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Human Computer Interaction

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Abstract

Human–computer interaction (**HCI**) is the study of interaction between users and computers. Here we discuss numerous ways how the interaction between human and computer can be simplified. In today's world when technological development throughout world is growing exponentially HCI is a field where we require considerable efforts to match up the current technological progress. Here we discuss various design methodologies which helps us to the futuristic developments that can be achieved. According to the view of computer scientists and Engineers in future we will be having such a technological advancement in this field that amazes world.

Keywords: *Human–computer interaction, Interface, Proximity, Interpretation.*

1. Introduction

Human–computer interaction (**HCI**) is the study of interaction between users and computers. Interaction between users and computers occurs at the user interface (or simply interface), which includes both software and hardware; for example, characters or objects displayed by software on a personal computer's monitor, input received from users via hardware peripherals such as keyboards and mice, and other user interactions with large-scale computerized systems such as aircraft and power plants.

According to **Association for Computing Machinery** human-computer interaction is defined as:

"A discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them."

The method has been designed to be used by systems and software developers to evaluate visual interfaces. These evaluations are carried out before releasing the version of the software to other teams.

In some companies, there are specific departments that carry out the human computer interaction process analysis on an interface. These departments are independent of the development team. Sometimes this interaction leads to redevelop and redesign of the interface because designers and developers did not use any method to analyze their interface prior the delivery of the version to those departments.

The main goal of Human Computer Interaction is to improve the interactions between users and computers. This means that computers can be more usable and receptive to the user's needs.

2. Why HCI is needed?

Consider you have to build a house. So as a owner you approach an architect and express your requirements. He designs the layout, colors & interiors making optimum use of space and your budget. Then you both approach the civil engineer or contractor who works on calculating stress, beam length, municipal laws and other engineering aspects to finally build this house. In the same way Product management/clients give requirements to Designer and they both work with Development to come up with software solution.

3. Elements of Human Computer Interaction

Human computer interaction is not a single term, it is rather, combination of three different elements to form a broad area of research i.e. HCI.

3.1 Human: Humans are the elements which uses the system i.e. users of the system.

Humans interpret information based on various attributes such as:

3.1.1 Physical Interpretation:

i) Mechanism for receiving light and transforming it into electrical energy.
ii) Light reflects from objects
iii) Images are focused upside-down on retina
iv) Retina contains rods for low light vision and cones for colour vision
v) Ganglion cells (brain!) detect pattern and movement.

3.1.2 Reading:
i) Visual pattern perceived.
ii) Decoded using internal representation of language.
iii) Interpreted using knowledge of syntax.
iv) Semantics, pragmatics.
v) Reading involves saccades and fixations.
vi) Perception occurs during fixations
vii) Word shape is important to recognition
viii) Negative contrast improves reading from computer screen

3.1.3 Hearing: Provides information about environment: distances, directions, objects etc.
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

Pitch	–	sound frequency
Loudness	–	amplitude
Timbre	–	type or quality

3.1.4 Touch: Touch provides important feedback about environment. That may be:
i) May be key sense for someone who is visually impaired.
ii) Stimulus received via receptors in the skin:
iii) Thermo receptors– heat and cold
iv) Nociceptors–pain
v) Mechanoreceptors– pressure (some instant, some continuous)
vi) Some areas more sensitive than others e.g. fingers.
vii) Kinethesis - awareness of body position affects comfort and performance.

3.2 Computer: A computer in an electronic device which carry out the tasks and operations performed by the users. Computer is made up of many elements. Each of which affects the interaction.

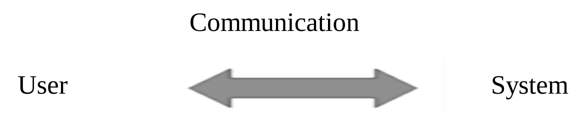

Fig1: Structure of HCI.

3.3. Interaction: The interaction means how the human and computer communicate. There are various ways and a numerous hardware and software interaction tools using which computer and user of computer communicates.

