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Technology Requirements for Wearable User Interface

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Objective: The objective of this research is to investigate the fundamentals of human computer interaction for wearable computers and derive technology requirements.

Background: A wearable computer can be worn anytime with the support of unrestricted communications and a variety of services which provide maximum capability of information use. Key challenges in developing such wearable computers are the level of comfort that users do not feel what they wear, and easy and intuitive user interface. The research presented in this paper examines user interfaces for wearable computers.

Method: In this research, we have classified the wearable user interface technologies and analyzed the advantages and disadvantages from the user's point of view. Based on this analysis, we issued a user interface technology to conduct research and development for commercialization.

Results: Technology requirements are drawn to make wearable computers commercialized.

Conclusion: The user interface technology for wearable system must start from the understanding of the ergonomic aspects of the end user, because users wear the system on their body. Developers do not try to develop a state-of-the-art technology without the requirement analysis of the end users. If people do not use the technology, it can't survive in the market. Currently, there is no dominant wearable user interface in the world. So, this area might try a new challenge for the technology beyond the traditional interface paradigm through various approaches and attempts.

Application: The findings in this study are expected to be used for designing user interface for wearable systems, such as digital clothes and fashion apparel.

Keywords: Wearable computer, Human-computer interaction, Hands-free, Fashion ICT fusion

1. Introduction

A smartphone that moved a computer within one's hand has changed our life style enormously together with the innovation brought about by the Internet. Due to the universal fact that wearing is more comfortable than carrying, wearable computers leading the computing environmental change from portable gadget to wearable gadget can realize human-oriented service.

A wearable computer refers to a personal computer that is wearable like glasses, a watch and clothes, and R&D on the wearable computers is carried out to complement

or enhance human's intelligence in the state of both free hands. Because a wearable computer is fundamentally used in the state of wearing it, not only existing mobile environment characteristics, but the new characteristics according to wearing the computer should be considered. The wearable computer should be developed in the type of easily used (user interface) anywhere, anytime (constancy), and the wearing should not be uncomfortable (sense of wearing), and should be developed in a safe and good to see type (stability and sociality). Also, an intuitive interface that can be fused with a device needs to be supported, rather than the interface used by user's learning how to use the device (Son et al., 2008). Because the device should be able to be used anywhere, anytime at the closest location with a human, the human computer interaction technology is an important factor to enhance the usability and utility of a wearable computer (Witt, 2007). In the IoT (Internet of Things) environment, where surrounding things become intelligent gradually and networked recently, the user interface technology using a wearable computer for overcoming temporal and spatial restrictions and efficient interaction with surrounding computing resources emerges as a core technology for human-centered devices and services implementation (Son et al., 2006; Shin et al., 2010).

The purpose of this paper is to examine the status and development issues of the wearable user interface technologies embodying HCI (Human Computer Interaction) with regard to wearable computers, and define key requirements needed to implement such interface technologies.

2. Wearable User Interface Technology

2.1 Evolvement of user interface technology

The recent trend of user interface is to offer the natural and intuitive computing environment (Wikipedia, 2015). As shown in Figure 1, the early CLI (Command Line Interface) was only available text input and output. Since then, a new input device like mouse and GUI (Graphic User Interface) with ample audio-visual information expressions was provided. However, this interface

