An Application of Augmented Reality on Hot-key Interface Design

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ABSTRACT

It is universal that graphical user interface (GUI) applies to operating system or computer-generated imagery interface design. It indicates that most users have relied on a mouse to choose icons or selected boxes, while operating a computer. In most cases, when a user needs to repeat keying certain function keys, it means the working efficiency is low. To solve this problem, software designers normally set hot-key groups on the keyboard for work efficiency.

However, it might be a trouble for the ordinary people, because they need to memorize the hot-keys' locations and functions. Given so, this research has focused on the application of augmented reality technology so that virtually visual digital information will be augmented and displayed on a real keyboard. It results in a better work efficiency by a better cognitive and memorized keyboard design.

Of this research, the conditions that the ordinary people use hot-key groups according to their age, sex, frequencies, learning and cognition were firstly analyzed. Afterwards, based on the guideline of User-Centered Design (UCD), the experimental augmented reality hot-key interface was designed. The finding reveals that a 28 to 30 percent of efficiency was increased on the subjects who seldom or never use hot-key groups. Moreover, the augmented reality (AR) hot-key interface effectively promotes the subjects' learning performance, without particular memorizing. Virtually visual digital images stimulate the subjects' cognitive ability.

Apart from raising the work efficiency on word processing, hot-key groups are also applied to graphic application software and the interface of on-line game operation as well. In the future, with the characteristics of augmented reality, the integration of human-computer interface could be employed in different users in diverse needs, so as to prompt the availability and popularity of hot-key groups.

Keywords: Visual Perception, Graphical User Interface, Augmented Reality, Human-computer Interaction, Human Factors

1. INTRODUCTION

1.1. Background and Motivation

Graphical User Interface (GUI) was first applied to the Xerox Star Information Systems in the 1970s. During that period of time, the computer system was still in disadvantages of low computing speed and limited software executing capability for Operation System (O S). Even so, with visual

display terminal (VDT) and pointing device of a mouse, the computer interface provided the users with the clear outlet of selected boxes and real-time operating feedback. The user could complete most works by simply manipulating a mouse.

However, the work efficiency was still low that users needed to repeat keying certain function keys or constantly moved a mouse to choose the selected boxes. Such a vexing behavior took users' operation time. To solve this problem, software designers normally set hot-key groups on the keyboard for better efficiency. For instance, to press the key "Ctrl" and any other "Capital Key" simultaneously meant to perform a particular function, which largely saved users' time on manipulating a computer.

Nevertheless, there is one thing critical; that is, users need to precisely memorize several sets of hot-key groups. If not doing so, the functions of hot-keys cannot be worked out. In other words, memorizing a set of hot-keys becomes essential. Generally, human's cognitive abilities include consciousness, memory, and attention that gradually regress with ages (Salthouse, 1992)(10). Human's memory is limited. When there is no frequent and reinforced input, messages and memory in human brains are easily forgettable. Messages keep in human brains as long-termed memory only via repeated reminding (Atkinson & Shiffrin, 1968)(1).

A friendly technology has fusion with human nature. So, an effective and efficient Human-Computer Interaction (HCI) has always been what human strives for. Accordingly, this research is attempted to study HCI from the base of User-Centered Design (UCD). It is to initially investigate the users' behaviors on hot-key groups, and then design a hot-key interface by the application of augmented reality technology. It is expected that the new designed augmented hot-key interface could improve the efficiency of keyboard manipulations.

1.2 The objectives

This research is attempted to design an efficient and user friendly hot-key interface. The specific objectives are as follows:

(1) To explore the feasibility of applying the augmented reality technology on hot-key interface design.

(2) To test the effect hereafter using augmented reality technology on hot-key interface design.

(3) To provide a knowledgeable reference for engineers who further develop a new key board interface.

2. LITERATURE REVIEW

2.1 Visual Perception

Robert (1995)(13) mentioned that cognition includes perception, memory and thinking processes. There are two major theories interpreting perception, i.e. constructive perception and direct perception. Constructive perception is proposed by Helomholtz and other scholars. It is the theory of perception in which the perceiver uses sensory information and other sources of information to construct a cognitive understanding of a stimulus. In other words, the internal experiences and knowledge may influence human's perception. The other theory is direct perception based on top-down information processing

processes. James Gibson has been considered as the most important proponent for such theory. Human can sense the external world without internal knowledge or experiences.

