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Visual Interaction Technique in Human Computer Interaction and its Usability in Virtual Keyboard

Heena Wadhwa[1], Radhika Mittal[2]
[1,2]Chitkara University Institute of Engineering & Technology, Chitkara University, Punjab, India

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*Corresponding author
Email:
heenakapila26@gmail.com
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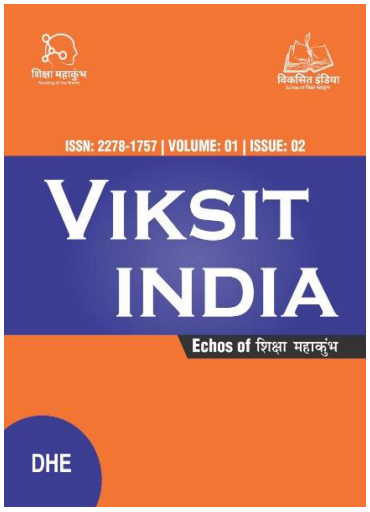

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Abstract
Human-Computer Interaction (HCI) is a field that mainly focuses on how computers and users interact with each other. In the early days of HCI it only used to focus on scientific testing but today HCI design user focused interfaces and helps in creating smart environments. But with these advanced technologies and development in HCI, a lot of challenges generates on how to implement modern and sustainable solutions. This research paper discusses how HCI had developed throughout these years and what challenges it had to face to design user-focused interfaces. Moreover, HCI can now be used in almost every field, for example, computer science, psychology, sociology, industrial design, etc. The eye tracking control-based system is also a result of development in HCI research, this system is useful in various fields. This research paper has also discussed how an eye-tracking system improves our learning methods and helps us in knowing more about our geospatial data efficiently and accurately through visual recognition. Along with this, a typing experiment is conducted in which a virtual keyboard is provided to the participants to understand the benefits of this technology in enhancing typing speed and accuracy of the users. This experiment is conducted with the help of the Technology Acceptance Model (TAM), this model helps us to know whether the users are adapting the proposed technology or not based on the TAM questionnaire. TAM questionnaire is made up of 5 items, perceived usefulness (PU), perceived ease of use (EOU), perceived interest (PI), attitude towards using (ATU), and behavioural intention (BI). After evaluating these 5 items we can discover the user acceptance of any technology. According to the results of the experiment and TAM questionnaire, most users found this system useful, easy to use, and easy to understand. The experiment found that the male participant's average speed is greater than female participants whereas for average accuracy the results are opposite.
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Keywords: User-Focused Approach, Typing Experiment, TAM Questionnaire, Eye Tracking System, Geospatial Data.

Introduction
HCI has been transformed from focusing on a single specialty area (scientific testing) to generating new user interface designs which include a community of tech professionals, researchers, designers, and creators, working together for better user experience. HCI has covered almost all forms of information technology.

Today, in this field we give importance to designing interactive computer interfaces and computing machines so that the user can have a better experience, easy-to understand software, smart environment, etc. The original technical focus of HCI was and is on the concept of usability.

Technologies like voice-based and Internet of Things (IoT) cognitive interaction have increased a lot, having the ability or skill to do everything. The interface is one of the main components that can upgrade the overall user experience. There are various interface-related features such as touch, click, voice, display size, color contrast, and brightness. Major job roles in HCI are usability engineer, human factor specialist, designer, researcher, etc.

HCI makes software and gadgets more useful for us by designing and implementing interactive interfaces which focus on different interface aspects as described in Fig. 1. All these aspects make sure that the user can adjust things according to their needs creating a better experience for them.

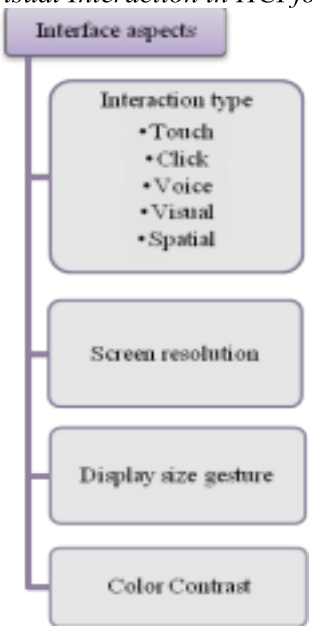

Fig. 1. Interface aspects to interact with users.

HCI has transformed a lot compare to its early days because of research, one great example of it is World Wide Web (WWW) [1]. WWW is a result of HCI research, through which we can store web pages or websites in a web server and connect to it through local computers. Through research, we have developed applications, such as drawing, text editing, hypertext, animation systems, gesture recognition system, eye tracking system, biometric tracking systems, cloud computing, speech recognition, etc.

