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Analysis in Role of Human Computer Interfaces in current trends

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Abstract

Human computer interface (HCI) plays an important role to evaluate scientific research. The main purpose of this systematic analysis is to examine and evaluate scientific HCI research. It is an interdisciplinary study subject that spans computer science, engineering, and human aspects. This article covers the fundamental concept, current technologies, and a variety of other topics that are relevant to the design of HCI systems. This study will present a conceptual foundation for the future generation of information searching by mixing new technologies. In this article author also explain the role of blockchain in HCI Many applications of blockchain are also discussed in this article to help researchers working in the field of HCI and Blockchain.

KEYWORDS

HCI, Emotional intelligence, Multimodal HCI, Ubiquitous Computing, Blockchain

1. INTRODUCTION

The arranging file and contemplate of interaction is the Human Computer Interface. It is about the human computer relationship as well as their common understanding strategies through which humans have been linked to computers. I can also suggest that using it for specific errands will make it more pleasurable and beneficial. This paper provides an overview of Human Computer Interaction frameworks as well as the interaction and technique used in HCI research. Human computer interface (HCI) refers to the methodinvolving the design, evaluation, and execution ofintelligent systems for man use.

1.2 Humans

The HCI item is delivered and used by the product's customers. Understanding people as an information-processing framework, how they communicate, and human/user characteristics as data processors Memory, thought, problem-solving, learning, inspiration, engine talents, mental models, and different traits are all important. Communication, engagement, and dialect - Linguistic perspectives Syntax, pragmatics, semantics, conversational interaction, and specialized dialects are all important aspects of language. Anthropometrics is the accurate estimates of a human's physical features, such as dimensional descriptors of body estimate and form, as well as physiological characteristics of persons and their link to

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their working environment and surrounding environment. People are excellent at completing both fuzzy and hard computations. Figure 1 depicts the HCI development model which is useful for current trends.

1.3 Computers

Because computers have unique components that can connect with clients, they are used for interaction with them. Additionally, computers provide a platform for clients to define and identify with the components, resulting in successful learning. Counting and measuring, accurate power and overview, rapid & read reflexes, document preparation, details, arduous operations, and performmore time, or "simple and firmly described items," are all skills that computers excel at.

1.4 Interaction

The list of skills is complimentary in certain ways. It is the collaboration of a computer and a person to produce a successful result. A two-way interaction between a client and a computer is possible.