The processing of visual perception is through perceptual stimuli which is diagnosed and analyzed via memory and life experiences in brains, and then makes proper responses and actions. At the sight of graphics, the processing of sense and cognition goes hand in hand. When the graphics are clearer, the users are easier to recognize them. When the users see the same graphics hereafter, graphics will turn to be part of their long-term memory, according to Robert (1996)(12).

2.2 Augmented Reality

Azuma (1997)(2) defined Augmented Reality (AR) as systems that have three characteristics: **(1)** to be combining with reality and virtuality **(2)** to be interactive in real time **(3)** to be registered in 3-D. Milgram(1994)(6) defined AR as a combination of the real scene view and a virtual scene generated by the computer. As Figure 1 shows, the left side of the line is real scene, and the right side is virtual scene; AR is categorized to the syntactic environment blending real and virtual objects.

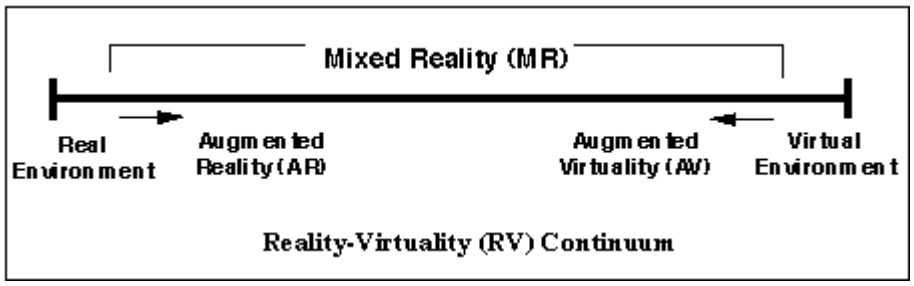


Figure 1 ：Simplified representation of an RV Continuum. (from：Milgram al etc. 1994)

Milgram(1994)(7) further mentioned that there were two main technologies to present augmented reality. One is Optical See-Through System and the other is Monitor-Based System.

(a) Optical See-Through System

As Figure 2 shows, Optical See-through system is one device that works by placing optical combiners in front of the user's eyes. These combiners are partially transmissive, so that the user can look directly through them to see the real world. The combiners are also partially reflective, so that the user sees virtual images bounced off the combiners from head monitors.

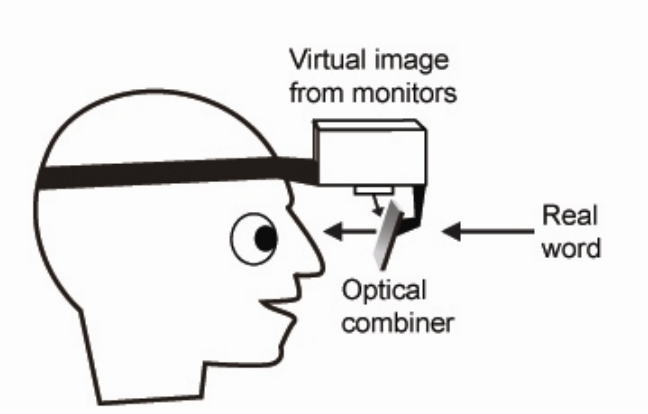


Figure 2：Optical see-through HMD conceptual diagram

(b) Monitor-based System

AR system is building by using monitor-based configuration. The cameras may be static or mobile. The video of the real world and the graphic images generated by a scene generator are combined, and the combined image is displayed in a monitor in front of the user.

2.3 Human Factors Engineering

Human Factors Engineering was proposed by the celebrated scholar, Henry Dreyfuss. He depicted the measure of man and woman so that designers developed products that adjust to human's body (Dreyfuss, 1993)(5). His work both popularized the field for public consumption, and made significant contributions to the underlying fields of ergonomics, anthropometrics, and human factors. Human Factors Engineering is dedicated to discover and survey human being's capability, limit, behavior and other features. And then apply it to the design of tools, facilities, systems, works and environments in order to enhance the quality of life and productivity.

Recently, Human Factors has been putting emphasis on User-Centered Design (UCD). Norman mentioned that the guideline of UCD is based on the people who use a product, knowing what they need and what they prefer on a product, and then the designer designs it according to their requirements (Norman, 1986)(7). The philosophy behind user-centered design is simply as: users know best. It includes focuses on functions, packaging, interface of products and so forth.

The present research applies one of Human Factors Engineering; namely, the human-machine system. The Human-Machine System is of a person interacting with a machine in some kind of environment. The person and machine are both modeled as information processing devices, each with inputs, central processing, and outputs. The inputs of a person are the senses and the outputs are effectors. The inputs of a machine are input control devices (e.g., keyboard and mouse) and the outputs are output display devices (e.g., screens). Such kind of processing is the interaction between human and machine, according to Sanders & McCormick (1992)(11).

