International Journal For Technological Research In Engineering *ISSN (Online): 2347 - 4718*
International Conference on Emerging Technologies in Engineering, Biomedical, Medical and Science (ETEBMS - 16)

HUMAN COMPUTER INTERFACE – FUTURE CHALLENGES & EMERGING TECHNOLOGIES

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Abstract: Human-computer interaction (HCI) is the study of how people design, implement, and use interactive computer systems and how computers affect individuals, organizations and society. This encompasses not only ease of use but also new interaction techniques for supporting user tasks, providing better access to information, and creating more powerful forms of communication. It involves input and output devices and the interaction techniques that use them; how information is presented and requested; how the computer's actions are controlled and monitored; all forms of help, documentation, and training; the tools used to design, build, test, and evaluate user interfaces; and the processes that developers follow when creating Interfaces. This paper is an attempt to highlights the study of interaction between people (users) and computers.

Keywords: Human Computer Interaction, Human Information Processing, Decision Making

I. INTRODUCTION

The rapid growth of computing has made effective human-computer interaction essential. HCI (human-computer interaction) is the study of how people interact with computers and to what extent computers are or are not developed for successful interaction with human beings. Utilizing computers had always begged the question of interfacing. The methods by which human has been interacting with computers has travelled a long way. The journey still continues and new designs of technologies and systems appear more and more every day and the research in this area has been growing very fast in the last few decades. The growth in Human- Computer Interaction (HCI) field has not only been in quality of interaction, it has also experienced different branching in its history. Instead of designing regular interfaces, the different research branches have had different focus on the concepts of multimodality rather than unimodality, intelligent adaptive interfaces rather than command/action based ones, and finally active rather than passive interfaces. Gustav Evertsson describes Human Computer Interaction is about designing computer systems so the user can carry out their activities productively and safely. It is not how easy something is to use, it is about how usable it is. Or, a broader definition of HCI is; ―Human Computer Interaction is a discipline concerned with the design, evaluation and implementation of interactive computer systems for human use and with the study of major phenomena surrounding them

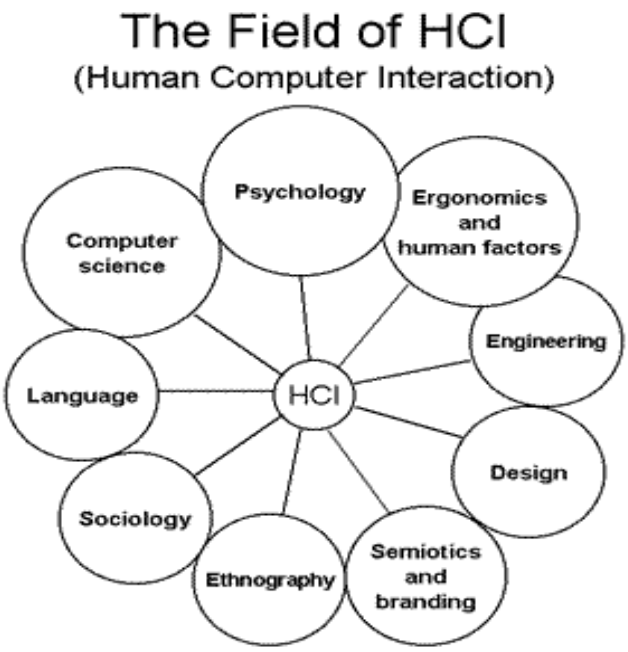

Figure 1: Some of the disciplines involved in the field of Human- Computer Interaction

Human–computer interaction (HCI) is the study of interaction between people (users) and computers. It is often regarded as the intersection of computer science, behavioral sciences, design and several other fields of study. Interaction between users and computers occurs at the user 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. The Association for Computing Machinery defines human-computer interaction 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. Because human-computer interaction studies a human and a machine in conjunction, it draws from supporting knowledge on both the machine and the human side. On the machine side, techniques in computer graphics, operating systems, programming languages, and development environments are relevant. On the human side, communication theory, graphic and industrial design disciplines, linguistics, social sciences, cognitive psychology, and human factors are relevant. Engineering and design methods are also relevant. Due to the

multidisciplinary nature of HCI, people with different backgrounds contribute to its success. HCI is also sometimes referred to as man–machine interaction (MMI) or computer–human interaction (CHI).

