ARHCI: Use Input and Output of Eyes to Interact with Things

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ABSTRACT
Augmented Reality (AR) applications have been widely spread on phone terminals. However, many of them are not deployed well in the phones obviously[1].We proposed a novel terminal—ARHCI, which can supply AR service and allow users to carry on hand-free operations on the information on the glasses. This design is not only an eye-glasses, but also the tracker of movements of head and eyes,[2] as well as the screen presenting the added information. This paper will show the architecture of ARHCI and a related project aiming to help physically challenged people while they go outside.

Author Keywords
Augmented Reality, Human Computer Interface, EOG, GPS, smart wheelchair, ubiquitous computing，wearable computing.

ACM Classification Keywords
H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems: Artificial, augmented, and virtual realities

General Terms
Human Factors, Design

INTRODUCTION
Goggle as an emerging ubiquitous computing terminal, has been proposed in two interesting areas: Augmented Reality and Human Computer Interface. AR researchers mainly focus on how to present extra information of physical world, while HCI researchers mainly exert their efforts on novel approaches of natural control patterns. The architecture of ARHCI combines the "inputs" of AR Goggle to achieve augmented information and the "outputs" of HCI Goggle to control machines or computers, which is bidirectional and more interactive. Due to the goal of a compact design of terminal, ARHCI only works for bio-signal acquisition and transparent screen display. Any other computations are managed by ordinary smart phones. Specifically, ARHCI in this paper is used to let users to interact with an electrically powered wheelchair.

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BASIC DISCUSSION
Following discussions center on several basic technologies to realize functions of ARHCI.

Features of Eye Signals
Since the electric potential change is nearly linear to the angle difference by eyes movement, we can get the filtered and amplified signal caused by eyes as shown in Figure 1.

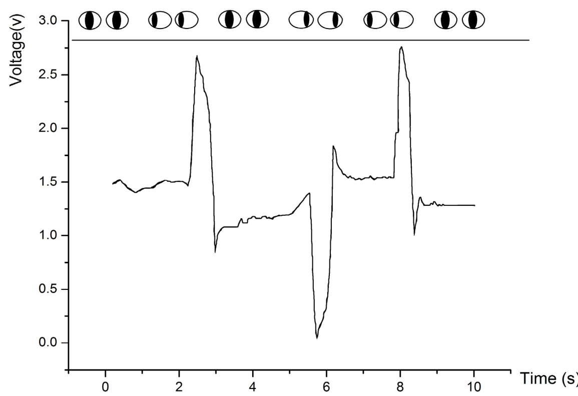

Figure 1. Voltage Change Caused by Eye Movement.

The circuits of signal processing module filter the EEG, ECG and EMG to get signals at frequency ranges from 0.05~15.02Hz and amplify them to the voltage ranges from 0~5V which suits AD converter in MCU [3].For eyes, moving from the straight to the right (or left) and back is regarded as a complete action to get the control signal. For head, a nod or a shake of the head can also be regarded as an action which will generate control signal.

Display Augmented Data on the Screen of Glasses
A combination of GPS and e-compass provides real-time direction of route to reach user's destination. In this system, e-compass in smart phone can not be effective because it is probably in user's pocket and not convenient to take out while driving. Therefore, glasses should be embedded with an e-compass. Direction which the user is facing could be recorded by the e-compass in order to transmit to the smart phone to synthesize with GPS. This helps user to get where

the user want to head to. Note that the augmented data acquired by GPS in the smart phone and e-compass in the glasses is irrelevant to some specific object in front of the user. In fact, many AR applications do consider specific properties of real 3D objects on the view plane to present accurate virtual projection on the screen. Properties such as scale, transparency and inter-object spatial relationship.[4]In these scenarios, there should be a front facing camera to record real-time situation of the front.

IMPLEMENTATION

This section discusses the approach to provide hand-free control over wheelchair using ARHCI. Due to the portability concern and power issue, glasses part of ARHCI is integrated with the following three modules: a).signal processing module, b).display driver module, and c).communicator module which interacts with cell phone and controls the wheelchair. All of the three modules above are integrated in the AR controller which is very portable. Most of computational complexity will be reduced in the ARHCI because smart phones like iPhone and Android can provide OpenGL and GPS technologies. The glasses in the ARHCI are of light weight for the reason that AR controller is in charge of signal processing. Figure 2 shows the prototype of ARHCI.

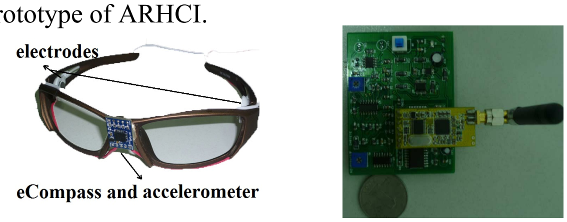

Figure 2.Hardware Components of ARHCI.

Figure 3 shows the architecture of hand-free controlled wheelchair using ARHCI. In this system, the user can operate the wheelchair without hands and receive the real-time direction data on the screen of glasses. Wheelchair is controlled by the movements of user's eyes and head, which is described by state diagram in Figure 4.Considering one situation that user may look the surroundings while the wheelchair is going forward, the system provides two modes. In mode **I** , the movement of eyes is enabled to control the wheelchair (Forward/e in Figure 4); in mode **II**, the users are free to look surroundings while the wheelchair is going forward (Forward/n in Figure 4).Shift between the two modes are carried by the user's nod.

Figure 3. Architecture of Smart Wheelchair Using ARHCI.

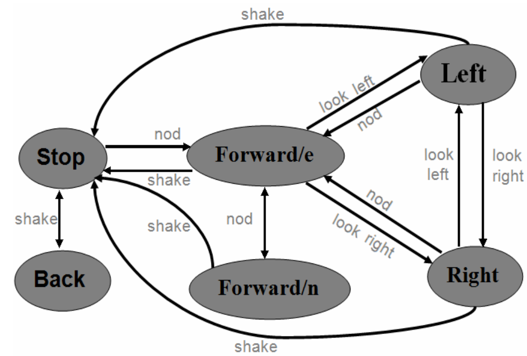

Figure 4. State Diagram of the Controlled Wheelchair.

SUMMARY

Augmented Reality system registers the virtual world to what the user is seeing. Therefore, eyeglasses which can best present the virtual world to people is a desired terminal. To maximize the function of eyeglasses, we bring the potential of skin resulting from eye movements and that of accelerometer recording head movement to the system. So the information on the eyeglasses could be selected without hand. In a daily scenario, the handicapped may feel exhausted to use their hand to use wheelchair. This system offers 2D navigation information [5] on the screen of eyeglasses and allows the user to control the wheelchair's direction without hand. Obviously, the hand-free driving of wheelchair would lessen the burden on user's family and improve user's confidence on life. In future, to reduce the potential damage on user's sight, screen made of OLED would be useful in related AR application.

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