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Design of Eye Movement Interactive Interface and Example Development

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Abstract: With the unceasing development of HCI (Human Computer Interaction) technology, natural interactive products are valued by more and more people. The next generation of man-machine interface may use touch, hearing or vision, etc. Among them, the visual sense is the most important channel to get information, but researches are mostly focused on the measurement of eye movement or data processing. In the future, the interaction of eyes with machines will have a very wide prospect. After concluding the pluses and minuses of available eye control systems, we puts forth the design principle, system concept and the state transition model of eyes interaction from the consideration of user-centered design principle. The system simplifies the measurement process, focuses on the fast tracking, calibration and accurate eye movement identification. At the same time, we use context information to reduce interaction time and combines with keys to eliminate eye movements' ambiguity. Based on the design scheme, we develop a system-EyeHUD(Eye Head Up Diaplay) which can be applied in driving. It includes an eye preset interface, an eye control interface and a virtual vehicle scene. Before starting cars, a driver uses the eye tracker to track and calibrate eyes, then chooses an interactive function, like one blink zoom in or two blink chick. When the eye control interface is opened, the driver can use auto eye control to operate it, or choose eyes+keys way to simulate a click. The evaluation results shows: EyeHUD can successfully achieve all the default function and participants don't need long time to understand the information provided by the interface. Compared with the eyes+keys way, the auto eye control has no obvious difference in recognition success rate.

Key words: Man-machine interaction, eye tracking, eye control interface, eye HUD

INTRODUCTION

As is known to all, the world has entered into "radio" era, wireless Internet access, wireless charging, wireless mouse, wireless keyboard, etc. All these reflect the future of human-computer interaction is toward "anytime and anywhere" in the direction of the development. So, it can be indicated that the new interactive way must be convenient to carry without additional equipment. For example, the population of iPhone, Microsoft company Kinect system is complied with this trend, they contain touch control, sound and motion control and all of these will be generally used in interactive way in the future. However, human vision is the most important way to obtain information. Information processing depends heavily on vision, about 80-90% of the external information is obtained through the people's eyes (Wang, 2008). And because the line of sight of people with naturalness and bidirectional which other information is unable to achieve (Jacob and Karn, 2003), people have strong interest in the research of the line of sight, with the hope that it will become the new interactive channel.

Eye Movement Technology as the main method of a visual channel information collection, has been an important role in the study of human-computer interaction, especially the Eye Tracking Technology and the line of sight Control Technology research, has had great development in recent years. At present, the line of sight tracking technology is relatively common, for its research mainly concentrated in the eye movement measurement method and the line of sight on the processing of data. And the research of regarding the intercept to the line of sight as an input channel to control program is developed in recent years and has a very wide prospects. This study puts forward an eye movement interaction system model based on an eye movement instrument, developing an eye movement interaction example EyeHUD applied to driving environment.

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EYE MOVEMENT INTERACTIVE SYSTEM MODEL

Eye movement instrument: Eye movement instrument is the important instrument of psychology research which can also complete the work of capturing the line of sight in human-computer interaction. It is an equipment based on hardware which is used in the line of sight tracking. Its basic working principle is to use the image processing technology and a special camera to focus on eyes and record the line of sight. So, as to achieve the purpose of recording eye movement trajectory characteristics of visual information processing (Guo and Jin, 2005). At present, eye movement instrument is widely used in note, vision, reading and other areas of research, generally divided into wearable and non-wearable, contact and non-contact cent. The existing different manufacturer production of various types of eye movement instrument, such as Eye Link movement instrument, EVM3200 eye movement instrument, faceLAB4 eye movement instrument, Eye Trace XY 1000 eye movement meter and so on, the different eye movement instrument for different ways of eye tracking and calibration (Zhang *et al*., 2009). In order to obtain a better user experience, making the auxiliary equipment cause the less interference during the interactive process. This study chooses Sweden Tobii company's X60 eye movement apparatus to follow the line of sight. The eye movement tracking system adopts advanced wide-angle wireless telemetry tracking technology, without wearing any head holder or helmet, allowing the head moving in a wide range of 3d and acquiring accurate data at the same time. Also Tobii company also provides open source supporting software toolkits, helping engineer to develop their own applications or eye movement control program. This instrument is shown in Fig. 1.