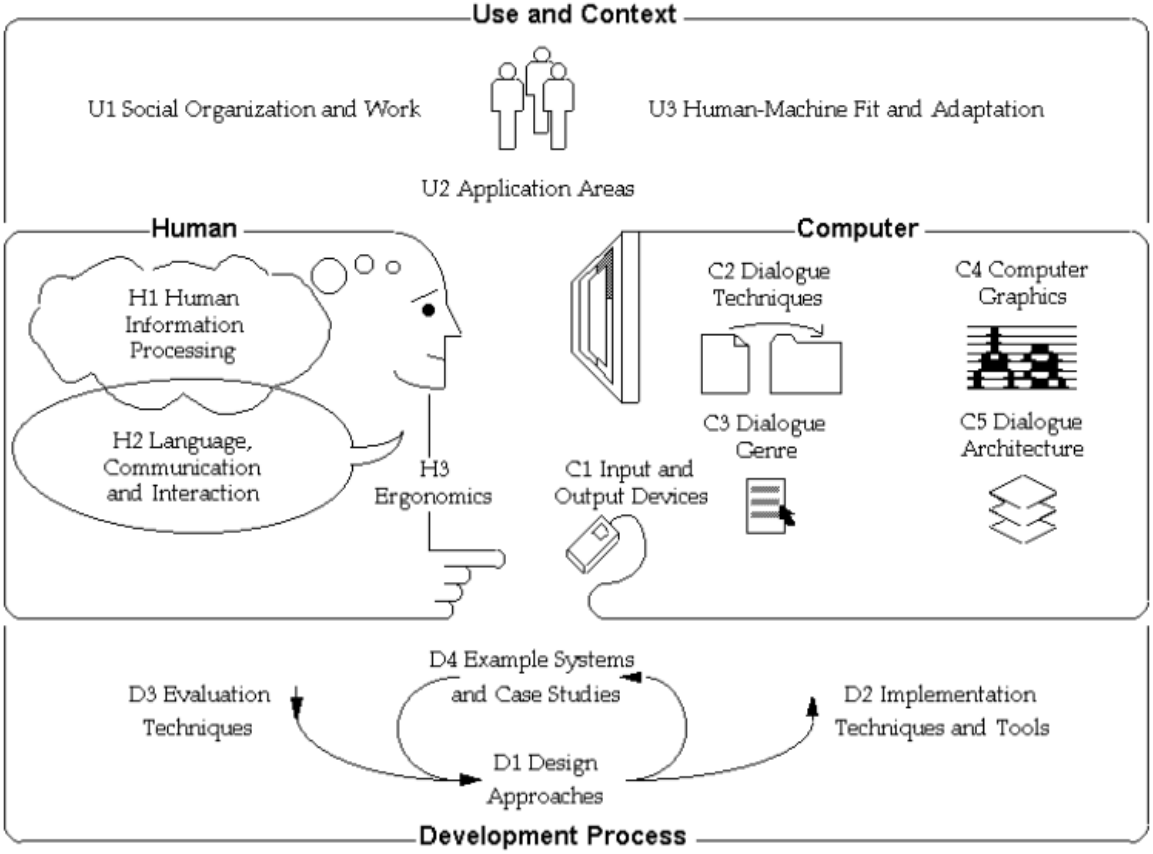

Figure 1: HCI development [92]

Buddha Journal of Engineering Sciences and Technology (BJEST)
Volume 1 | Issue 1 | August 2025Website: www.journal.bit.ac.in Email: bjt@bit.ac.in

1.5 HCI: Definition, Terminology

HCI is often referred to as Human-Machine Interaction (HMI) or System Interfacing, and has been automatic depicted with the introduction of the computer, or more generally the machine itself. The logic is simple: even the most powerful computers are useless if humans cannot manage them properly. Utility and convenience are the two most important criteria to consider while designing HCI [1.] The essential words that should be addressed in the design of HCI are presented in this fundamental subject.
What a framework can accomplish, i.e. how its capabilities can help the framework achieve its aim, is ultimately what explains why a framework is actually meant. A framework's usefulness is determined by the number of activities or serve it gives to its users. In any case, the benefit of usability becomes apparent when it is possible for the client to use it successfully [2]. The ease of use of a framework determines the extent and degree to which it may be use successfully and enough to achieve certain goals for specific customers. A system's genuine adequacy is attained when a proper balance is made between a framework's usefulness and its convenience [3] [4]. For example, an aviation parts design programmed must be able to see and create parts with great precision, but graphic editing software may not.Technology can also have an impact on the design of multiple forms of HCI for the same objective. You may use any computer's capability by using commands, menus, GUIs, or virtual reality applications. More on modern techniques and gadgets for connecting with computers is covered in the next section.

2. EXISTING HCI TECHNOLOGIES

Practicality and attention to human behavior are both essential in the design of an HCI. Human participation in working with a computer is often hidden when compared to the technique itself, which is simple at first glance. A machine's functionality and usability, as well as its financial and commercial characteristics, dictate the complexity of its interface in today's world.An electric kettle, for example, does not require a sophisticated medium because its mainaim is to warm water, & having anything more than a thermostatic on/off button would be prohibitively expensive. A simple website with limited functionality, on the other hand, must be complicated enough in terms of usability to catchusers [1].Acustomerattract with a computer must thus be carefully examined while developing an HCI. Physical activity, cognitive activity, and emotional activity are the three categories of user activity identified [5–7]. Mechanics are important in HCI, but perception and engagement with the system are the focus of cognitive HCI. When it comes to making the user's connection with the machine enjoyable, but also influencing the user in a way that keeps them using the computer, the emotional aspect is a relatively new notion.An enhanced user interface may be created by combining several forms of user interaction (multimedia interactions) and improving the performance of those techniques (intelligent interactions) using advances in the physical side of interaction. It's easy to say that the intended human sensations of HCI devices are what distinguish current physical techniques in the field today. These gadgets rely on vision, sound, and touch as their primary modalities of input. The most widely used input devices are vision-based devices, which are frequently based on switches or signaling devices. [9]. A switch-based device is described as any medium that utilizes buttons and switches, such as a keyboard. It's possible to input data with your computer's pointing device or a pen-based input device [11]. Switches and pointing capabilities are included in the joystick. Display or printing equipment can be used as a means of output. Hearing-based systems are