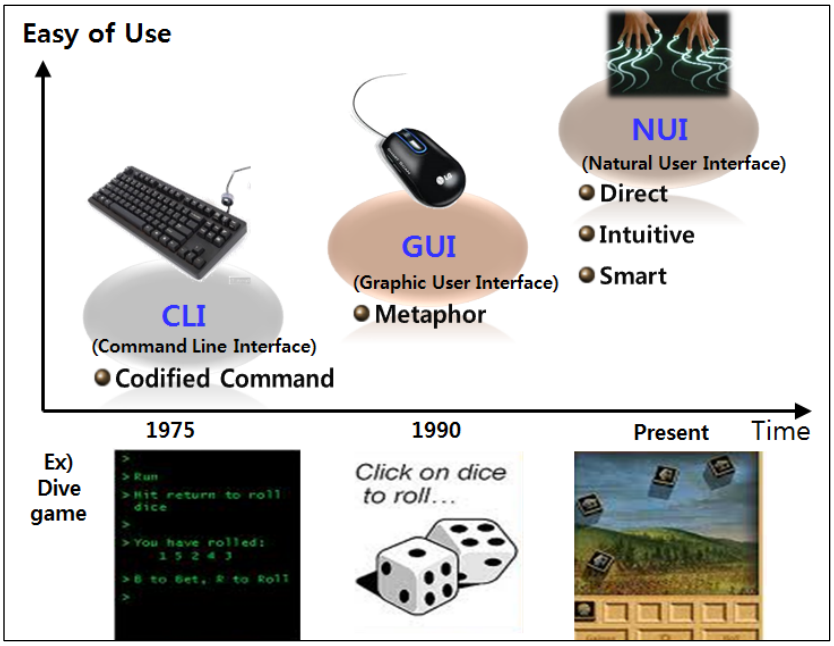
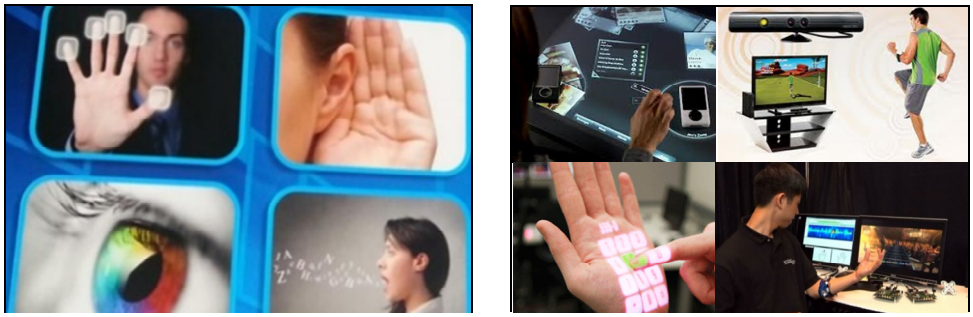


Figure 1. The evolution of the user interface technology

was not properly represented human's natural sense. The user interface pursued in the recent computing environment is the actual and intuitive NUI (Natural User Interface) like manipulating real things.

For example, a dice game was executed by typing the execution file name using the keyboard, and the result could be displayed on the monitor with text in the CLI environment. In the GUI environment, the game was executed by clicking the dice game icon with the mouse, and the dice was displayed on the monitor with graphic. In the NUI environment, if the smartphone, corresponding to a container where the dice is in, is shaken, a user can enjoy the game that realistically expresses the vibration and sound. Therefore the user interface similar to reality is offered (Brown University, 2015).

Intel and Microsoft are developing new user interface technologies under the names of RealSense technology (Intel Inc., 2015) and NUI (Natural User Interface) (Microsoft Research, 2015), respectively (Figure 2). Studies on such user interfaces develop intuitive and human-friendly technology which are like talking with humans by implementing the senses corresponding to human's visual, auditory and tactile senses with the camera, microphone and touch panel of a computer. Those studies aim to provide the convenience-maximized computing environment by recognizing complex situation through motion recognition, voice recognition and touch recognition, and by identifying user's intentions.



(a) Intel RealSense (b) MS NUI

Figure 2. Intel RealSense and MS NUI

2.2 Classification of wearable user interface technologies

As shown in Figure 3, the wearable devices released so far can be classified into four groups according to sensing performance (input) and information expression performance (output). The characteristics of user interface required by each group are as follows:

1) Industry and Military: These are the classical R&D areas of wearable computers which have been carried out from the early stage of wearable computer development. In view of the characteristics of work to perform, it is necessary to precisely sensing of large number of data, and express the collected information in various styles.
2) Healthcare and Medical: The most important factor is to precisely detect user's bio-signal, rather than an ability of information expression.
3) Fitness and Wellness: In this field, it is enough to deliver user-desired information briefly, rather than precise sensing of bio-signal and physical acidity.
4) Infotainment: In this field, an output device is emphasized so that various contents can be presented, rather than the accuracy

or reliability of information.

If the characteristics in each field are properly defined and implemented from the requirement defining stage in designing a system, more convenient and appropriate devices and services can be developed for users.

