



Human Computer Interaction: Review of Existing Technologies and a Look into Recent Advances

Kuldip Kumar

Deptt. Of Computer Science, St. Bede's College, Shimla (H.P.) INDIA
Email ID: kuldeep4it@gmail.com

ABSTRACT: This paper intends to provide an overview on the Human-Computer Interaction and tries to cover existing technologies and recent advances in this field. The overview includes the basic definitions and recent advances such as ubiquitous computing and ambient intelligence in the field. Though this paper tries to cover all the major and general aspects of HCI yet it may be noted that this paper is not an authenticated document which contains all the aspects of HCI, as this field is changing very abruptly and is spreading over a wide range.

Keywords: Human Computer Interaction, Ubiquitous computing, Ambient Intelligence, Adaptive HCI.

INTRODUCTION

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. Research in human-computer interaction (HCI) has been spectacularly successful and has changed computing fundamentally. 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.

Definition: Most sophisticated machines are worthless unless they can be used properly by men. This basic argument simply presents the main terms that should be considered in the design of HCI: functionality and usability. Why a system is actually designed can ultimately be defined by what the system can do i.e. how the functions of a system can help towards the achievement of the purpose of the system. Functionality of a system is defined by the set of actions or services that it provides to its users. However, the value of functionality is visible only when it becomes possible to be efficiently utilized by the user¹. Usability of a system with a certain functionality is the range and degree by which the system can be used efficiently and adequately to accomplish certain goals for certain users. The actual effectiveness of a system is achieved when there is a proper balance between the functionality and usability of a system². HCI is a design that should produce a fit between the user, the machine and the required services in order to achieve a certain performance both in quality and optimality of the services³. Determining what makes a certain HCI design good is mostly subjective and context dependant.

HCI technologies at present: 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 market in design of HCI, the degree of activity that involves a user with a machine should be thoroughly thought. The user activity has three different levels: physical⁴, cognitive⁵, and affective⁶. The physical aspect determines the mechanics of interaction between human

and computer while the cognitive aspect deals with ways that users can understand the system and interact with it. The affective aspect is a more recent issue and it tries not only to make the interaction a pleasurable experience for the user but also to affect the user in a way that make user continue to use the machine by changing attitudes and emotions toward the user⁷.

The focus of this paper is mostly on the advances in physical aspect of interaction and to show how different methods of interaction can be combined (Multi-Modal Interaction) and how each method can be improved in performance (Intelligent Interaction) to provide a better and easier interface for the user. The existing physical technologies for HCI basically can be categorized by the relative human sense that the device is designed for. These devices are basically relying on three human senses: vision, audition, and touch⁷.

Input devices that rely on vision are the most used kind and are commonly either switch-based or pointing devices^{8 & 9}. The switch-based devices are any kind of interface that uses buttons and switches like a keyboard¹⁰. The pointing devices examples are mice, joysticks, touch screen panels, graphic tablets, trackballs, and pen-based input¹¹. Joysticks are the ones that have both switches and pointing abilities. The output devices can be any kind of visual display or printing device².

The devices that rely on audition are more advance devices that usually need some kind of speech recognition¹². These devices aim to facilitate the interaction as much as possible and therefore, are much more difficult to build¹³. Output auditory devices are however easier to create. Nowadays, all kind of non-speech¹⁴ and speech signals and messages are produced by machines as output signals. Beeps, alarms, and turn-by-turn navigation commands of a GPS device are simple examples.

The most difficult and costly devices to build are haptic devices¹⁵. "These kinds of interfaces generate sensations to the skin and muscles through touch, weight and relative rigidity¹." Haptic devices¹⁶ are generally made for virtual reality¹⁷ or disability assistive applications¹⁸. The recent methods and technologies in HCI are now trying to combine former methods of interaction together and with other advancing technologies such as networking and animation. These new advances can be categorized in three sections: wearable devices¹⁹, wireless devices²⁰, and virtual devices²¹. The technology is improving so fast that even the borders between these new technologies are fading away and they are getting mixed together. Few examples of these devices are: GPS navigation systems²², military super-soldier enhancing devices (e.g. thermal vision²³, tracking other soldier movements using GPS, and environmental scanning), radio frequency identification (RFID) products, personal digital assistants (PDA), and virtual tour for real estate business²⁴.