increasingly sophisticated and usually need speech recognition [12]. Due to their desire to allow as much interaction as possible, these technologies are substantially more challenging to design. With that being the case, creating an acoustic escape device is a lot less difficult. Machines today produce a broad variety of non-speech [14] and speech signals and messages as their output signals. You may use a GPS device to acquire instructions by hearing beeps and notifications while you drive. Haptic devices are the most difficult and expensive to build. [15] Touch, weight, and relative stiffness can be used to create sensations in the skin and muscles [1]." Many people use haptic devices in virtual reality (VR) and assistive technology (AT). Recent HCI approaches and technologies are attempting to mix more advanced technology, such as networkingand animation, with more primitive methods of interaction, such as gestures. Wearable gadgets [19], wireless devices [20], and virtual devices [14] are the three types of new innovations. A fast advancement in technology is blurring and dissolving the boundaries between these new inventions. Some of these new technologies have enhanced and integrated current interaction methods. A keyboard solution is shown in Figure 2 by the Compaq iPAQ's Canesta. Using red light, this virtual keyboard creates a QWERTY layout on a flat surface. Motion sensors are used to detect the movement of the user's fingers while they type, and then the keys are returned to them.

3. UNIMODAL HCI SYSTEMS

As mentioned earlier, the amount and variety of inputs and outputs, whichserve as message channels via which users may cooperate with the computer, determine the interface. Each of the multiple self-governing unique channels is called a technique [16]. A system that relies exclusively on one approach is referred to as "unimodal." Based on their nature, the various approaches may be classified into three groups.

a) Visual-Based b) Audio-Based c) Sensor-Based

Each strategy is detailed in detail in the subsections below, along with examples and references.

3.1 Visual-Based HCI

The most common type of HCI research is visual-based HCI. The researchers aimed to tackle different aspects of human responses that may be seen as a visual signal. They considered a variety of applications along with many open issues and methods. The key themes of their research are as follows:

- Facial appearancestudy
- Body Movement Tracking
- Gesture detection
- Eyes Movement Tracking

Although the goals of each sector are different, we can form a general picture of each region. Face expression analysis focuses on identifying emotions using visual methods [19].As the name implies, the major focus of this field is on the identification of movement in the body [11] [10] and the recognition of

hand gestures [13] in order to facilitate direct communication between a person and computer in a command-and-action situation. In context-sensitive circumstances, gaze detection [12] is used to better comprehend the user's attention, purpose, or concentration [14]. Eye tracking systems for people with impairments, on the other hand, make extensive use of eye tracking in control and accomplishment situations, such as pointer movement and blinking to click [15]. Some studies have tried to use visual aids to support or even take the place of other forms of communication, such as audio or sensory methods.Lip movement tracking has been proven to be a viable strategy for fixing speech recognition difficulties [9].

3.2 Audio-Based HCI

Another major feature of HCI systems is audio-based communication. This section explains how different audio signals gather information. Even while visual signals can be more flexible, aural cues are more reliable and effective, and in certain situations, unique. This section's research may be broken down into the following subcategories:

• Speech detection

• Speaker detection

• Auditory sentimentexamination

• Human-Made Noise

• Musical Interaction

Voice recognition [12] and speaker recognition [17] have long been the subject of research. Audio signal analysis [18] has been used in recent attempts to incorporate human emotions into intelligent human-computer interaction. Apart from voice data, common human auditory indications such as sighing, gasping, and so on supported sentiment analysis in the construction of a more intelligent HCI system [10]. Music production and interaction is a newer HCI issue that has been studied in audio-visual-based HCI systems [9]. It has been researched in audio-visual-based HCI systems and has applications in the art world.

3.3 Sensor-Based HCI

This topic encompasses a wide variety of disciplines with several applications. The common denominator across these disparate industries is the employment of at slightest one physical sensor to enhance user-machine interaction. These sensors might be extremely basic or quite complex, as detailed below.