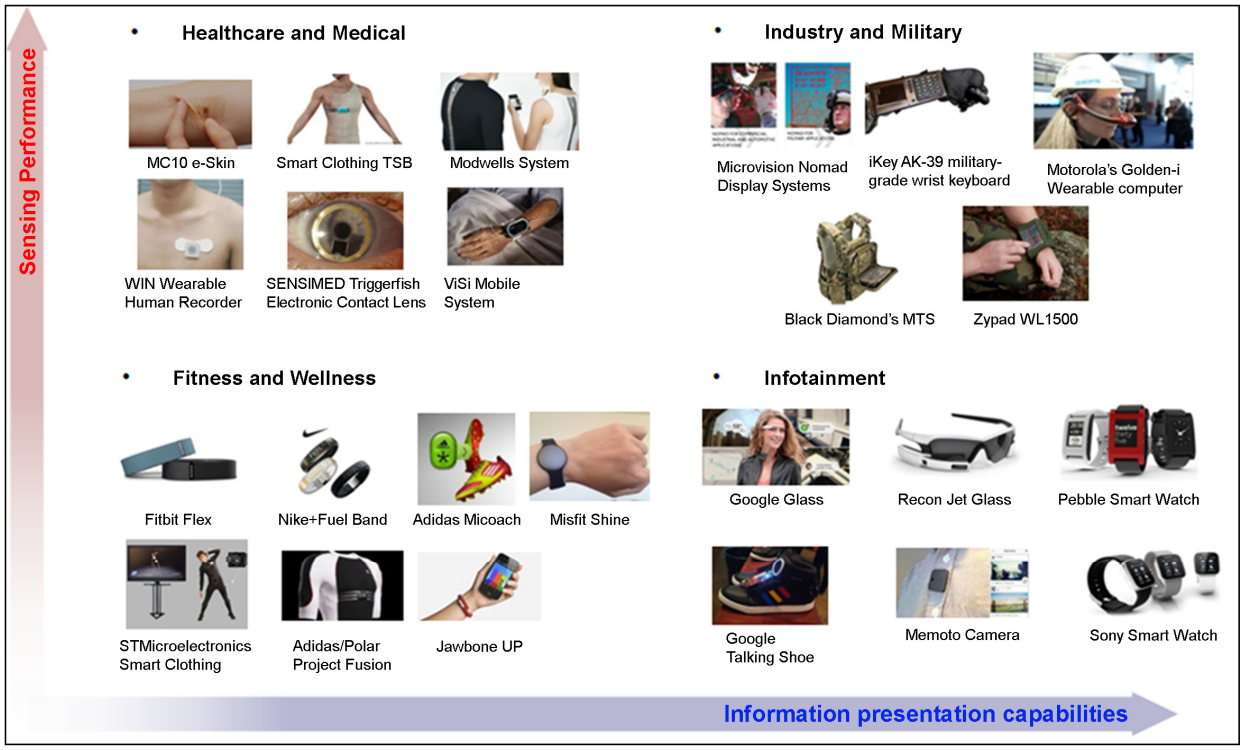


Figure 3. The characteristics of wearable user interfaces

2.3 Trend in wearable user interface technology development

A wearable technology is a fusion area that should consider even miniaturization, lightweight, low power consumption and design aspects. In the Gartner's 2015 Hype Cycle for Emerging Technologies (Gartner Group, 2015), most core technologies required for the implementation of wearable computers and user interfaces have already reached or approached the mature stage (Figure 4). Judging from this, the commercialization potential of wearable devices is expected to be higher than in the past. Voice and gesture recognitions are representative user interface technologies applied to currently commercialized devices, and they are utilized as a means to assist smartphone functions (Kim et al., 2014). Especially, the gesture recognition technology of a representative wearable user interface is located in the stage 4, the technology mature stage of Gartner's Hype Cycle, which is composed of five stages as shown in Figure 4. The technology in this stage is predicted to be included as a basic function of a commercialized product within two or five years.

In this section, we analyzed the wearable devices from the user interface point of view based on the wearing location.