Another approach is design thinking, which is a practice that originated from the design discipline and aims towards solving problems through a human-focused approach [2]. This practice concerns real-world problems, which can be solved through empathy, prioritizing users, their needs, innovative solutions, and synthetic reasoning. It also makes sure that the innovation is useful, realistic, noticeable, and addresses human values. HCI designers and practitioners follow an approach that concerns user requirements. A deeper exploration of similarities or differences between design thinking and HCI design can reveal new ways for practitioners in shaping innovative technologies for the future. Few Institutes around the world organize different workshops in which we discuss new ideas, recently facing problems, how to solve them, new methods, the idea behind HCI, its history, and much more for researchers, designers, practitioners, beginners, others interested in innovation to help them understand the issues involved in designing and implementation of HCI.

Because of this transformation in HCI and the rapid increase in technology, people with different abilities can use it in their everyday life. Due to this people lacking knowledge, and formal training can easily interact with computers and need not worry about the complications that arise during the early stage of learning any computing system. Hence, we can say that user-friendly interfaces and computing systems make sure that everything is easy and clear for everyone.

II. Applications of HCI

A. HCI In Our Daily Lives

Nowadays, the internet and advanced technology have changed every area of our life from waking up to sleep at night we experience HCI technology throughout the day, one simple example is a light switch. A person does not need to own a computer system or a laptop or a smartphone to have an impact on HCI in their lives. Examples of HCI in our daily lives are railway ticket-selling machines, health trackers, smart TVs, wearable systems, etc.

B. Industry and Business

Today companies or industry which is reliant on technology or computing machines needs HCI in their daily routine. Employees can work more efficiently and fast if the computing machines would be well-designed, easy to use, and easy to understand. HCI plays an important role in safety-control systems and many more.

C. Accessibility

In this world a lot of people have disabilities so it becomes very difficult for them to understand computing machines. HCI plays a very important role in this case, as HCI offers a very secure, easy-to-understand, efficient, and usable environment. So, by focusing on user-cantered techniques and functions people with disabilities will also be able to use computing machines comfortably. In the early days of technology computing machines used to be very expensive and not everyone could afford them. But by looking at the benefits of technology, designers, researchers, manufacturers, and providers made sure that everyone could get access to smart devices by making technology cheap without compromising its quality.

D. Beginners or Untrained

Nowadays very few people read manuals as they are lengthy and hard to understand for a beginner. And in this case, HCI makes people learning and accessing computer systems easy. HCI makes user-friendly and easy-to-use interfaces and computing systems so that a beginner can understand everything within a few minutes.

III. Future Challenges of HCI

Fig. 2. Challenges HCI had to face.

There are various challenges and problems that HCI had to face through the years and will also have to face in the future too as described in Fig. 2.

A. Human-Technology Symbiosis

With the rise in the development of AI, everything is getting automated so it becomes very crucial that human's control everything, not various algorithms and computers. Therefore, we should create technology which is supporting users in their daily lives and respecting humans, their rights, and establishes trust. To that we need three factors which are transparency, understandability, and accountability, which will build a fair relationship of trust between humans and machines.

B. Human-Environment

Interactions in changing and smart environments have been transformed from conventional to focusing on the user's emotions, touch, and gestures meaning shifting from HCI to HEI (human-environment interaction) [3]. A major concern in this approach is the disappearance of computers as they become visible in distinctive devices, creating a smart

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environment as the computers become part of the furniture (tables, walls, etc) [3]. As technology keeps growing the need for adapting these changes in our everyday life is also important and concerning that these technological changes do not disturb our environment [4].

The important role of HCI is to make sure that there is smart interaction between both worlds, creating a hybrid world that consists of physical and digital worlds both. Having smart robots working with and for us, computers embedded in our environment.

C. Ethics, Privacy, and Security

The goal is to provide these advanced HCI technologies to a large number of people to have a potential impact and to do that it becomes very important to take care of human privacy, ethics, and security. So, the question arises, 'How do we create and implement guidelines, privacy, security, and standards for HCI and AI technologies that are universally acceptable and also recognize human rights?' [5]. The answer to this question is research, experiments, and cyber security.

Nowadays as everything is digital cybercrimes have taken a rise and people have become more cautious of their privacy and security. Today one can track every information of the other through cyber-attacks and that's why maintaining cyber security becomes very important. Technology provides answers to this problem with various systems like surveillance cameras, IOT-connected home appliances, smart door locks, facial recognition systems, etc.