- Pen-Based Interaction
- Mouse & Keyboard
- Joysticks
- Motion Tracking Sensors and Digitizers
- Haptic Sensors
- Pressure Sensors

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Volume 1 | Issue 1 | August 2025Website: www.journal.bit.ac.in Email: bjt@bit.ac.in

- Taste/Smell Sensors

While some of these sensors are relatively new, others have been in use for a while. Given their connection to handwriting recognition and pen gestures [8], pen-based sensors in mobile devices are especially intriguing. In Section 3.1, keyboards, mice, and joysticks were covered earlier. [eighth] [9th] [10th] [Twelfth] [12] [12] Motion-detection sensors and digitizers are state-of-the-art devices that have transformed the video game, animation, film, and art industries. Computers have become far more capable of interacting with reality thanks to wearable fabric or joint sensors, and people have been able to digitally design their own world.Figure 3 depicts a device similar to this. Robotics and virtual reality applications are particularly interested in haptic and pressure sensors [15] [16] [18]. The latest humanoid robots include hundreds of tactile sensors, making them touch sensitive and aware [12] [13]. These sensors are also used in medical surgical applications [14]. Although not as well-known as other areas, taste and smell sensors have also been the topic of research [15].

Figure 2: Wearable motion capture cloth for making of video games

4. Developing an HCI Agenda for Block chain

We've seen a few examples of the myriad ways in which block chain efforts and applications combine technical complexity with political aspiration and societal impact in the examples provided. These fields demand an interdisciplinary approach that HCI excels at, and that's what we're here for. HCI research (e.g. [1]) aims to combine infrastructural knowledge with the complicated realities of lived experience and the values of humans, and we look at that work in the field. Montréal, Canada, April 21–26, 2018 W28: CHI 2018 Workshop, page 3.

There are a number of new and ongoing research projects in this subject, but we feel the HCI community has yet to find its voice. Workshop organizers are hoping to bring together the best researchers and designers in the field to debate the future of this technology and the unique role that the CHI community can and should play. This session provides, at its most basic level, a chance to exchange similar experiences, difficulties, and best practices. However, we will build a research programmed based on four main strands:

Studying Block chain Applications

- Existing user communities
- New function areas
- Infrastructural studies
- Case studies

Critiquing Block chains

- The policy of block chain
- Increasing theories and concepts
- Critical design approaches
- Algorithmic accountability

Designing for Block chains

- Co-designing with block chains
- Participatory methods
- Toolkits
- Using off-the-shelf applications
- Design probes
- Lessons learned

Envisioning Block chain Futures

- Expanding the imagination of block chain applications
- Artist projects
- Speculative approaches
- Designing 'critical infrastructure'

The HCI Agenda for Block chain includes a block chain security module for brain-computer interface (BCI) with Multimedia Life Cycle Framework.In the healthcare industry, the Internet of Medical Things (IoMT) is a strong and appealing service architecture that is developing from the Internet of Things (IoT) (IoMD). A wide range of applications and services are taking advantage of sensors, actuators, networking, and the data they generate. Many people's lives will be impacted and the healthcare industry will be revolutionized by welfare applications. As an example, residents in smart buildings would be able to perform common tasks such as cleaning and adjusting the temperature remotely when they arrive at home. Internet-connected medical devices can be utilized in healthcare institutions and services to collect and provide more meaningful data for decision-making. As a result of this frequent utilization, patient-physician interaction will be minimized.

5.MULTIMODAL HCI SYSTEMS

The usage of many modes of transportation is referred to as "multimodal." The means by which the system responds to inputs, or communication channels, are referred to as modalities in MMHCI systems [3]. These channels are made possible by the five senses that humans use to communicate: taste, smell, touch, hearing,