3.3.1 Terms used in interaction:

Domain: The area of work under study, e.g. graphic design

Goal: What you want to achieve, e.g. create a solid red triangle

Task: How you go about doing it. Ultimately in terms of operations or actions. e.g. select fill tool, click over triangle

3.3.2 Interaction Model

Donald Norman's Model: Norman's model basically concentrates on user's view of the interaction. This model consisted of seven stages which defines what is the actual goal to be achieved is. This goal is totally depends on user's perception, i.e. how user view the goal. Based on this perception the user executes the goal to achieve by applying various actions and operation to the system which are then evaluated by the system to provide what user have achieved after application of several operations.

e.g.: Let us suppose we want to draw a solid rectangle of blue colour.
The system using which the goal is achievable is called domain i.e. graphics design software such as Photoshop, MS paint.

Domain: Graphics Design software.

Then the first thing that user identifies is goal i.e. what has to be done.

Goal**:** To draw a solid rectangle of blue colour.

Now, how the user achieves this goal?
That is how user goes about doing this task to achieve goal. For this user performs a number of operations on the system.

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***Task*:** Click over rectangle, select fill tool, fill blue colour, etc.

This is more clearly explained with the help of diagram:

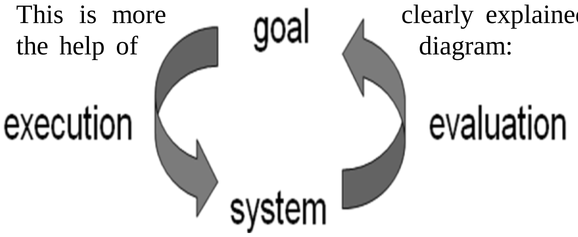

Fig2: Donald Norman's Model of interaction.

The various stages of Donald Norman's Model are:

i) User Establishes The Goal: Here user identifies the goal i.e. what is to be done.

ii) Formulates Intention: The user percept what are the steps to achieve the goal i.e. how it has to be done.

iii) Specifies Actions At Interface: The user performs a number of actions and operations based on his perception of the problem.

iv) Executes Action: User executes what he has done on the system.

v) System State: The user identify the system's state at the time of giving input to the system for evaluation i.e. no of programs running, amount of memory required and amount of free space available etc.

vi) Evaluation of System With Respect To Goal: Here the system generates the output with respect to the given actions and operations performed by the user on the system.

Here system state is combination of two stages i.e. perceive system state and interpret system state.

4. Human Computer Interaction (HCI) Design

While design a good human computer interaction system we must to take care of various points which are discussed below:

4.1 HCI Design Objectives

Before designing any HCI system we must be aware of the purpose of the system. It can be described by considering various facts such as:

4.1.1 Gain Perspective:

i) Importance of the user interface
ii) Impact of good and bad user interfaces
iii) Diversity of users and applications

4.1.2 Learn Methods And Tools:

i) Design tradeoffs of dialogue types/devices
ii) Importance of training materials
iii) Importance/difficulty of evaluating usability

4.1.3 Appreciate Limitations: Know when and how to work with:

i) HF Specialists -- for design and evaluation of the user interface
ii) Technical writers -- for designing and producing online and printed user guidance
iii) Statisticians -- for valid and reliable measurement and analysis of user interfaces
iv) Graphic designers -- for designing effective and motivating displays

4.2 HCI Design Characteristics

In order to reduce the costs of this interaction, the HCI Method has been designed with three characteristics in mind:

Easy to use: It does not require expert knowledge on Human Computer Interaction.

Simple: It does not involve knowledge acquisition of new languages.

Web-based Tool Support: It provides a web-based tool to document the HCI on the design.