Recent Advances in HCI: In following sections, recent directions and advances of research in HCI, namely intelligent and adaptive interfaces and ubiquitous computing, are presented. These interfaces involve different levels of user activity: physical, cognitive, and affection.

Intelligent and Adaptive HCI: Although the devices used by majority of public are still some kind of plain command/action setups using not very sophisticated physical apparatus, the flow of research is directed to design of intelligent and adaptive interfaces. The exact theoretical definition of the concept of intelligence or being smart is not known or at least not publicly agreeable. However, one can define these concepts by the apparent growth and improvement in functionality and usability of new devices in market.

As mentioned before, it is economically and technologically crucial to make HCI designs that provide easier, more pleasurable and satisfying experience for the users. To realize this goal, the interfaces are getting more natural to use every day. Evolution of interfaces in note-taking tools is a good example. First there were typewriters, then keyboards and now touch screen tablet PCs that you can write on using your own handwriting and they recognize it change it to text²⁵ and if not already made, tools that transcript whatever you say automatically so you do not need to write at all.

One important factor in new generation of interfaces is to differentiate between using intelligence in the making of the interface (Intelligent HCI)²⁶ or in the way that the interface interacts with users (Adaptive HCI)²⁷. Intelligent HCI designs are interfaces that incorporate at least some kind of intelligence in perception from and/or response to users. A few examples are speech enabled interfaces²⁸ that use natural

language to interact with user and devices that visually track user's movements²⁹ or gaze³⁰ and respond accordingly.

Adaptive HCI designs, on the other hand, may not use intelligence in the creation of interface but use it in the way they continue to interact with users³¹. An adaptive HCI might be a website using regular GUI for selling various products. This website would be adaptive -to some extent- if it has the ability to recognize the user and keeps a memory of his searches and purchases and intelligently search, find, and suggest products on sale that it thinks user might need. Most of these kinds of adaptation are the ones that deal with cognitive and affective levels of user activity⁷.

Another example that uses both intelligent and adaptive interface is a PDA or a tablet PC that has the handwriting recognition ability and it can adapt to the handwriting of the logged in user so to improve its performance by remembering the corrections that the user made to the recognized text.

Finally, another factor to be considered about intelligent interfaces is that most non-intelligent HCI design are passive in nature i.e. they only respond whenever invoked by user while ultimate intelligent and adaptive interfaces tend to be active interfaces. The example is smart billboards or advertisements that present themselves according to users' taste^{32 & 33}. In the next section, combination of different methods of HCI and how it could help towards making intelligent adaptive natural interfaces is discussed.

Ubiquitous Computing and Ambient Intelligence: The latest research in HCI field is unmistakably ubiquitous computing (UbiComp). The term which often used interchangeably by ambient intelligence and pervasive computing, refers to the ultimate methods of human-computer interaction that is the deletion of a desktop and embedding of the computer in the environment so that it becomes invisible to humans while surrounding them everywhere hence the term ambient³⁴.

The idea of ubiquitous computing was first introduced by Mark Weiser during his tenure as chief technologist at Computer Science Lab in Xerox PARC in 1998. His idea was to embed computers everywhere in the environment and everyday objects so that people could interact with many computers at the same time while they are invisible to them and wirelessly communicating with each other²⁷.

UbiComp has also been named the Third Wave of computing. The First Wave was the mainframe era, 'many people one computer'. Then it was the Second Wave, 'one person one computer' which was called PC era and now UbiComp introduces 'many computers one person era' computing³⁴.

CONCLUSION

Human-Computer Interaction is an important part of systems design. Quality of system depends on how it is represented and used by users. Therefore, enormous amount of attention has been paid to better designs of HCI. The new direction of research is to replace common regular methods of interaction with intelligent, adaptive, multimodal, natural methods.

Ambient intelligence or ubiquitous computing which is called the Third Wave is trying to embed the technology into the environment so to make it more natural and invisible at the same time. Virtual reality is also an advancing field of HCI which can be the common interface of the future. There are already sensors that can be embedded in a patient's eye to monitor eye pressure. I think for computing embedded in humans we can opt for a variety of health related issues (cooling, radiation, toxicity of construction, rejection) and we need some kind of HCI technology for such factors. So perhaps these issues can be interesting areas of research. This paper attempted to give a review on these issues and provide a survey of existing research through a comprehensive reference list.

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