The human–computer interaction can be described as the point of communication between the human user and the computer. The flow of information between the human and computer is defined as the loop of interaction. The loop of interaction has several aspects to it including:
1. Task Environment: The conditions and goals set upon the user.
2. Machine Environment: The environment that the computer is connected to.
3. Areas of the Interface: Non-overlapping areas involve processes of the human and computer not pertaining to their interaction. Meanwhile, the overlapping areas only concern themselves with the processes pertaining to their interaction.
4. Input Flow: The flow of information that begins in the task environment, when the user has some task that requires using their computer.
5. Output: The flow of information that originates in the machine environment.
6. Feedback: Loops through the interface that evaluate, moderate, and confirm processes as they pass from the human through the interface to the computer and back

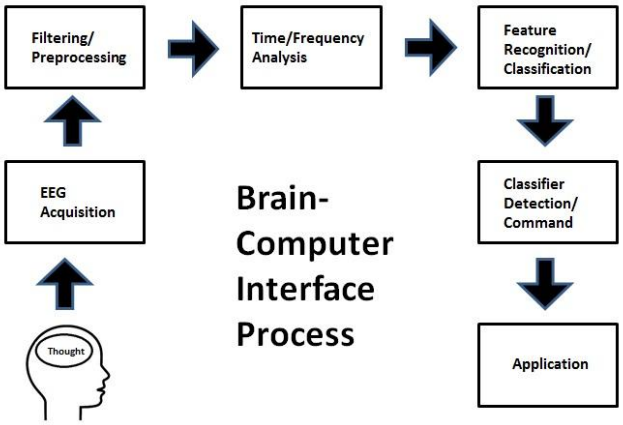

Fig 2 Flow Chart of Brain Computer Interface Process

The Goals of HCI
The basic goal of HCI is to improve the interactions between users and computers by making computers more usable and receptive to the user's needs. The goals of HCI are to produce usable and safe systems, as well as functional systems. Usability is concerned with making systems easy to learn and easy to use. Specifically, HCI is concerned with:
with good usability developers must attempt to:

- Methodologies and processes for designing interfaces(i.e., given a task and a class of users, design the best possible interface within given constraints, optimizing for a desired property such as learning ability or efficiency of use).
- Methods for implementing interfaces (e.g. software toolkits and libraries; efficient algorithms)
- Techniques for evaluating and comparing interfaces
- Developing new interfaces and interaction techniques
- Developing descriptive and predictive models and
- theories of interaction
- Understand the factors that determine how people use technology.
- Develop tools and techniques to enable building suitable systems.
- Achieve efficient, effective and safe interaction.
- Put user first

