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Human Computer Interaction: An intellectual approach

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Abstract

This paper discusses the research that has been done in the field of Human Computer Interaction (HCI) relating to human psychology. 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.

Keywords: *Future Devices, AI, HC Interaction.*

I INTRODUCTION

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. This paper intends to provide an overview on the state of the art of HCI systems and cover most important branches as mentioned above. In the next section, basic definitions and terminology of HCI are given. Then an overview of existing technologies and also recent advances in the field is provided. This is followed up by a description on the different architectures of HCI designs. The final sections pertain to description on some of the applications of HCI and future directions in the field.

A vision of future devices

We will be able to create (mobile) devices that can see, hear and feel. Based on their perception, these devices will be able to act and react according to the situational context in which they are used. In this paper it will be shown that this vision is not as far ahead as it seems. In our research we start with the perception of simple concepts and with their exploitation. Providing a number of examples and demonstrators it is discussed how basic perception could enable a shift from explicit towards implicit HCI.

II HUMAN-COMPUTER INTERACTION: DEFINITION, TERMINOLOGY

Sometimes called as Man-Machine Interaction or Interfacing, concept of Human-Computer Interaction/Interfacing (HCI) was automatically represented with the emerging of computer, or more generally machine, itself. The reason, in fact, is clear: 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 user. 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 system.

Having these concepts in mind and considering that the terms computer, machine and system are often used interchangeably in this context, 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 services . Determining what makes a certain HCI design good is mostly subjective and context dependant. For example, an aircraft part designing tool should provide high precisions in view and design of the parts while a graphics editing software may not need such a precision. The available technology could also affect how different types of HCI are designed for the same purpose. One example is using commands, menus, graphical user interfaces (GUI), or virtual reality to access functionalities of any given computer.

III OVERVIEW ON HCI

The advances made in last decade in HCI have almost made it impossible to realize which concept is fiction and which is and can be real. The thrust in research and the constant twists in marketing cause the new technology to become available to everyone in no time. However, not all existing technologies are accessible and/or affordable by public. In the first part of this section, an overview of the technology that more or less is available to and used by public is presented. In the second part, an outlook of the direction to which HCI research is heading has been drawn.

A. Existing HCI Technologies

HCI design should consider many aspects of human behaviours 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. 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. The user activity has three different levels: physical , cognitive , and affective . 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 user

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 touch.

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

The devices that rely on audition are more advance devices that usually need some kind of speech recognition. These devices aim to facilitate the interaction as much as possible and therefore, are much more difficult to build . Output auditory devices are however easier to create. Nowadays, all kind of non-speech 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 devices. "These kinds of interfaces generate sensations to the skin and muscles through touch, weight and relative rigidity.Haptic devices are generally made for virtual reality or disability assistive applications.

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 devices , wireless devices , and virtual devices. 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 systems, military super-soldier enhancing devices (e.g. thermal vision , tracking other soldier movements using GPS, and environmental scanning), radio frequency identification (RFID) products, personal digital assistants (PDA), and virtual tour for real estate business. Some of these new devices upgraded and integrated previous methods of interaction. As an illustration in case, there is the solution to keyboarding that has been offered by Compaq's iPAQ which is called Canesta keyboard as shown in figure 1. This is a virtual keyboard that is made by projecting a QWERTY like pattern on a solid surface using a red light. Then device tries to track user's finger movement while typing on the surface with a motion sensor and send the keystrokes back to the device..

Figure 1 virtual keyboard

B. 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 text 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) or in the way that the interface interacts with users (Adaptive HCI) . 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 interfaces that use natural language to interact with user and devices that visually track user's movements or gaze 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 users. 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 activity.

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 recognised 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 . 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 ambient.

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 other .

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 . Figure 2 shows the major trends in computing.

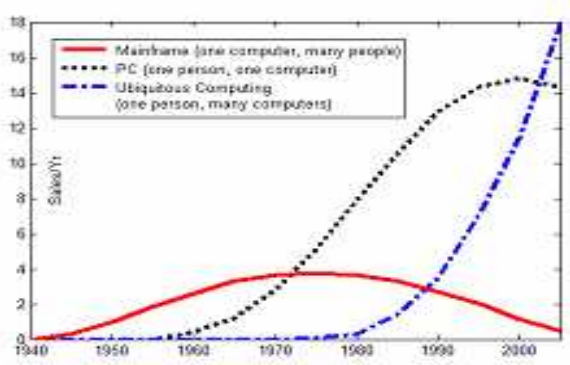

Figure 2 : Major Trends in Computing

IV HCI SYSTEMS ARCHITECTURE

Most important factor of a HCI design is its configuration. In fact, any given interface is generally defined by the number and diversity of inputs and outputs it provides. Architecture of a HCI system shows what these inputs and outputs are and how they work together.
Following sections explain different configurations and designs upon which an interface is based.