and sight. These are just a few examples of the various ways that people can interact with machines. Therefore, by providing two or more input methods in addition to the standard keyboard and mouse, a multimodal interface facilitates human-computer interaction.The quantity, types, and interactions of available input modalities can vary greatly amongst multimodal systems. Words, gestures, looks, facial expressions, and other unconventional input methods are used in multimodal interfaces. The most common methods are voice and gestures [4]. Despite the fact that a multimodal HCI system should be made up of a collection of interconnected independent modalities, each modality's practical limits and unsolved concerns diminish the integration constraints. Despite all of the advances in MMHCI, the majority of modern multimedia systems still treat the approaches independently, with the results of the various methods only being merged at the end.Developing a reliable tool for each sub-field will need additional effort, since there are still unresolved issues in each area that need to be addressed. It is also unclear what each modality's role and contribution is to the overall process of engagement. “Humans, on the other hand, use a variety of communication methods to convey their thoughts and feelings[2]." Thus, in order to achieve a human-like multimodal analysis of input data from varied sensors, the signals must first be processed individually and then contextualized at the conclusion of the experiment. Data must be processed in a shared characteristics space and utilizing a context-dependent model, even though this is expected. A shared feature space of this scale and complexity would have to be dealt with, as well as issues like constructing context-dependent models to integrate multisensory data. Large dimensionality, several feature formats, and temporal alignment are some of the issues [5]. "The exciting aspect of multimodality is the use of many technologies to promote confessions. Visualization-based lip movement can help with audio-based speech recognition, and command capture in gesture recognition can help with audio-based speech recognition (visualization-based). Here are some examples of how intelligent multimodal systems may be put to use[1].

6. Intelligent and Adaptive HCI

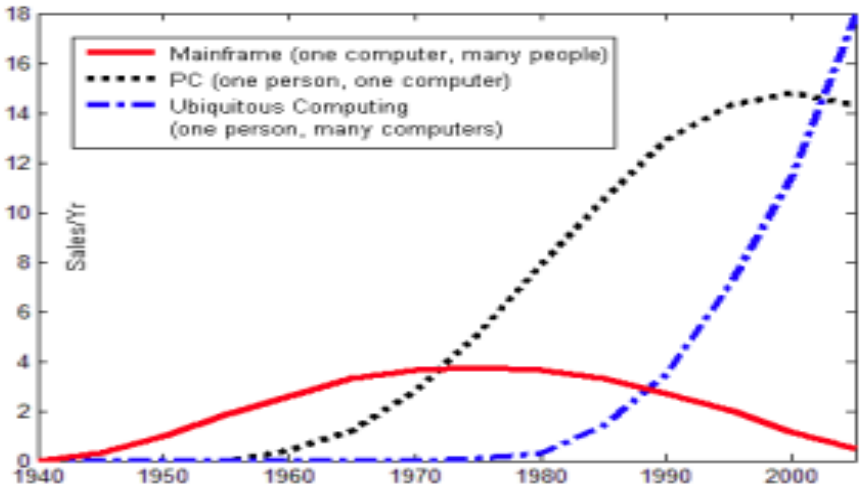
The research effort is concentrated on developing intelligent and adaptable interfaces, even though the majority of people's devices are still simple command/action combinations using less complex physical equipment. For the most part, people don't agree on what "intelligence" or "intelligence" means in theory. As new technology appears to increase in usefulness and utility, these concepts may be explained. Making HCI designs that simplify, amuse, and reward users is both economically and technologically essential, as has been stated before in this piece. Every day, interfaces become more intuitive to use in order to reach this aim. An annotation tool interface is a wonderful exampleThere are already touch screen tablet PCs that can recognize your handwriting and turn it into text [6], as well as coders that automatically transcribe everything you say, so you don't need to write anything at all. The difference between intelligent and adaptive HCI is one of the most crucial features of next-generation interfaces. User interfaces that perceive and/or react to users intelligently are known as intelligent HCI [7] designs. Devices that visually detect the user's gaze or motions [10] and voice-enabled interfaces [8] that converse with the user in natural language are two examples. If you're a fan of adaptive HCI [19] designs, you may not employ intelligence in your interface, but you may do so in your interactions with humans [13]. Examples of flexible HCI include an online store that offers many different items while employing a single visual user interface (UI). This site

Buddha Journal of Engineering Sciences and Technology (BJEST)
Volume 1 | Issue 1 | August 2025Website: www.journal.bit.ac.in Email: bjt@bit.ac.in

would be more useful if it could recognize the user, remember their searches and purchases, search intelligently, and find and suggest products that they might need. Nearly all of these changes aim to improve user behavior's cognitive and affective components. A PDA or tablet PC with handwriting recognition features is another example of an intelligent and flexible interface. It can adjust to the handwriting of the logged-in user to improve performance by remembering the user's changes to the detected text. Also keep in mind that passive HCI designs only respond when the user asks for it but active HCI designs are more responsive and can adapt to the needs of the users [13] Users' preferences are taken into account while displaying adverts on smart billboards, for example. Adaptable natural interfaces may be created by merging several HCI methods.