D. Well-Being, Health, and Eudaimonia

Technological advances offer various opportunities for humans to have a more advanced and less expensive healthy lifestyle and become more fit.

Eudaimonia is a concept of feeling meaningfulness, realizing one's potential, feeling positive, and creating a balance between skills and challenges. Because of these various advanced technologies humans have created 'Personal Medical Devices' (PMDs) that one can wear, interact with, carry, or attach to it, to monitor their health and generate medical data. PMDs not only refer to wearable devices but there are a lot of self-monitoring applications in smartphones that can improve the overall health of the user because they are easy to use, easy to understand, and low cost [2]. In such cases, users become more motivated through these applications to do better than others, eat healthily, and exercise more consistently resulting in a better life with fewer and fewer diseases.

E. Accessibility and Universal Access

Accessibility of technology is one of the main topics of HCI research, which aims to provide these advanced technologies to everyone including older users, children, users with impairments, etc. For this we need to ensure that everyone has the availability to ICTs (Information and Communication Technologies), to implement this we need to provide a useful, cheap well-organized distribution and maintenance system [6]. Another fascinating and useful approach to assistive technology for disabled people is the use of smartphones [6]. Nowadays the need for technology to be available to everyone is really important, as the future is not just about smart homes or workplaces or devices but smart cities too, creating a whole new advanced environment for humans to live in. By Universal access, more people will be able to use and benefit from technology and the internet.

F. Learning and Creativity

As people with different backgrounds, skills, interests, and countries, connect through technology they can solve different problems, and create new technologies, styles, etc. Because of this technology can now support various new learning methods to support everyone. As a result, everything is available on the internet today but this also creates some concerning issues as the students now prefer a 'copy and paste' ideology, there are no restrictions to unethical content which the students should not see at all. As the new generation is dependent on the internet for everything their learning and adapting patterns are also different from the previous generations.

Creating some issues as the previous generations perceive these advanced technologies differently. But still, the main focus of technological advancement in the learning field will always be human needs and not just age-specific, as the main goal is to provide efficient learning methods.

G. Social Organization and Democracy

As technology keeps growing various factors need to be watched and safeguard like democracy, stability, poverty, employment, pollution, equality, justice, etc. HCI plays an important role in this as democracy can be influenced by new advanced technologies and environmental changes.

Advanced technologies like AI and Big-Data can be very helpful to everyone but also very dangerous and limited as people think because of the internet or social media one can learn more things than ever but the reality is that these algorithms can control what we see, how much we see, what we think and how we act, shaping users thought process [2]. Threatening user's privacy, intelligence, thinking, and behaviour, can lead to big democratic changes. HCI can be very helpful in this issue as through HCI we can design and implement better solutions to these problems.

IV. Evolution of HCI

Fig. 3. No. of users increased over past years.

The evolution of HCI in designing new interactive, efficient, easy to use and easy-to-understand interfaces has evolved a lot in the past few decades by focusing on graphical user interfaces (GUIs) as described in Fig. 3. that because of the evolution of HCI the number of users using internet and technology has increased rapidly. With the help of GUI, users can now have a whole new experience while dealing with technology, using touch screens have now become a part of our lives by using desktops, smartphones, and tabs [7]. Now the designers are also focusing on Voice User Interfaces (VUIs) to interact with users but our design system is still focused mainly on GUIs hence, for now, it may not be fully possible to design, implement and focus on VUI [7].

A lot of studies, research, and experiments have been done to improve HCI. Various articles and research papers have been published by practitioners, researchers, designers, and users about various problems, their solutions, etc these articles and research papers can help us a lot in evolving HCI [8]. We can go through them and can experiment with a few effective methods, then implement them. Over the years it has been seen that the "living laboratory" has created new ways of experimenting with new methods and developing HCI by analytical analysis, stats, coding, and hypothesis generation on data [9].

One other approach is that we can use design patterns as design tools to solve individual problems. We can also use pattern-oriented designs for different related design problems, which help designers in creating visionary designs [10]. The design pattern's goal is that how patterns can be reused, and provide proven and valid design solutions [10].

As the technology and HCI both evolved new learning solutions and technologies were introduced, which help humans in every way such as gesture-based interaction, a new learning solution for autistic children, and much more.

A. Gesture-Based Interaction

It is a type of interaction in which users interact with the computing system through a set of gestures. In this type of interaction, the user uses physical gestures for instance, swiping, tapping, pinching, and scrolling, instead of using input devices such as a keyboard, mouse, etc. HCI aims to make interactions smooth and to do that their most significant technique is gesture recognition, this system makes sure that it is easy to use, provides mobility, and requires less hardware [11]. Gesture-based applications can be very useful for elderly users as with their aging they lose their sensory, motor, and cognitive abilities [12]. So, they can easily interact with the help of movements of their hands, face, and other body parts because of the advantage of simplicity.