A. Unimodal HCI Systems

As mentioned earlier, an interface mainly relies on number and diversity of its inputs and outputs which are communication channels that enable users to interact with computer via this interface. Each of the different independent single channels is called a modality . A system that is based on only one modality is called unimodal. Based on the nature of different modalities, they can be divided into three categories:

1. Visual-Based
2. Audio-Based
3. Sensor-Based

The next sub-sections describe each category and provide examples and references to each modality.

Visual-Based HCI

The visual based human computer interaction is probably the most widespread area in HCI research. Considering the extent of applications and variety of open problems and approaches, researchers tried to tackle different aspects of human responses which can be recognized as a visual signal. Some of the main research areas in this section are as follow:

- Facial Expression Analysis
- Body Movement Tracking (Large-scale)
- Gesture Recognition
- Gaze Detection (Eyes Movement Tracking)

While the goal of each area differs due to applications, a general conception of each area can be concluded. Facial expression analysis generally deals with recognition of emotions visually . Body movement tracking and gesture recognition are usually the main focus of this area and can have different purposes but they are mostly used for direct interaction of human and computer in a command and action scenario. Gaze detection is mostly an indirect form of interaction between user and machine which is mostly used for better understanding of user's attention, intent or focus in context-sensitive situations . The exception is eye tracking systems for helping disabilities in which eye tracking plays a main role in command and action scenario, e.g. pointer movement, blinking for clicking . It is notable that some researchers tried to assist or even replace other types of interactions (audio-, sensor-based) with visual approaches. For example, lip reading or lip movement tracking is known to be used as an influential aid for speech recognition error correction.

Audio-Based HCI

The audio based interaction between a computer and a human is another important area of HCI systems. This area deals with information acquired by different audio signals. While the nature of audio signals may not be as variable as visual signals but the information gathered from audio signals can be more trustable, helpful, and is some cases unique providers of information. Research areas in this section can be divided to the following parts:

- Speech Recognition
- Speaker Recognition
- Auditory Emotion Analysis

• Human-Made Noise/Sign Detections (Gasp, Sigh, Laugh, Cry, etc.)
• Musical Interaction

Historically, speech recognition and speaker recognition have been the main focus of researchers. Recent endeavors to integrate human emotions in intelligent human computer interaction initiated the efforts in analysis of emotions in audio signals . Other than the tone and pitch of speech data, typical human auditory signs such as sigh, gasp, and etc helped emotion analysis for designing more intelligent HCI system . Music generation and interaction is a very new area in HCI with applications in art industry which is studied in both audio- and visual-based HCI systems.

Sensor-Based HCI

This section is a combination of variety of areas with a wide range of applications. The commonality of these different areas is that at least one physical sensor is used between user and machine to provide the interaction. These sensors as shown below can be very primitive or very sophisticated.

1. Pen-Based Interaction
2. Mouse & Keyboard
3. Joysticks
4. Motion Tracking Sensors and Digitizers
5. Haptic Sensors
6. Pressure Sensors
7. Taste/Smell Sensors

Motion tracking sensors/digitizers are state-of-the-art technology which revolutionized movie, animation, art, and video-game industry. They come in the form of wearable cloth or joint sensors and made computers much more able to interact with reality and human able to create their world virtually. Figure 3 depicts such a device. Haptic and pressure sensors are of special interest for applications in robotics and virtual reality. New humanoid robots include hundreds of haptic sensors that make the robots sensitive and aware to touch . These types of sensors are also used in medical surgery application. A fewresearch works are also done on area of taste and smell sensors; however they are not as popular as other areas.

Figure 3: Wearable motion capture cloth for making of video games (Taken from Operation Sports)

B. Multimodal HCI Systems

The term multimodal refers to combination of multiple modalities. In MMHCI systems, these modalities mostly refer to the ways that the system responds to the inputs, i.e. communication channels. The definition of these channels is inherited from human types of communication which are basically his senses: Sight, Hearing, Touch, Smell, and Taste. The possibilities for interaction with a machine include but are not limited to these types.