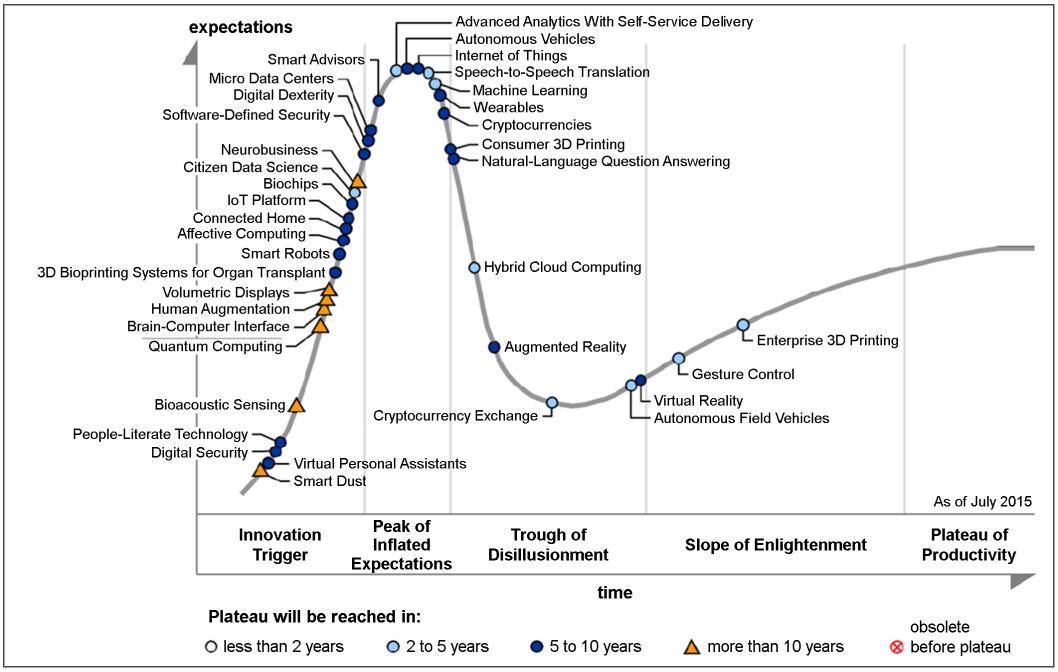


Figure 4. Hype cycle for emerging technologies, 2015

2.3.1 Head-worn type wearable device

A wearable device worn on the head with important sense organs are researched and developed for the purpose of implementing services closely related with human senses. There is a head-mounted or head-up wearable device, such as Google Glass in Figure 5, which recently received a lot of attention (Google Inc., 2015). They are implemented as a see-through type so that daily life can be carried out in the state of wearing the device. The device is controlled by voice or gesture recognition, and the button or touch input.

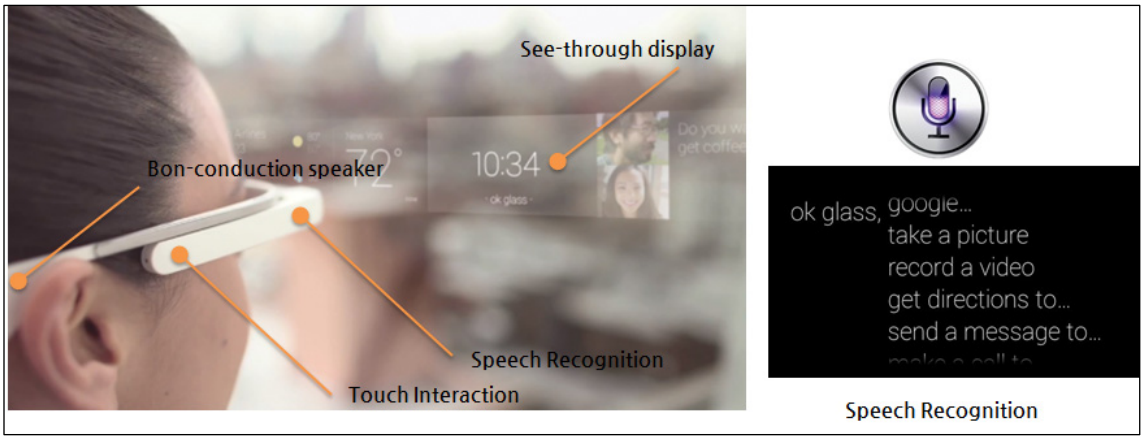


Figure 5. Google glass

2.3.2 Wrist-worn type wearable device

A wrist-worn type wearable device is used in additional simple input and output devices that support functions in connection with the smart phone in the form of a watch and band. Most companies are trying to develop their own specialized services, but innovative services have yet to be developed. The output device with the similar screen size as an existing watch, and voice and touch recognitions are equipped with as a basic interface.