7. Ubiquitous Computing and Ambient Intelligence

There is no question that ubiquitous computing is the most recent study in the field of HCI (Ubicomp). HCI has evolved in recent years to encompass techniques like ambient intelligence and ubiquitous computing, which both refer to techniques in which computers are integrated into their surroundings, making them almost invisible to users. What comes to mind when you think of "environment?" Xerox PARC's Computer Science Lab's lead technologist, Mark Weiser, was the first to propose the idea of ubiquitous computing in 1998. His idea was to incorporate computers into ordinary objects and situations so that people may interact with several computers simultaneously while staying invisible to them and connecting wirelessly [17]. Ubicomp is a term used to describe the coming third wave of computing. There was a time when most



people only had one computer, known as the mainframe. In the second wave, which is known as the PC period, Ubicomp delivers a wide range of single-user computers [17]. Figure 4 depicts some of the most important developments in the computer industry.

Figure 3: Major trends in computing

. HCI Design

Buddha Journal of Engineering Sciences and Technology (BJEST)
Volume 1 | Issue 1 | August 2025Website: www.journal.bit.ac.in Email: bjt@bit.ac.in

HCI design may be seen of as a problem-solving process with elements including anticipated usage, target area, resources, cost, and feasibility. To balance offsets, determines the product similarity criterion. The four basic actions of interface design are as follows.

- Identify necessities
- Building alternative designs
- Developing interactive versions of the designs
- Evaluating designs

Three principles for user-centered approach are

- Early focus on users and tasks
- Empirical Measurement

Iterative Design

8.1 The Mental Model

Mental models are the most significant notions in human-computer interactions. This mental model represents the user's perception of current systems, and it is based on beliefs rather than facts. Users build expectations based on a mental model and then act on them. Each user's mental model is unique to him or her. Mental models are in flux, meaning they flow rather than being fixed in an external medium when they are entered into the brain. Mixed mental models - These models confound several aspects of the system since many users have not modelled their screen functioning.The design team and the user have opposing mental models, and the design team must think with the user while designing something for the user, which is a major issue.

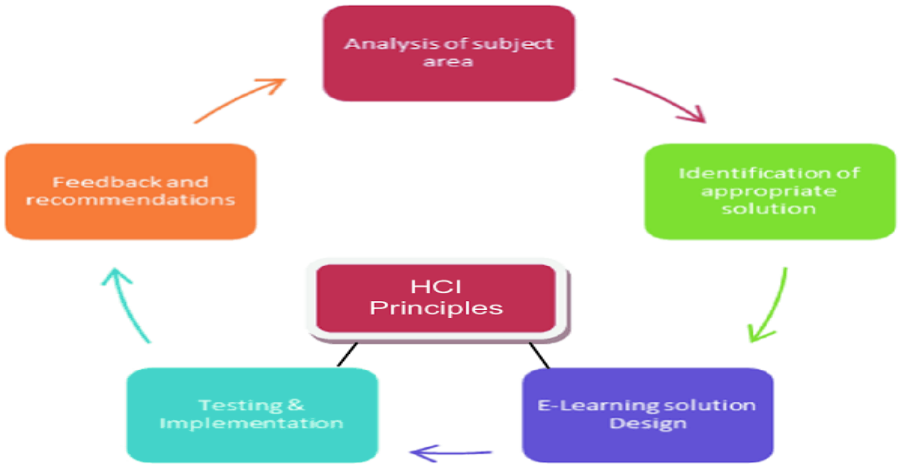


Figure 4.Human-Computer Interaction flow chart

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Volume 1 | Issue 1 | August 2025Website: www.journal.bit.ac.in Email: bjt@bit.ac.in

8.2 Human –Computer Interaction Process

It covers approaches and strategies for developing human-computer interfaces, assessing the usability of computer systems [15], and addressing broader human-centered issues like how people use computers. HCI designers are at the center of a system interaction between humans, machines, technology, and other people in social contexts where computers are used, and they are based on a set of assumptions about how people interact and perceive data [17]. This interaction also introduces the situation to design concepts like visual hierarchy, color, and typography.