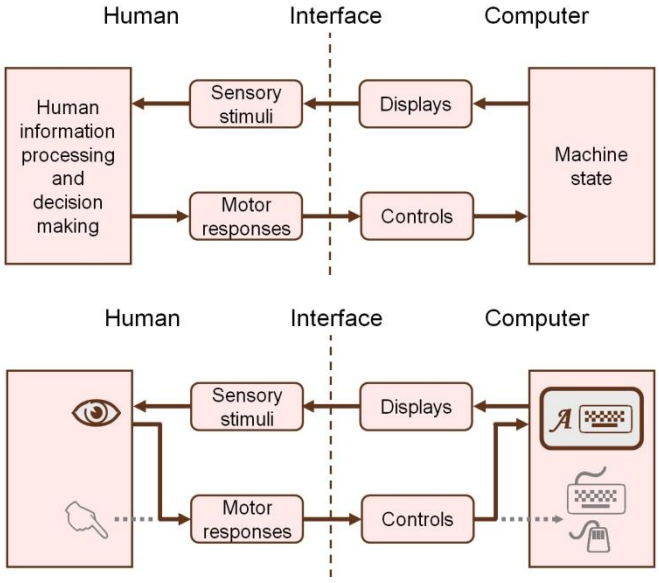

Fig 3 Process Human Interface Computer

II. HUMANS USE COMPUTING

For millions of years, humans have used tools to ease the tasks they need to perform in order to survive. From historical tools such as chiseled-rock spear points to tools of the 21st century, humans have used their innovative talents and their enriched understanding of science to create technologies and tools to support their needs. Computing systems are the latest and arguably most complex tools that humans have ever created. Their use continues to evolve and grow as their speed and capability increase. From their earliest days, computers were used for scientific, engineering, and cryptographic computations. Early human users of computers both wrote and read the bits that computers understood. With the advent of programming languages and translators such as assemblers and compilers, humans used characters (numbers, letters, and punctuation) and words to write instructions in ways that humans understood, and which translators turned into computer readable commands. Conversely, computers converted the bits that comprised the results of computations into numbers, words, and sentences that humans understood. Humans viewed the content created by computers as reflecting that computers could think which greatly expanded the potential roles computers could play. Computers could not just

compute, but could also produce sentences that people could understand. Understanding what a computer is doing in human terms rather than in computer terms was an early step in human-computer interaction. As humans observed what computers could do, they adapted the computer's capabilities to satisfy their needs and desires. Today humans' use computers to communicate, interact, and share in diverse ways:

1. To write and talk to each other
2. To exchange artifacts of personal interest such as photos, music, and videos
3. To exchange artifacts used in the workplace such as text files, drawings, and visualizations

Ideas about what computers could do for humans grew as single stand-alone computers that performed only one set of calculations using data on external media such as tapes evolved into our multifunctional 21st century systems. More ideas came as networks of computing systems were built to transmit bits almost instantaneously around the world for other computers and software and people to use. In a seemingly never-ending cycle, new computer-enabled capabilities, devices and environments are envisioned, developed and deployed for use by ever larger, more diverse, and more demanding populations. These human activities have greatly expanded computer usage.

Humans use computers to meet their needs and desires as long as they can easily do so. A user will not invest in learning to use a computer when such learning is disproportionate to meeting those needs and desires. User communities assess ease-of-use differently, and the great variability in human needs and capabilities means that ease-of-use has many aspects. For example, astrophysicists will invest extraordinary effort to use fast new (and difficult-to-use) computing systems to conduct their research because they have no viable alternative. Each science and engineering community has its own assumptions, data, information, vocabulary, computing needs, and ways to communicate, interact, and share. Each community has developed its own computing system capabilities. Building easily traversed bridges among such systems and across nations, languages, and cultures, is a demanding task.

Computing systems have become part of almost all the human activity. The following are key areas in which computing systems are used:

- National defense and national security
- The workplace
- Education and training
- Health care
- Manufacturing
- Research and development (R&D) in science, engineering, and technology

Humans use data and information to:

- Understand and learn about the world from direct Observation, Environment, Receptors, Effectors, Processor, Memory
- Understand and learn about the world from artifacts
- Create new information
- Make decisions
- Control processes
- Communicate with other people
- Communicate with computing systems
- Share what they have learned and created with others
- Explain, inform, and teach

Table 1: Factors to be considered in the Design of Human Computer Interaction

System Productivity	Human Performance	Training time and effectiveness	Cognitive Processes	Subjective satisfaction
1. Applicability of system to task 2. Number of tasks completed 3. Quality of output	1. Speed of performance 2. Rate and type of errors 3. Quality of solutions to problems	1. Time to learn how to use the system 2. Frequency of reference to documentation 3. Human retention of commands over time	1. Appropriateness of the mental model 2. Degree of mental effort	1. Satisfaction with self 2. Satisfaction with system 3. Satisfaction with performance

HCI Technologies

Gustav Evertsson describes HCI design is about designing the computer system for the people and not the people for the computers. There are a lot of important factors that have to be considered by designers. Example of factors is:

- Physiology such as the human behavior and mental processes.
- Organizational such as the influence of one individual in a group with the other member as attitude and behavior.
- Ergonomics such as how people interact with different artifacts.

HCI design should consider many aspects of human behaviors and needs to be useful. The complexity of the degree of the involvement of a human in interaction with a machine is sometimes invisible compared to the simplicity of the interaction method itself. The existing interfaces differ in the degree of complexity both because of degree of functionality/usability and the financial and economical aspect of the machine in the market. For instance, an electrical kettle need not to be sophisticated in interface since its only functionality is to heat the water and it would not be cost-effective to have an interface more than a thermostatic on and off switch. On the other hand, a simple website that may be limited in functionality should be complex enough in usability to attract and keep customers. Therefore, in design of HCI, the degree of activity that involves a user with a machine should be thoroughly thought.