2.4 Human-Computer Interface (HCI)

The interface between users and computers is called Human-Computer Interface (HCI). Through the HCI, users may realize the software which interacts with users. Visual graphics have been employed for a long time since the invention of HCI. Graphical User Interface (GUI), is a type of user interface that allows users to see clear graphics, including graphic icons, selected boxes, pointing device, windows, and menus. Users could click on graphical icons to operate the computer easily

(Norman, 1988)(8).

Elements of graphical user interface include windows, pull-down menus, buttons, scroll bars, iconic images, wizards, the mouse, etc. Applications typically use the elements of the GUI that come with the operating system and add their own graphical user interface elements and ideas. The advantage is that users interact by using a mouse rather than having to type a complex command, which saves much time of users on manipulating a computer, and largely increase working efficiency.

3. METHODOLOGY

3.1 Overview

This research firstly investigate the behaviors that the subjects use hot-key groups, so as to analyze what difficulties the ordinary users meet with and what requirements they further have. The subjects were randomly selected with five male and female respectively ages from twenty to fifty-five. Next, the authors use the results of the investigations on the subjects as a valuable reference to modify the design by applying augmented reality onto hot-key interface. The assessment of this research will be conducted by experimental evaluation, observational evaluation and investigational evaluation.

3.2 Experimental Procedure

The experimental procedure is based on the implementation divided into four stages as follows:

Stage 1: Analyze the behaviors that the subjects use hot-key groups

* Independent Variable: age, sex, hot-key uses, figure and size of Capitals on keyboard

* Dependent Variable: recognition on hot-key groups, efficiency, learning, memorizing

* Procedure:

(1) Each subject memorizes the hot-key groups within 5 minutes; namely, the groups are “Ctrl+A”, ”Ctrl+Z”, ”Ctrl+S”, ”Ctrl+X”, ”Ctrl+V”, ”Ctrl+C”, and ”Ctrl+W”, respectively.

(2) The researcher and subject enter each individual testing room simultaneously. After the subject is notified with test items and then take tests (see Appendix A), the researcher notes down the time when the subject has finished the test items.

(3) After testing, the researcher conducts a semi-structured questionnaires interview with the subjects (see Appendix B).

Stage 2: Augment the selected virtually digital graphical system on a keyboard.

Design a clear graphical card corresponding to each capital letter. Figure 3 shows the design of the graphic capital cards corresponding to hot-key groups and visual images. A camera reads the graphics of the graphical card and afterwards the read virtual image will be augmented on the location of keyboard. The VDT of the computer will serve as the visual interface in which the augmented virtual keyword image will be displayed.

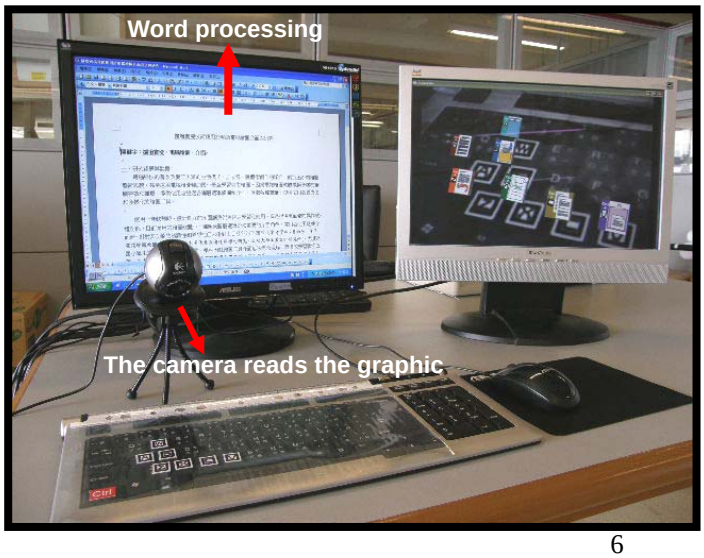
graphics	
virtual image	
hot-key group	Ctrl+A、Ctrl+C、Ctrl+S、Ctrl+V、Ctrl+W、Ctrl+X、Ctrl+Z

Figure 3. The graphic capital cards corresponding to hot-key groups and visual images.