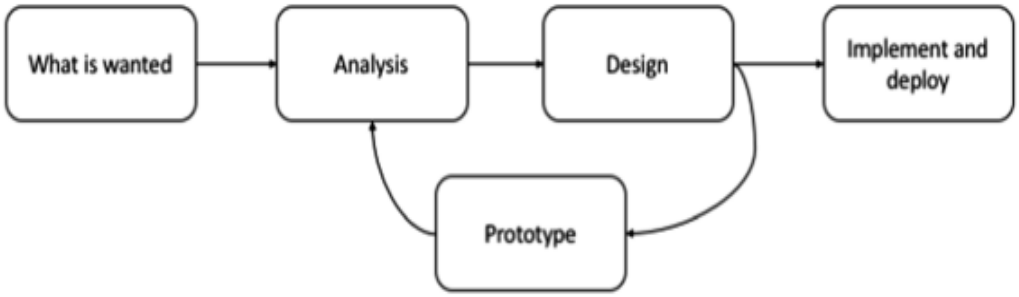

Figure 5: HCI design process

8.3 Design Thinking Process

With a focus on creating original solutions from a user-centric viewpoint [16], Design Thinking (DT) is a systematic and fascinating approach to problem solving that combines technological, business, and human factors [17]. An increasing number of businesses and organizations, from startups like Airbnb to industry heavyweights like IBM, have embraced this user-centric innovation approach, along with the mindset and toolkit that go along with it.Design thinking emerged from the methods used by designers, such as user experience and user understanding. In recent years, its application has expanded to cover more ground, including how businesses and other organizations may find new strategic directions, create new services, or implement procedural changes. The DT incorporates nonlinear process phases with iterative loops [16], and each step offers a variety of instruments to accomplish each goal [84, 89]. Because DT commonly uses the Simon [17] model [18], the particular procedures, including tools, may change [15].Design Thinking is centered on recognizing several stages of innovation - identifying and expressing issues across processes in order to interact with people and define obstacles. This idea leads to stages of thought and prototyping, after which potential solutions may be tried and polished before being implemented.

Buddha Journal of Engineering Sciences and Technology (BJEST)
Volume 1 | Issue 1 | August 2025Website: www.journal.bit.ac.in Email: bjt@bit.ac.in

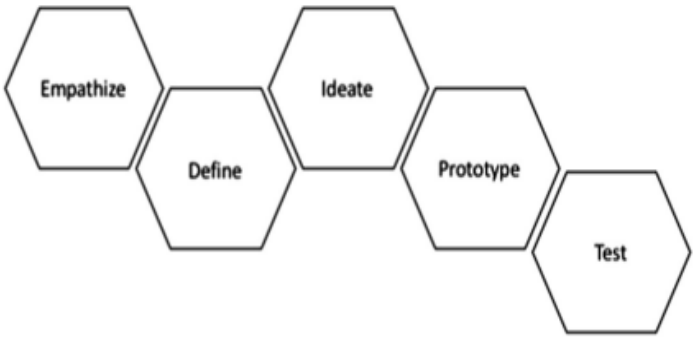

Figure 6: Design thinking process

The Stanford HassoBlattner Institute of Design (School School) [15] offers five steps: empathies, define, think, prototype, and test. Empathy is the foundation of this approach since it relies on observations, contextual inquiries [13], and interview activities [11] to get a better knowledge of users, their needs, intentions, emotions, and experiences [12].

8.4 Research Methodology

Examining, evaluating, and interpreting all possible research on particular research topics, interests, or themes is the goal of a systematic review [7]. The three phases outlined by Kitchenham [20] guided our approach to a comprehensive study of HCI and DT processes:

(1) Planning

(2) Execution

(3) Results analysis

With advice from a design thinking researcher, this review was undertaken by a researcher with a background in visual design and HCI.