Apple has recently presented digital crown (Apple Inc., 2015) with a function like the home button of iPhone, and Samsung has presented a new type of user interface that controls the Gear S2 (Samsung Inc., 2015) through the circle-shaped bezel (Figure 6). However, the innovative interface technology that can dominate the markets has yet to appear.

A band-type device just offers service to the extent of measuring bio-signal including physical activity and heart rate of a user, and most devices are at simple input device level. The MYO (Thalmic Labs, 2015), a representative interface device beyond existing touch and motion recognition technology, announced a technology to control the device by measuring electromyogram generated, when muscles move; however, more R&D is necessary for mass production for general users.

(a) Samsung Gear S2 (b) Apple Watch

Figure 6. Samsung bezel and apple digital crown

2.3.3 Skin patch type wearable device

R&D on skin patch type wearable devices, which can be the next stage of current mainstream accessory type devices, is actively conducted. The skin patch devices to be used for healthcare and medical purpose are mainly researched and developed to measure bio-signals including heart rate and body temperature so far (Son et al., 2015). The relevant technology advances will also be able to develop skin patch displays and haptic devices.

3. Drawing Core Requirements of User Interface for Wearable Computer

Most user interface technologies applied to the wearable computers are the technologies used for existing mobile devices. However, using the wearable devices providing such interface functions all the time may cause a risky situation, beyond inconvenience. For instance, a user wearing glass-type device should focus his/her vision on the screen to view the information displayed on the screen. In doing so, because the user cannot properly cope with the front situation, a risky situation may be caused. To solve such a problem, a new user interface technology that can utilize wearable computer's characteristics and merits needs to be developed.

Park et al. (2014) said the following user-friendly interface technology must be developed so that wearable devices can succeed in the consumer markets, as the multi touch technology has enormously contributed to the popularization of smartphones:

- Voice recognition, motion recognition and augmented reality technologies can be leading interface technologies for wearable devices.
- In view of wearable device's feature that a user needs to use both hands freely, the touch technology can be utilized limitedly, and thus the control of a device with voice or motion recognition is the most natural method.
- Augmented reality is a user interaction technology combining additional information with real world's objects or images and showing them, and it is the core function of wearable devices like smart glasses.

3.1 Drawing human-friendly user interface technology

To develop a natural and human-friendly wearable interface technology, research on the intuitive method fully using human senses is necessary. As shown in Figure 7, this study classified the user interface technologies that can utilize human senses, which can be used for a wearable computer, into input and output technologies.