4.3 Design Principles

While evaluating an user interface (current or designing a new user interface), it is important to keep in mind the following experimental design principles:

i) **Empirical Measurement**: Test the interface early on with real users who come in contact with the interface on an everyday basis. Keep in mind that results may be altered if the performance level of the user is not an accurate depiction of the real human-computer interaction. Establish quantitative usability specifics such as: the number of users performing the task(s), the time to complete the task(s), and the number of errors made during the task(s).

ii) Iterative Design: After determining the users, tasks, and empirical measurements to include, perform the following iterative design steps:

I. Design the user interface
II. Test
III. Analyze results
IV. Repeat.

With the above mentioned points we also give considerable focus on the following principles:

i) Visibility
ii) Consistency
iii) Familiarity
iv) Affordance
v) Navigation
vi) Control
vii) Feedback
viii) Style
ix) Constraints
x) Flexibility

4.4 HCI Design Methodologies:

A number of methodologies focusing specifically on techniques for human–computer interaction design have emerged since the rise of the field in the 1980s. The main focus of most design methodologies is to model for how users, designers, and technical systems interact. Modern models tend to focus on a constant feedback and conversation between users, designers, and engineers and push for technical systems to be wrapped around the types of experiences users want to have, rather than wrapping user experience around a completed system.

4.4.1 User-Centered Design:

User-centered design (UCD) is a modern, widely practiced design philosophy focusing on user satisfaction. The main idea is that users must take center-stage in the design of any computer system. Users, designers and technical practitioners work together to articulate the wants, needs and limitations of the user and create a system that addresses these elements. Often, user-centered design projects are informed by ethnographic studies of the environments in which users will be interacting with the system. This practice is similar but not identical to Participatory Design, which emphasizes the possibility for end-users to contribute actively through shared design sessions and workshops.

4.4.2 Body Storming:

Body storming is a creativity technique used in interaction design. The idea is to imagine what it would be like if the product existed, and act as though it exists, ideally in the place it would be used.

4.4.3 Contextual Design (CD):
Contextual design is a user-centered design process which incorporates ethnographic methods for gathering data relevant to the product, field studies, rationalizing workflows, system and designing human-computer interfaces. In practice, this means that researchers aggregate data from customers in the field where people are living and applying these findings, into a final product. Contextual Design can be seen as an alternative to engineering and feature driven models of creating new systems.
i) **Contextual Inquiry:** Contextual inquiry is a technique to capture detailed information about how users of a product interact with the product. This information is captured by observation of user's behavior and conversations with the user while he/she works.

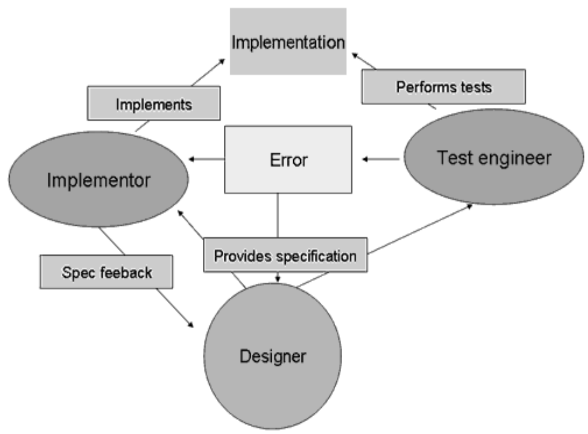

Fig3: Contextual Design Model

ii) **Work Modeling:** Work practices are analyzed and detailed work models are created in order to understand the workflow. Contextual design consists of five work models which are used to define the work and details of the working environment.

<u>Contextual Design Work Models</u>

i) Flow Model: It represents the coordination, interaction and responsibilities of the people in a certain work practice.

ii) Sequence Model: It represents the required steps to accomplish a certain activity.

iii) Cultural Model: This model represents the norms, influences, and pressures that are present in the work environment.

iv) Artifact Model: This model represents the documents or other products that are created while working. Artifacts often have a structure or styling that could represent the user's way of structuring the work.

v) Physical Model: It represents the physical environment where the work tasks are accomplished; often, there are multiple physical models representing, e.g., office layout, network topology, or the layout of tools on a computer display.

4.4.4 Consolidation:

Data from individual customer interviews are analyzed in order to reveal patterns and the structure across distinct interviews. Models of the same time can be consolidated together. Another method of processing the observations is making an affinity diagram (described by Beyer & Holtzblatt).