9. CONCLUSION

There is nothing more fundamental to the human-computer interface than a human-to-computer contact. As a result, it is very user-friendly and relies solely on the input of humans (users). Research in HCI is the most important subject of study in the science of AI (Artificial Intelligence). Diaconate HCI design is capable of revolutionising society. HCI technology's ability to better comprehend human behaviour might have a significant impact on the world. One of the most significant aspects of designing a system is HCI. The way users represent and use the system determines its quality. New HCI designs have thus drawn a lot of interest. The goal of current research is to substitute more intelligent, flexible, multimodal, and natural communication methods for traditional ones. The objective of the third wave of technology, also referred to

as environmental intelligence or ubiquitous computing, is to incorporate technology into the surroundings so seamlessly that people are no longer aware of its existence. Virtual reality and other human-computer interface technologies have the potential to become the norm in the future. These topics were covered in depth in this article, and a complete reference list was used to offer an overview and review of the current research.

Reference

1.D. Te'eni, J. Carey and P. Zhang, Human Computer Interaction: Developing Effective Organizational Information Systems, John Wiley & Sons, Hoboken (2007).

2.B. Shneiderman and C. Plaisant, Designing the User Interface: Strategies for Effective Human-Computer Interaction (4th edition), Pearson/Addison-Wesley, Boston (2004).

3.J. Nielsen, Usability Engineering, Morgan Kaufman, San Francisco (1994).

4.D. Te'eni, "Designs that fit: an overview of fit conceptualization in HCI", in P. Zhang and D. Galletta (eds), Human-Computer Interaction and Management Information Systems: Foundations, M.E. Sharpe, Armonk (2006).

5.A. Chapanis, Man Machine Engineering, Wadsworth, Belmont (1965).

6.D. Norman, "Cognitive Engineering", in D. Norman and S. Draper (eds), User Centered Design: New Perspective on Human-Computer Interaction, Lawrence Erlbaum, Hillsdale (1986).

7.R.W. Picard, Affective Computing, MIT Press, Cambridge (1997).

8.J.S. Greenstein, "Pointing devices", in M.G. Helander, T.K. Landauer and P. Prabhu (eds), Handbook of Human-Computer Interaction, Elsevier Science, Amsterdam (1997).

9.B.A. Myers, "A brief history of human-computer interaction technology", ACM interactions, 5(2), pp 44-54 (1998).

10.B. Shneiderman, Designing the User Interface: Strategies for Effective HumanComputer Interaction (3rd edition), Addison Wesley Longman, Reading (1998).

11.A. Murata, "An experimental evaluation of mouse, joystick, joycard, lightpen, trackball and touchscreen for Pointing - Basic Study on Human Interface Design", Proceedings of the Fourth International Conference on Human-Computer Interaction 1991, pp 123-127 (1991).

12.L.R. Rabiner, Fundamentals of Speech Recognition, Prentice Hall, Englewood Cliffs (1993).

13.C.M. Karat, J. Vergo and D. Nahamoo, "Conversational interface technologies", in J.A. Jacko and A. Sears (eds), The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Application, Lawrence Erlbaum Associates, Mahwah (2003).

14.S. Brewster, “Non speech auditory output”, in J.A. Jacko and A. Sears (eds), The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Application, Lawrence Erlbaum Associates, Mahwah (2003).

15.G. Robles-De-La-Torre, “The Importance of the sense of touch in virtual and real environments”, IEEE Multimedia 13(3), Special issue on Haptic User Interfaces for Multimedia Systems, pp 24-30 (2006).

16.V. Hayward, O.R. Astley, M. Cruz-Hernandez, D. Grant and G. Robles-De-La-Torre, “Haptic interfaces and devices”, Sensor Review 24(1), pp 16-29 (2004).

17. J. Vince, Introduction to Virtual Reality, Springer, London (2004).

18.H. Iwata, “Haptic interfaces”, in J.A. Jacko and A. Sears (eds), The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Application, Lawrence Erlbaum Associates, Mahwah (2003).

19.W. Barfield and T. Caudell, Fundamentals of Wearable Computers and Augmented Reality, Lawrence Erlbaum Associates, Mahwah (2001).

20. M.D. Yacoub, Wireless Technology: Protocols, Standards, and Techniques, CRC Press, London (2002)