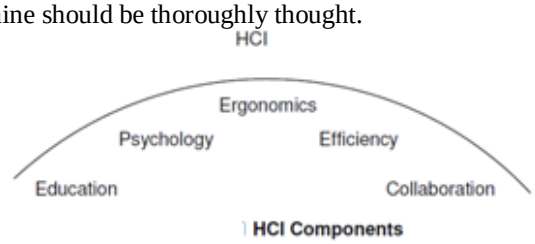

Fig 4. HCI Components

HCI Theories and Principles

There are typically many thousands of rules which have been developed for the assessment of usability and there have been many attempts to reduce the complexity to a manageable set of rules. Jacob Nielsen has produced 10 rules which he calls usability heuristics and which are designed to explain a large proportion of problems observed in interface design, which he recommends should be followed by all user interface designers.

1. Simple and natural dialogue: Efforts should be made to avoid irrelevant information. Nielsen says that every extra unit of information competes with units of relevant information and diminishes its visibility.
2. Speak the Users' language: All information should be expressed in concepts which are familiar to the user rather than familiar to the operator or the system.
3. Minimize the Users' memory load: It is important that the user should not have to remember information from one part of a dialogue to another. Help should be available at easily retrievable points in the system.
4. Consistency: Words situations and actions should always mean the same thing no matter where they occur in the system.
5. Feedback: Users should always be informed about what is going on in the system in a timely and relevant way.
6. Clearly marked Exits: Errors are often made in choosing functions which are not required and there needs to be a quick emergency exit to return to the previous state without having to engage in extended dialogue.
7. Shortcuts: Required by the expert user (and unseen by the novice user) to speed the interaction with the system.
8. Good error messages: These need to be expressed in a plain language that the user understands which are specific enough to identify the problem and suggest a solution.
9. Prevent Errors: A careful design will prevent a problem from occurring.
10. Help and documentation: The best systems can be used without documentation. However, when such help is needed it should be easily to hand, focused on the users task and list specific steps to solutions.

III. HCI: LOOKING FORWARD INTO FUTURE

Considering the diverse number of researches and technological breakthroughs, it is not hard to discern the moment in future where the term natural will get transparently embedded into the world of science and technology. Looking at the goals HCI has to offer with a slightly different perspective, there is a conclusion which states that the developments in HCI can intervene in the rapidly changing world. Designs in HCI will need to be more sensitive and aware towards the human society and values. Various encumbrances in such a pathway like changing human values, techno-dependency and stress, technophobia, disregard for the natural beauty and finally, no single interface stability, will have to be dealt in a much more different way and must be included in the goals of HCI practitioners. For accomplishing this seamless transition into innovation, HCI will have to integrate itself with several adjoining disciplines. In the near future, as the HCI 2020 [6] states, the relationship of the society with the technology will not just be a user based experience. Unlike today, computers will be flowing everywhere and most of our lives will be directed by computers. Meanwhile, the darker side of this proliferation can be explained by examples such as violation of privacy due to the presence of ubiquitous machines, wrong use of HCI computer applications, and respective cultural trends and values even in a digitized modern world. Hence, the main agenda of HCI practitioners gets defined as visualizing a human in a completely digitized future, where in technology understands human desires, expectations and aspirations and at the same time is human-centric and includes ethics and values from user's society.