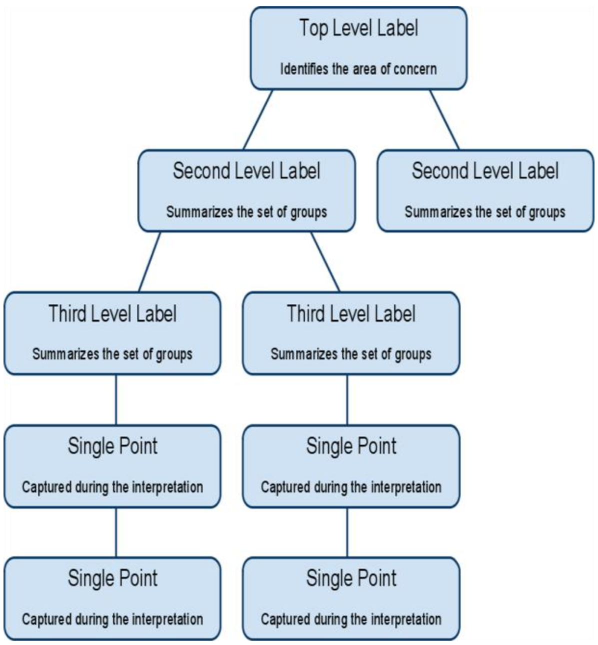

Fig4: Affinity Diagram

The affinity diagram is a Bottom-up method which defines how to carry out details based on observation and information gathered from each user. . Also the design ideas and relevant issues that arise during the process should be included in the affinity diagram.

i) A single observation is written on each piece of paper

ii) Individual notes are grouped according the similarity of their contents

iii) These groups are labeled with colored post-it notes, each color representing a distinct level in the hierarchy

iv) Then the groups are combined with other groups to get the final construct of observations in a hierarchy of up to three levels.

4.4.5 The User Environment Design:

The User Environment Design captures the floor plan of the new system. It shows each part of the system, how it supports the user's work, exactly what function is available in that part and how the user gets to and from other parts of the system. Contextual Design uses the User Environment Design (UED) diagram, which displays the focus areas, i.e., areas which are visible to the user or which are relevant to the user. Focus area can be defined further as functions in a system that supports a certain type or part of the work. The UED also presents how the focus areas relate to each other and shows the links between focus areas.

4.4.6 Test with Customers:

Testing the design ideas with paper prototypes or even with more sophisticated demos before the implementation phase helps the designers communicate with customers about the new system and develop the design further. Prototypes test the structure of a User Environment Design and initial user interface ideas, as well as the understanding of the work, before the implementation phase. Depending on the results of the prototype test, more iterations or alternative designs may be needed. This method helps in modeling the exact need of the users and reduces time and thereby enhancing performance of the under designed system.

4.4.7 Iterative Design:

Iterative design is a design methodology based on a cyclic process of prototyping, testing, analyzing, and refining a product. Based on the results of testing the most recent iteration of a design, refinements and changes are made. This process is intended to improve the quality and functionality of a design.

Iterative Design Process: The iterative design process may be applied throughout the new product development process. However, changes are easiest and less expensive to implement in the earliest stages of development.

I. The first step in the iterative design process is to develop a prototype. The prototype should be evaluated by a focus group or a group not associated with the product in order to deliver non-biased opinions.

II. Then information from the focus group is synthesized and incorporated into the next iteration of the design.

III. This process is then repeated until user issues have been reduced to an acceptable level.

5. How HCI Methods Works

Once a user interface is designed, the following steps are applied:

Step I. **Identify Task**: Select a task that can be done on the system. E.g. Write an email, save file, print document, insert picture on document, etc.

Step II. **Select Function**: Select the function The answers to this question are the functions that can be used to accomplish the task. Select one function.

***Step III*. Access Step**: How can you reach that function? The different actions to reach the function are grouped under the access step.

Actions can be:
i) Click-on File Menu
ii) Look at Properties
iii) Click on Properties
iv) Select Description tab

***Step IV*. Enter Step**: Once the function has been reached, ask what do you need to enter in order to execute the function? The answer are the actions for the enter step.

***Step V*. Confirm and Save**: The actions to execute this step are the verification of data inserted/ changed/ deleted in previous step and the trigger of the selected function (click on "Save" button).