B. New Learning Solution for Autistic Children With the help of HCI, we can provide new learning solutions for children with autism spectrum disorder (ASD). Research has concluded that the use of computer technology combined with HCI in the education of children with ASD has positive and beneficial effects [13]. Augmented Reality (AR) technology can be used to create a familiar environment in which autistic children can learn their learning content in real-time through audio and video [14]. However, the HCI community has not been paying much attention to providing usable and efficient solution to autistic children but a few solutions are still there for instance robot-supported learning solution. These solutions come with many challenges and researchers are trying to overcome them.

V. Different Waves of HCI

There are a total of three waves in HCI and they represent the challenges faced by HCI over the past 3 decades and the development that has happened because of HCI, you can also consider these three waves of HCI as the three paradigms of HCI [15].

The first wave started from the primary days of HCI to 1992, it was all about linguistics, computer modelling, learning, and human factors. But in 1992 when the second wave started a huge difference was there as a significant change from focusing on the human factor and model-driven approach shifted towards the human actor. The research has shifted from closed scientific labs to real-life experiments. Applying various experiments on how users interact, prototyping, and participatory designs so that users can interact better with technology and computing machines [15].

In 2006 when the second wave meets the third wave, we observed that the technology is more feasible and the users now have different devices so the experience with them is also different. The methodology is still related to the ideas and concept of the second wave to focus more on human emotions, terms, conditions, values, etc, rather than focusing on computing models and human subjects [16]. New challenges, problems, and opportunities also increased due to third waves. As the third wave brings us new and smart environments, there is also a rising demand for the fourth wave. In the fourth wave, users expect the technology to show us new visions that focus on politics, human values, and ethics and also strengthen the methodology of the previous wave [17]. But now designers and researchers are focusing more on user experience, GUI, easy to use, easy to understand, and availability. By focusing more on these factors and because of the impact of the third wave, technology is now everywhere, it is not just limited to adults in workplaces but has also become a part of our everyday lives [18].

VI. Eye Tracking Control System

Eye tracking systems are used to measure the activity of our eye, it measures the position of our eyeballs, gaze direction, and the movement of the eye can be measured with different technologies [19]. Eye trackers can help HCI researchers to understand visual and display-based information and this information can be used in improving usability interfaces, various products, websites, apps, etc [20]. Eye tracking technology is available for 100s of years but for the past few years, the development in this field has increased a lot. Zhang et al. [19] have mentioned 4 techniques for it: infrared-oculography (IROG), sclera search coil method (SSC), electrooculography (EOG), and video-oculography (VOG).

This system is now commonly used in medical and psychological research to understand human visual behaviour more effectively. This can also be very helpful for people with disabilities and in our workplaces as a security system [21]. Nowadays users prefer biometric systems more as their security system and with the growing interest in this tool in medicine, market research, web design, marketing, security, digital media, product design, defines, etc it has become more affordable than before. A few years back eye trackers used to be very expensive and not everyone could afford them but with the rapid increase in demand for eye trackers in various fields, low-cost eye-tracking devices became available in the market for example Gaze Point (GP3) HD 150 Hz, HTC Vive Pro Eye, smart eye aurora – 60/120 Hz, Eyeteeth VT3 mini – 40/60 Hz, Smart Eye AI-X, etc.

A. Eye Trackers for Geospatial Vision

In this new digital era, a lot of geospatial data produce every day and collection of it is not a problem but how to use it is. This kind of data may be unstructured and users might have problem understanding it. To be able to recognize the data we need to examine it from different viewpoints such as visual analytics and geovisual exploration tools [1]. This generates the need to have visual data recognition system to better explore the geospatial data. HCI can be very helpful in this as it is a user-focused approach. This geospatial data can help us how to visualize maps, modify them and reform them according to our needs. To that, we need tools like eye-tracking systems to discover new patterns and insights. Eye

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tracking is a process of measuring human gaze points or the movements of an eye. Integrating eye tracking systems with machine learning based on HCI.

B. New Learning Methods

This system can also help users in their learning methods with the help of interactive and revolutionized ways of teaching. McCormick et al. [22] in their work indicate that more than 80% of human beings learn things faster through visual representation. Thus, the visual power of learning is much better than other cognitive processes. The user experience of HCI and eye-tracking technology can be used in a much more effective way to enhance digital learning. In this system, the eye movement data is so important but, in the past, observing the movements through the eyes was not objective enough, less accurate, etc. The main component of cognitive psychology is the information processing model [23-27]. It is a framework used by cognitive psychologists to describe the processes of the human brain.

