perceptions, and cognitive processes.
- Methods are procedures that include a series of operators and sub-goals that the user employs to accomplish a goal.
- Selection Rules refer to a user's personal decision about which method will work best in a particular situation in order to reach a goal.

Con…

- The GOMS model is based on human information processing theory, and certain measurements of human performance are used to calculate the time it takes to complete a goal.
- For example, the average time it takes a human to visually fixate on a web page, move eye fixation to another part of the web page, cognitively process information, and make a decision of what to do next can be measured in milliseconds.
- The times it takes for each of these operators can be added up to produce the total time for a particular method.
- Multiple methods can be compared based on the total time to complete a task in order to determine which is the most efficient method for accomplishing the task.

Software Engineering And HCI

- SE & HCI are both relatively new disciplines of computer science. Furthermore, as both names suggest, they each have strong connections with other subjects.
- SE is concerned with methods and tools for general software development based on engineering principles.
- SE depends on the software ability which needed for the system to perform its tasks, achieve its objectives, and meet its requirements.
- SE is the **systematic engineering approaches for software product/application development**.
- It is an engineering branch associated with analyzing user requirements, design, development, testing and maintenance of software products.
- HCI engineering depends on the tasks of people using the system or product and interactions that the users need to perform their tasks on the environment in which they work.
- HCI consists of three parts: **the user, the computer itself, and the ways they work together**.(components of HCI).

HCI in Software Engineering

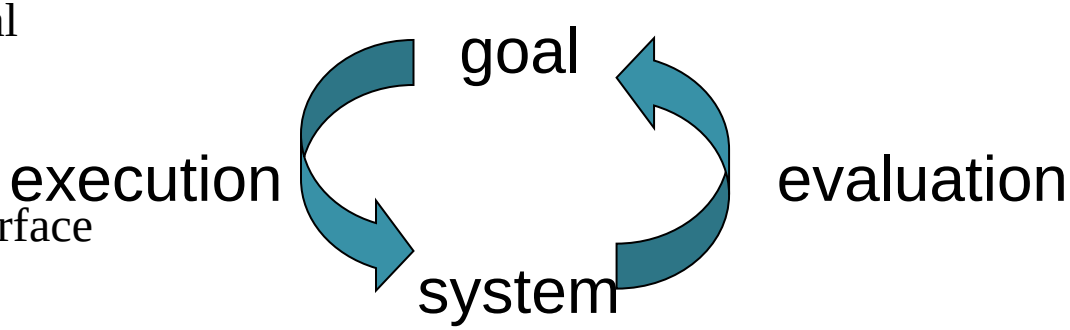
- Software engineering is a study
  - Applies systematic way of developing software
    - Produces quality software products
    - Applicable for large problems
- But there are Many software development disasters:
    - Cost overruns, late delivery
    - Reduced or wrong functionality, non-existent documentation
    - Cost of failure becoming very high: Financial crises, Loss of equipment
- So specially HCI helps in the software engineering process to avoid those disasters that are caused due to poor interface design and they are so much related

The Interaction

- Communication b/n user and a system
- **Common interaction styles**
  - Command line interface
  - Menus Selection
  - Form-fills
  - Direct Manipulation.
  - Natural language(spoken commands)
  - Question/answer and query dialogue
  - Point and click

Donald Norman's model

- Normans model concentrates on user's view of the interface
- Seven stages
  - 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



Thank you!

Question?