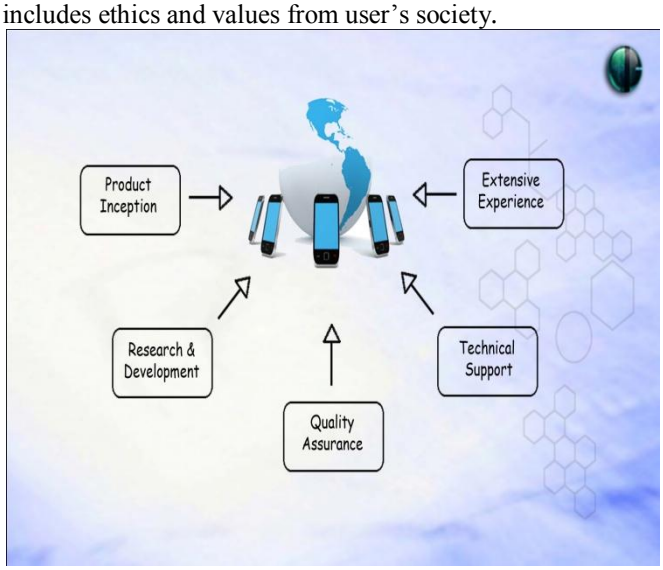

Fig 5 HCI computer applications

IV. CHALLENGES FOR THE EVALUATION OF EMERGING APPLICATIONS

Emerging HCI systems

Emerging HCI systems and environments have a tendency to become multi-modal and embedded and thereby allowing people to interact with them in natural ways. In some cases, the design of computer interfaces is merging with the design of everyday appliances where they should facilitate tasks historically outside the normal range of human-computer interaction. Instead of making computer interfaces for people, people have started to make people interfaces for computers [Coen, 1998].

The nature of applications is changing. Looking beyond traditional productivity-oriented workplace technologies where performance is a key objective, HCI is increasingly considering applications for everyday life. HCI interface design now encompasses leisure, play, culture and art. Compared to traditional HCI systems, we can identify four main trends in HCI systems:

- **New sensing possibilities** New sensing technologies allow for the design of interfaces that go beyond the traditional keyboard and mouse.

Automatic speech recognition is common in many telephone applications. The current state of video tracking allows not only for localization of human users, but also to detect their actions, identity and facial expressions. This opens up possibilities to make interfaces more natural. Humans will be able to interact in ways that are intuitive. However, this comes at a cost of having to reconsider the syntax of the application. When using speech or gestures, the vocabulary is almost infinite. Moreover, many of the 'behaviors' that we can recognize, must be interpreted in relation to the context. Context aware applications employ a broad range of sensors such as electronic tags, light sensing and physiological sensing. However, integration and the subsequent interpretation of these signals is hard, and context aware systems are likely to consider contexts differently than users do. Related to the use of a multiplicity of sensors is the trend that sensors are moving to the background. This moves interfaces away from the object-oriented approach that is traditionally considered.

- **Shift in initiative** Traditional HCI systems embrace the explicit way in which the dialog with the user is maintained. Nowadays, pro-active systems are more common. Some HCI systems even aim at fulfilling the role of social actor or companion. Ju and Leifer [to appear] define an initiative dimension in their framework for classifying implicit interactions. They state that, when regarded more generally, there is direct manipulation at the one end, and autonomy at the other. They argue that, for HCI, neither of these states are appropriate. Instead, the interaction is likely to be mixed-initiative. This implies that there must be a way to coordinate the interaction, which should be the focus of interaction design.
- **Diversifying physical interfaces** The physical forms of interfaces are diversifying, as was foreseen by Weiser. One movement is to make interfaces bigger, such as immersive displays and interactive billboards. Another movement is to make interfaces smaller, such as wearable and embedded displays. This last movement is largely motivated by the popularity of mobile devices. The market for mobile phones is still growing, and so is the number of applications. With the increased connectivity and bandwidth, it is possible that people interact remotely with the same application. The trend of diversifying physical interfaces is most visible for general purpose desktop computers. These are increasingly often replaced by more purpose-designed and specialized appliances.
- **Shift in application purpose** There is a shift in application purpose for HCI systems. This shift is partly a consequence of new technology, and partly motivates the development of technology. Whereas traditional systems are, in general, task-based, new applications are more focussed on everyday life, thus on the user. User Experience (UX), although associated with a wide variety of meanings, can be seen as the countermovement of the dominant task and work related 'usability' paradigm. UX is a consequence of a user's internal state (e.g. predispositions, expectations, needs, motivation and mood). The literature on UX reveals three major perspectives: human needs beyond the instrumental; affective and emotional aspects of interaction; and the nature of experience. Hassenzahl and Sandweg argue that future HCI must be concerned about the pragmatic aspects of interactive products as well as about hedonic aspects, such as stimulation (personal growth, increase of knowledge and skills) identification (self-expression, interaction with relevant others) and evocation (self maintenance, memory). The task is no longer the goal, but rather the interaction itself.

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