Therefore, a multimodal interface acts as a facilitator of human-computer interaction via two or more modes of input that go beyond the traditional keyboard and mouse. The exact number of supported input modes, their types and the way in which they work together may vary widely from one multimodal system to another. Multimodal interfaces incorporate different combinations of speech, gesture, gaze, facial expressions and other non-conventional modes of input. One of the most commonly supported combinations of input methods is that of gesture and speech.

Although an ideal multimodal HCI system should contain a combination of single modalities that interact correlatively, the

practical boundaries and open problems in each modality oppose limitations on the fusion of different modalities. In spite of all progress made in MMHCI, in most of existing multimodal systems, the modalities are still treated separately and only at the end, results of different modalities are combined together.

The reason is that the open problems in each area are yet to be perfected meaning that there is still work to be done to acquire a reliable tool for each sub-area. Moreover, roles of different modalities and their share in interplay are not scientifically known. "Yet, people convey multimodal communicative signals in a complementary and redundant manner. Therefore, in order to accomplish a human-like multimodal analysis of multiple input signals acquired by different sensors, the signals cannot be considered mutually independently and cannot be combined in a context-free manner at the end of the intended analysis but, on the contrary, the input data should be processed in a joint feature space and according to a context-dependent model. In practice, however, besides the problems of context sensing and developing context-dependent models for combining multisensory information, one should cope with the size of the required joint feature space. Problems include large dimensionality, differing feature formats, and time-alignment]." An interesting aspect of multimodality is the collaboration of different modalities to assist the recognitions. For example, lip movement tracking (visual-based) can help speech recognition methods (audio-based) and speech recognition methods (audio-based) can assist command acquisition in gesture recognition (visual-based). The next section shows some of application of intelligent multimodal systems.

V APPLICATIONS

A classic example of a multimodal system is the "Put That There" demonstration system. This system allowed one to move an object into a new location on a map on the screen by saying "put that there" while pointing to the object itself then pointing to the desired destination. Multimodal interfaces have been used in a number of applications including map-based simulations, such as the aforementioned system; information kiosks, such as AT&T's MATCHKiosk and biometric authentication systems .

Multimodal interfaces can offer a number of advantages over traditional interfaces. For one thing, they can offer a more natural and user-friendly experience. For instance, in a real-estate system called Real Hunte, one can point with a finger to a house of interest and speak to make queries about that particular house. Using a pointing gesture to select an object and using speech to make queries about it illustrates the type of natural experience multimodal interfaces offer to their users. Another key strength of multimodal interfaces is their ability to provide redundancy to accommodate different people and different circumstances. For instance, MATCHKiosk allows one to use speech or handwriting to specify the type of business to search for on a map. Thus, in a noisy setting, one may provide input through handwriting rather than speech. Few other examples of applications of multimodal systems are listed below:

- Smart Video Conferencing
- Intelligent Homes/Offices
- Driver Monitoring
- Intelligent Games
- E-Commerce
- Helping People with Disabilities

In the following sections, some of important applications of multimodal systems have been presented with greater details.

VI FUTURE OF HUMAN COMPUTER INTERACTION

Predicting the future is notoriously difficult. Suppose 100 years ago someone suggested that every home in the United States would soon have a bell that anyone in the world could ring anytime, day or night. Would you have believed it?

Nevertheless, the telephone caught on and has become a technology conspicuous only by its absence.
So we can't say anything about future, where it will take us. It depends on both advancement in Computer industry and Psychology of human. We only know basics about human. If we can understand human more better then we can make better interaction designs.
New areas like AI and Virtual Reality are opening new doors for Human Computer Interaction. New interfacing devices like wearable clothes and etc. are the future of HCI.

VII CONCLUSION

The subject of Human Computer Interaction is very rich both in terms of the disciplines it draws from as well as opportunities for research. Discussed here was just a small subset of the topics contained within HCI. The study of user interface provides a double-sided approach to understanding how humans and machines interact. By studying existing interfaces (such as the graphical user interface or the command line interface), we gain an understanding of how the human mind processes information. We gain insight into how human memory deals with the information presented, as well as its limitations.

Alternatively, from studying how human physiology and psychology, we can design better interfaces for people to interact with computers. Work in this domain is only beginning (indeed the number of papers written on this topic has increased in the past few years), and there is much that we don't yet know about the way the human mind works that would allow more perfect user interfaces to be built.

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