***Step VI*. Monitor**: If there is a change on the system state that need to be monitored, the actions to do that monitoring are grouped on this step.

NOTE: *Steps III to VI are not required on all the tasks. Furthermore, the quicker the user reach the Confirm and Save, the faster the final user will be able to accomplish the task".*

6. HCI Display Designs

Displays are human-made artifacts designed to support the perception of relevant system variables and to facilitate further processing of that information. Before a display is designed, the task that the display is intended to support must be defined (e.g. navigating, controlling, decision making, learning, entertaining, etc.). A user or operator must be able to process whatever information that a system generates and displays; therefore, the information must be displayed according to principles in a manner that will support perception, situation awareness, and understanding.

6.1 Principles of Display Design

These principles of human perception and information processing can be utilized to create an effective display design. A reduction in errors, a reduction in required training time, an increase in efficiency, and an increase in user satisfaction are a few of the many potential benefits that can be achieved through utilization of these principles.

Certain principles may not be applicable to different displays or situations. Some principles may seem to be conflicting, and there is no simple solution to say that one principle is more important than another. The principles may be tailored to a specific design or situation. Striking a functional balance among the principles is critical for an effective design.

6.1. PERCEPTUAL PRINCIPLES

6.1.1. Make displays legible (or audible)

A display's legibility is critical and necessary for designing a usable display. If the characters or objects being displayed cannot be discernible, then the operator cannot effectively make use of them.

6.1.2. Avoid absolute judgment limits

Do not ask the user to determine the level of a variable on the basis of a single sensory variable (e.g. color, size, loudness). These sensory variables can contain many possible levels.

6.1.3. Top-down processing

Signals are likely perceived and interpreted in accordance with what is expected based on a user's past experience. If a signal is presented contrary to the user's expectation, more physical evidence of that signal may need to be presented to assure that it is understood correctly.

6.1.4. Redundancy gain

If a signal is presented more than once, it is more likely that it will be understood correctly. This can be done by presenting the signal in alternative physical forms (e.g. color and shape, voice and print, etc.), as redundancy does not imply repetition. A traffic light is a good example of redundancy, as color and position are redundant.

6.1.5. Similarity causes confusion: Use discriminable elements

Signals that appear to be similar will likely be confused. The ratio of similar features to different features causes signals to be similar. For example, A423B9 is more similar to A423B8 than 92 is to 93. Unnecessary similar features should be removed and dissimilar features should be highlighted.

6.2 MENTAL MODEL PRINCIPLES

6.2.1. Principle of pictorial realism

A display should look like the variable that it represents (e.g. high temperature on a thermometer shown as a higher vertical level). If there are multiple elements, they can be configured in a manner that looks like it would in the represented environment.

6.2.2. Principle of the moving part

Moving elements should move in a pattern and direction compatible with the user's mental model of how it actually moves in the system. For example, the moving element on an altimeter should move upward with increasing altitude.

6.3 PRINCIPLES BASED ON ATTENTION

6.3.1. Minimizing information access cost

When the user's attention is diverted from one location to another to access necessary information, there is an associated cost in time or effort. A display design should minimize this cost by allowing for frequently accessed sources to be located at the nearest possible position. However, adequate legibility should not be sacrificed to reduce this cost.

6.3.2. Proximity compatibility principle

Divided attention between two information sources may be necessary for the completion of one task. These sources must be mentally integrated and are defined to have close mental proximity. Information access costs should be low, which can be achieved in many ways (e.g. close proximity, linkage by common colors, patterns, shapes, etc.). However, close display proximity can be harmful by causing too much clutter.

6.3.3. Principle of multiple resources

A user can more easily process information across different resources. For example, visual and auditory information can be presented simultaneously rather than presenting all visual or all auditory information.

6.4 MEMORY PRINCIPLES

6.4.1. Replace memory with visual information: knowledge in the world

A user should not need to retain important information solely in working memory or to retrieve it from long-term memory. A menu, checklist, or another display can aid the user by easing the use of their memory. However, the use of memory may sometimes benefit the user by eliminating the need to reference some type of knowledge in the world (e.g. an expert computer operator would rather use direct commands from memory than refer to a manual). The use of knowledge in a user's head and knowledge in the world must be balanced for an effective design.