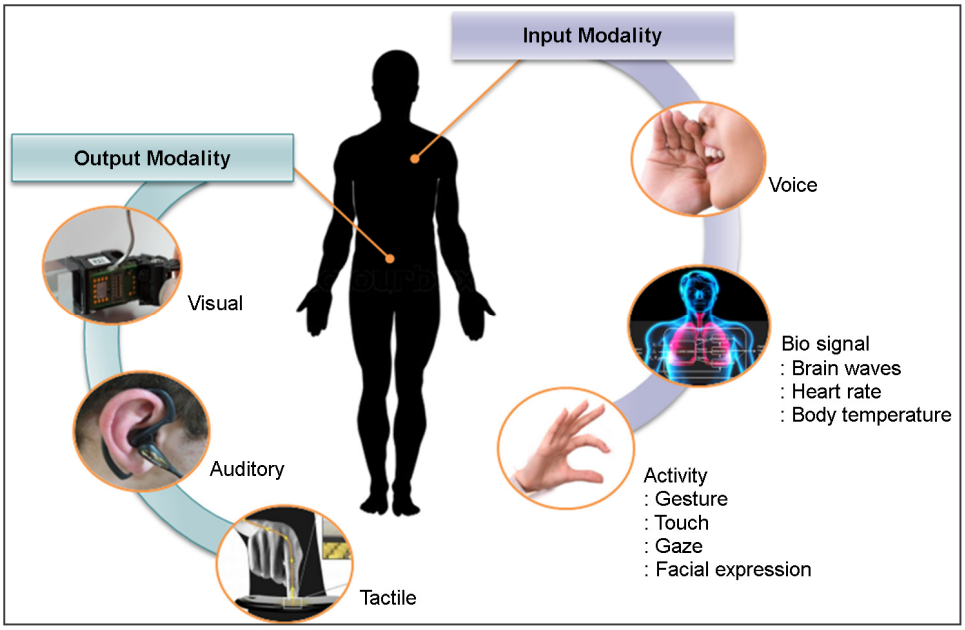


Figure 7. Type of wearable user interfaces

Input modality is an input method used for a user to give a command to a computer, and the representative input modality includes a method using voice, bio-signal and physical activity. Output modality is a method to output information to express according to user's request, and the representative output modality includes an output method responding to human's visual, auditory and tactile senses.

3.2 Requirements of wearable user interface technology

Although a wearable computer is different from a general computer from the use environment perspective of wearing, both are viewed to follow the technology trend pursing NUI from the user interface perspective. A wearable user interface technology aims at servicing of a computer through interaction like talking with a friend, while a user wearing a computer without discomfort. However, the current technology level can just target the interfaces that can be implemented with available technology, due to various technological limitations. Meanwhile, wearable computers need to develop user interfaces in consideration of the more restrictive user interface environment in terms of 'wearing'. Based on the characteristics and merits of wearable computers examined thus far, the core requirements of user interfaces to take into account in the wearable computer development stage are outlined as follows:

1) Hands Free: An interaction method, in which both hands are free so that a user can freely use a wearable computer during the work, in addition to natural interaction in everyday life, is necessary.
2) Distraction Free: To interface with a device offering a touch interface such as a smartphone, a user should view and focus on the screen, and then select and control his/her desired functions. Such an interface is accompanied by a risk to use in everyday life, in particular while the user is walking. Therefore, a new interaction method such as conversation type or bio-signal detect type that can be conveniently used on the move is required.
3) Constancy: A device should provide a standby mode that can immediately respond to user needs, and a non-suspended linking channel between a user and a computer is necessary.
4) Stability: A safe interaction method through which physical fatigue is small in the long time use, and that can guarantee harmlessness to human body with regard to power supply or electromagnetic waves is required.
5) Sociality: An interface without discomfort or cultural sense of difference according to wearing or use, with a shape in line with social/cultural common idea, and protecting individual privacy and not giving burden to users is needed.
6) A new interface with a new output mode overcoming the limitation of information expression through a small display or delivering the information to users is necessary.

4. Conclusion

A wearable system demanded by consumers is a small, convenient and simple device that can guarantee mobility and with which a user can carry out business efficiently, while a user can use both hands freely. Above all, the stability, convenience, fashion and design aspects seem to hugely affect user's technology acceptance, in addition to system performance or technological aspects in that a user wears a wearable system. As the success cases of iPod/iPhone show, people tend to prefer novel design products convenient to use with simple functions, rather than products with excellent performance and complex functions. A user interface technology needs to start from the understanding of the ergonomic aspect on humans, and developers should not focus on a new system development on the basis of obsession with cutting-edge technologies without an analysis of user needs. An effort to develop convenient interaction technologies in order to support user-desired services and make various wearable systems into human-oriented service devices is needed.

Currently, there is no wearable user interface technology perfectly dominating markets in the world. The wearable user interface can be an area that needs a new challenge for innovative technology development beyond existing user interface paradigm

through various attempts and approaches. In particular, ergonomic approach-based studies on user convenience maximization should be preceded. Indeed, the wearable user interface technology is an R&D area requiring fusion between disciplines and industries through cooperation with researchers in the fields of ergonomics, electronics/computer, psychology/cognition/emotion and fashion design.

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