VII. Experimental Results

A typing experiment is conducted in which we are evaluating how fast participants react or move through visual changes. A virtual keyboard is provided to the participants. In this experiment we are using TAM, introduced by Davis et al. [24], it is an information system that tells us how the user accepts and rejects any proposed system or technology. In TAM we are using a TAM questionnaire to get the results, in it we need to evaluate 5 items, PU, EOU, ATU, BI, and PI according to the system adopted by Davis et al. [24] and Venkatesh et al. [25]. We are using the TAM questionnaire at the end of this experiment to know if the proposed technology is comfortable, beneficial, and easy to use for the participants.

In this experiment, more than 1000 participants were part of this experiment and survey. Out of which 64.3% were males and 35.7% were females, with some experience involved in using computing devices. Participants were students of age group from 17 to 25 years old. At first, the participants were introduced to the virtual keyboard and then spent 2-3 minutes with it by themselves to get familiar. After that participants were told only to look at the virtual keyboard to avoid any errors and increase the system's accuracy. After the experiment participants filled out the TAM questionnaire for the proposed virtual keyboard
system. This experiment involves 5 simple steps.

- Go to the website link: https://www.typing.com/student/tests.
- Enter the button "Start 1-minute test".
- Now type the letter which is in "blue" color on the screen and make sure to be as fast as you can and avoid any typing errors.
- Then after 1 minute, you can check your speed and accuracy.
- After that participant completed their surveys.

The result of this experiment is defined in Table I. The speed is calculated in Words Per Minute (WPM) and the accuracy is in percentage (%). According to the results, the average speed of male participants (36.5 wpm) is greater than female participants (28.4 wpm), indicating that males can react to visual changes faster than females. The average accuracy of males is 91% whereas that of females is 96%, indicating that females can type with few errors than males. The difference in average accuracy and speed between males and females is shown in Fig.4.

Table I. Typing Experiment Results

	Average Speed (wpm)	Average Accuracy (%)
Males	36.5	91
Females	28.4	96

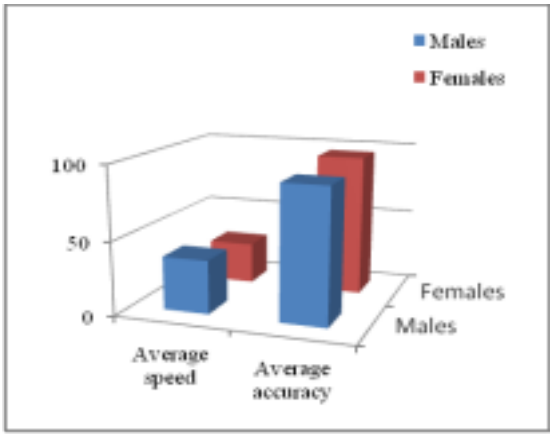

Fig. 4. Average speed and accuracy results.

According to the results of TAM questionnaire, 44.6% of participants use this system in their daily routine or at work while 42.9% use it sometimes. 91.1% of participants think that this system is easy to use and easy to understand. 66.1% would like to use this system in future also. 73.2% participants think that this virtual keyboard typing practice system can help them in improving their performance at work. The results of the TAM questionnaire are described below in table II.

Table 2. Result S of the Survey

Decision	Does it improve your perform acne at work?	Is this system easy-to-use and easy understand ?	Do you use it in your daily routine?	Would you like to use it in future?
Yes	73.2	91.1	44.6	66.1
No	7.1	7.1	12.5	26.7
May be	19.6	1.7	42.9	7.1

Conclusion

Virtual keyboard typing practice system can be very beneficial for those who need to type in their jobs or studies. As through this system users can know where they lack, so they can keep practicing to improve their typing speed and accuracy dramatically. Typing fast with great accuracy can save a lot of an individual's time, allowing them to be more productive with few errors in their work places and studies. To know if this application is really helpful or not for students and working professionals, a survey is conducted with the help of

TAM model. To understand user's acceptance of this application TAM questionnaire was used in this survey. TAM questionnaire includes 5 essential points which tell us how the user feels about the proposed system, if it is useful for them or not, if it is beneficial for them in their daily lives or not, what do they think about the proposed system. In the above typing experiment and survey, we concluded that the participants liked the proposed system and would like to continue using it to enhance their speed with great accuracy. According to the results most participants think this system is useful, beneficial, easy-to-use and easy-to-understand, so they would like to use it in future for themselves to improve their skills.

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