6.4.2. Principle of predictive aiding

Proactive actions are usually more effective than reactive actions. A display should attempt to eliminate resource-demanding cognitive tasks and replace them with simpler perceptual tasks to reduce the use of the user's mental resources. This will allow the user to not only focus on current conditions, but also think about possible future conditions. An example of a predictive aid is a road sign displaying the distance from a certain destination.

6.4.3. Principle of consistency

Old habits from other displays will easily transfer to support processing of new displays if they are designed in a consistent manner. A user's long-term memory will trigger actions that are expected to be appropriate. A design must accept this fact and utilize consistency among different displays.

7. Benefits of Human Computer Interaction System

The benefits of using the HCI methods are summarized as follow:

i) Find usability problems on your prototype prior delivery to other team member (HCI experts, software testing team, beta testers and users).

ii) Users would be able to complete their task successfully & efficiently.

iii) No or Reduced Training time.

iv) Increased productivity.

v) Reduce re-development cycle time by fixing problems immediately.

vi) Descriptions can be used on system training and documentation.

8. Problems in Development of HCI

8.1. Diversity of users: novices, experts, occasional users.

8.2. Diversity of applications: command and control, graphics, word processing, home appliances, etc.

8.3. Changing Technology: teletypes, CRT, high resolution, touch screens etc.

9. HCI Applications

The focus of this section is on classes of application domains and particular application areas where characteristic interfaces have developed.

i) Characterization of application areas (e.g., individual vs. group, paced vs. Unpaced).
ii) Document-oriented interfaces: Text-editing, document formatting, illustrators, spreadsheets, and hypertext.

iii) Communications-oriented interfaces: Electronic mail, computer conferencing, telephone and voice messaging systems.
iv) Design environments: programming environments, CAD/CAM.
v) On-line tutorial systems and help systems.
vi) Multimedia information kiosks.
vii) Continuous control systems: process control systems, virtual reality systems, simulators, cockpits, video games.
viii) Embedded systems: Copier controls, elevator controls, consumer electronics and home appliance controllers (e.g., TVs, VCRs, microwave ovens, etc.)

10 Future Scope of HCI

i) Display technologies will soon allow us to embed screens of all sizes in a variety of fabrics. In 2020 we will still be reading paper books and magazines; but we'll also be using paper-like digital screens to distribute content. For example, "paper" used in books and magazines may be digitized on foldable screens we can put in our pockets; and our clothing may be capable of performing health diagnostics.

ii) Cheap and easily-accessed digital storage allows consumers to electronically record and store more aspects of our lives - allowing us to share information and interact with people across the globe. This hyper connectivity liberates us from fixed telephone lines, desks and offices, while advances in robotics develop the computer's ability to learn and make decisions.

iii) New computing technology is tremendously exciting, but the interaction between humans and computers is evolving into a complex ecosystem where small changes can have far-reaching consequences. While new interfaces and hyper connectivity mean we are increasingly mobile, we can see that they are blurring the line between work and personal space.

iv) Huge storage capabilities raise fundamental privacy issues around what we should be recording and what we should not. The potential of machine learning might well result in computers increasingly making decisions on our behalf. It is imperative that we combine technological innovations with an understanding of their impact on people.

Conclusions

HCI is a Multidisciplinary Approach

HCI caters various fields which may or may not be related to computer science, but if it is related to human then it is related to HCI. Anything human do with any kind of system is taken as a part of HCI. It basically focuses on how human works and how the other machine or system reacts. HCI is widely related to the following and many more disciplines.

I. Psychology - behavioral and conceptual issues.

II. Sociology - how does advanced technology impact the workplace (micro) or our society (macro)?

III. Industrial engineering - computers and organizations.

IV. Computer science - develops algorithms for user interface design - software development.

V. Computer information systems - supporting the growing complexity of information systems and software products.

Others - medical field (carpal tunnel syndrome, hand/eye coordination, input/output device designs).

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