Based on the guideline of User-Centered Design (UCD), the authors have combined the augmented reality technology with virtually visual digital images to develop the new AR hot-key interface in this research. The interface acts as an aid to help the user fast recognize hot-key groups. The design counts on visualization with symbolizing images to foster learning motivation and work efficiency. The core of visual digital images design is visualizing, simplifying, and recognizable, so as to connect with users' experiences and memory. To enable the subjects to read the graphics with ease, the graphic capital cards are depicted with black and white dot matrix so that computer software could read and differentiate. The users could eventually easily recognize its figure and size so as to achieve the goal of successful human-computer interaction. Figure 4 shows the equipments including software and hardware for this new AR hot-key interface. Figure 5 shows that the augmented image is showed on the visual display terminal (VDT). Figure 6 describes that the keyboard is covered with a transparent plastic sheet on which graphics are printed.

The equipment of AR hot-key interface:

* Hardware: double monitor, digital camera, keyboard, plastic card, mouse
* Software: sr_portfolio



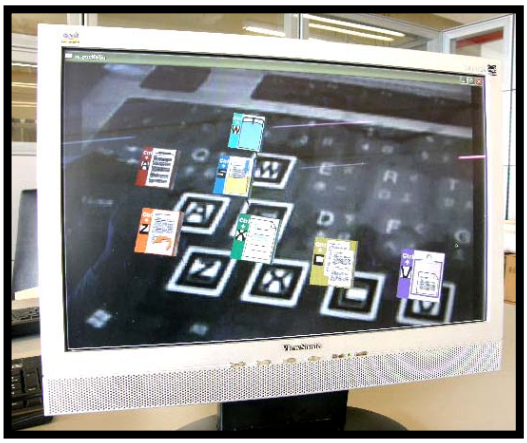


Figure 5：Augmented image is showed on the visual display terminal (VDT)

Figure 4：The equipment of AR hot-key interface

Figure 6：The keyboard (covered with graphics)

Stage 3: The augmented reality hot-key interface design and experiments

* Independent variable: the size and figure of capitals on graphic cards, virtual image, hot-key use, age, sex

* Dependent variable: recognition of hot-key, efficiency, memorizing, learning

* Procedure:

(1) Set up the computer peripheral of AR interface

(2) Make sure that the subject can clearly see the augmented images showed on the VDT of computer.

(3) The researcher and subject entered each individual testing room simultaneously. As Figure 7 shows, the subject is notified with test items and then take tests (see Appendix A), before the researcher notes down the time when the subject has finished the test items.

Figure 7. The scene of the subject on testing

(4) After testing, the researcher conducts a semi-structured questionnaires interview with the subjects (see Appendix C).

Stage 4: Analyze the results of the questionnaires to examine the effect of the new designed augmented hot-key.

4. RESULTS AND DISCUSSIONS

Among the ten subjects, the most frequent users of hot-key groups are four male between the age 20 to 50, and one female aged 20 to 30. The users who never or seldom use hot-key groups are one male and one female above the age 50, and three female aged 30 to 50. Accordingly, male uses hot-key groups more frequently than female does. The user aged over 50 has less frequency. The subjects who use more hot-key groups finish word processing within 30 to 50 seconds. The less frequent users finish that within 100 seconds. A finding appears that the more frequent hot-key users perform better efficiency on editing software.

From the interviews in Stage 1, the reason why users use hot-key groups is saving time, especially upgrading working efficiency (male between ages 30 to 50), or the reason is speeding on editing software and on-line games (male between ages 20 to 30). In other words, users opt for hot-key groups when they would like to save time and raise the speed. The users seldom or never use hot-key groups in that they are not familiar with their functions or locations, or they are easily forgetful of and need more time to memorize that.

Moreover, the subjects consider that it is hard to make connection from the capitals on keyboard. For instance, to connect “C” with “copy” is difficult for non-English users. As regards to the figure and size of capitals on keyboard, the subjects within age 50 could recognize them with ease, while the subjects above age 50 think they’re too small to recognize. With literature review and the results of Stage 1, the new augmented hot-key interface is designed, including virtually visual images and graphics. The subjects who use hot-key groups less than 3 times have been selected to test the experimental augmented hot-key, so to examine the effect of the new experimental interface.

The results of testing and semi-structured interviewing indicates that the frequency of using hot-key groups increase 4 to 6 times, and finish testing items within 50 to 70 seconds. It reveals that a 28 to 30 percent of efficiency has been increased by the new augmented hot-key design.

The subjects consider it is easier to use hot-key groups, compare to conventional one; they don’t need particularly to memorize. Through the AR hot-key interface, the subjects use hot-key groups consciously without much thinking through the VDT of computer. They also indicate that the visual graphics with different colors along with the larger size of capitals contributes to their easy recognition.

5. CONCLUSIONS AND RECOMMENDATIONS

The use of keyboard is executed via exact coordination, while pointing device via precise but yet relative coordination. Therefore the processing of keyboard is faster than the mouse (Booth, 1989(3); Charness, 1995)(4).

Due to its convenience and availability, a keyboard serves as an indispensable equipment of

computer. Keying performance is advanced by constant improvement and invention. Good keying performance results in better working efficiency. The application of hot-key groups is one of keying performances. However, memorizing and practicing hot-key groups decrease the learning motivation and confidence of users.

Based on the guideline of User-Centered Design (UCD), the augmented reality hot-key interface design must be with the considerations of the users' behaviors. It indicates that without particular learning and memorizing, users easily execute the functions of hot-key groups via this new interface design. The findings of this research summarizes as follows:

(1) The characteristics of Augmented Reality (AR), coupled with virtually visual graphics and computer peripheral such as keyboard, create a both virtual and real user-centered interface.

(2) The virtually digital graphical image of hot-key groups effectively promotes the learning and recognition of users who never or seldom use hot-key groups.

(3) The application of the features of Augmented Reality (AR) to keyboard effectively raises the frequency of hot-key uses and the efficiency of word processing as well.

The recommendations of this experimental research are as follows:

(1) Taking into account that ages and sex of users influencing the result, the users' educational background and experiencing life may yield different results. And future research may consider that the subjects sampled will be in larger amount of quantity and more diversified of background in order to validate its effect.

(2) To develop more satisfying user-centered and augmented hot-key interface will increase its application on diversified and related products in daily life.

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Appendix A

The subjects took testing items on editing software, i.e. Word System.

(1)Open the document file 1 (by the researcher).

(2)Cut the bold words in the document file 1.

(3)Open another document file 2, and copy the whole text of file 1.

(4)Save the file 2 and then close it.

(5)Renew the original text of the file 1.

Appendix B

1. (1)Name_____ (2) Age_____ (3)Sex_____

(4)Occupation/Position_____

2. (1)The frequency of using hot-key groups ,check with "∨" ___1___2___3___4___5

* 5: very often, 4: often, 3: always, 2:seldom, 1:never. And explain why?

Answer_____

(2)Check with "∨" if you already know the functions of hot-key groups

☐ CTRL+A ☐ CTRL+Z ☐ CTRL+X ☐ CTRL+W

☐ CTRL+V ☐ CTRL+C ☐ CTRL+S

(3) After testing, the subjects received semi-interview questionnaires as following.

a. How many times did you use hot-key groups when you took testing items?

Answer_____

b. Is the figure of capitals on the keyboard easy to recognize? And explain why?

Answer_____

c. Is the size of capitals on the keyboard easy to recognize? And explain why?

Answer_____

d. Is the color of capitals on the keyboard easy to recognize? And explain why?

Answer_____

e. Is it difficult to differentiate the functions of hot-key groups when using them?

And explain why? Answer_____

f. Is it difficult for you to learn the functions of hot-key groups? And explain why?

Answer_____

Appendix C

1. (1)Name_____ (2) Age_____ (3)Sex_____

(4)Occupation/Position_____

2. (1)The frequency of using hot-key groups ,check with "∨" ___1___2___3___4___5

* 5: very often, 4: often, 3: always, 2:seldom, 1:never. And explain why?

Answer_____

(2)Check with "∨" if you already know the functions of hot-key groups

☐ CTRL+A ☐ CTRL+Z ☐ CTRL+X ☐ CTRL+W

☐ CTRL+V ☐ CTRL+C ☐ CTRL+S

(3) After testing, the subjects received semi-interview questionnaires as following.

a. How many times did you use hot-key groups when you took testing items?

Answer_____

b. Is the figure of capitals on graphic cards easy to recognize? And explain why?

Answer_____

c. Is the figure of capitals on graphic cards easy to recognize? And explain why?

Answer_____

d. Is the color of capitals on graphic cards easy to recognize? And explain why?

Answer_____

e. Is it difficult for you use the new augmented reality hot-key interface? And explain why? Answer_____

f. Do the virtually visual images aid you to connect and recognize the functions of hot-key groups? And explain why? Answer_____

g. Are the virtually visual images easy to recognize? And explain why?

Answer_____

h. Do you think that the new AR hot-key interface aids you to use hot-key groups?

And explain why? Answer_____