Fig. 1: Tobii X60 eye movement instrument

Eye movement interactive system framework: According to the eye movement interaction design principles, this study puts forward a scalable eye movement interaction system framework, as shown in Fig. 2.

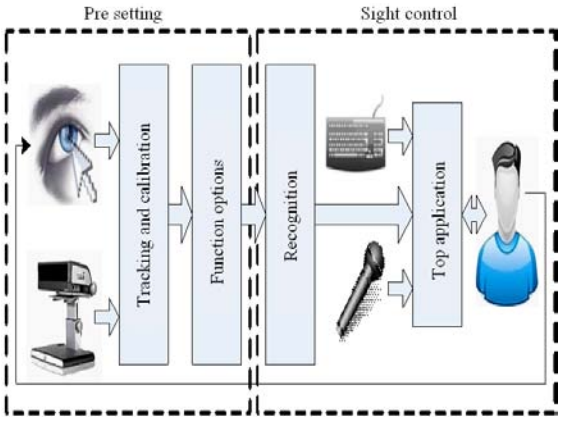

Fig. 2: Eye movement interactive system framework

This Eye movement interaction system mainly includes two major module, the first is the line of sight pre-setting Module (Eye Preset Module), the user completes eye tracking, checking and interactive function selection through it. Eye movement instrument marks out the line of sight which goes into the interactive region from a wide range of view and then calibrate the position of interactive objects and the line of sight. If calibration succeeds, then activate follow-up function selection and recognition module, avoiding the whole system being active and analyzing all eye movement. After calibration, the user can choose to open the line of sight Control Module (Eye Control Module), then control the top application through the multichannel input. System scalability reflects in:

- **Interaction function can be expanded:** In addition to the commonly use such as click, rolling but also can be enlarged, turning the page and other function. As long as the user builds a one-to-one mapping relation between the selected eye movement type and interactive function, then can complete the function such as amplification through the eyes
- **Eye movement type extensible:** Eye movement types are divided into static eye movement (watch, blink, etc.) and dynamic eye movement (cross line, draw circle, etc.), can be chosen for customers. In the definition of eye movement set, developers should choose some kinds of low correlation and conform to

the mainstream user interaction habits of eye movement type, when the system switches into the recognition process, can only start one of the two modes ,static recognition or dynamic recognition. so as to decrease the system calculation load. On the other hand, due to the system focusing on a particular type of recognition and thus be able to the exclusion of other unconscious eye movement interference to reduce the recognition error rate

- **Identification method can be extended:** In addition to judge fixation time or blink frequency outside, system can also use context information to reduce recognition time. For example, in two blink corresponding click interaction. First, keep the user first blinking location information, then remind the user that the current target has been chosen once. If the user doesn't choose any other target in the next any moment, after the second eye blinking toward the original target then it can be selected. This will reduce the repetition time caused by midway interrupt
- **Higher application can be expanded:** According to different application scene, the line of sight control interface can be different. In accordance with the eye movement interaction design principle, the same preliminary settings interface can be corresponding to different line of sight control interface. So that, the visual professional development personnel can not only focus on the line of sight tracking, calibration, identification of bottom technology, but also accelerate the development of the prototype system effectively. In addition, it can be expanded multiple input channels (Bloch and Hammoud, 2009), constraint the ambiguity of eye movement

Eye movement interactive state transition model: According to the eye movement interaction framework and the contact type and non-contact type interactive state transition model (Wu *et al*., 2009). This study proposes a kind of eye movement interactive state transition model as shown in Fig. 3, standardizing the eye movement interaction process and reducing the effect of MIDAS contact.

In Fig. 3, the state 0, state 1 and state 2 state belongs to the line of sight pre-setting module, state 0 means not in the tracking area, the line of sight will not have any influence on the interface. State 1 means the line of sight have entered the tracking area but not yet calibrated, the line of sight fluctuations will not affect subsequent calibration and identification. State 2 means the line of sight has been correct tracked, the cursor in the interface will be moved according to the line of sight, at this time choose magnification or click to complete the function of interactive; After the set into the line of sight control module, the whole process has been tracked the line of sight, the state 4 means the system will judge whether the current state exists and which predefined type of eye movement exists according to the context. If it is static

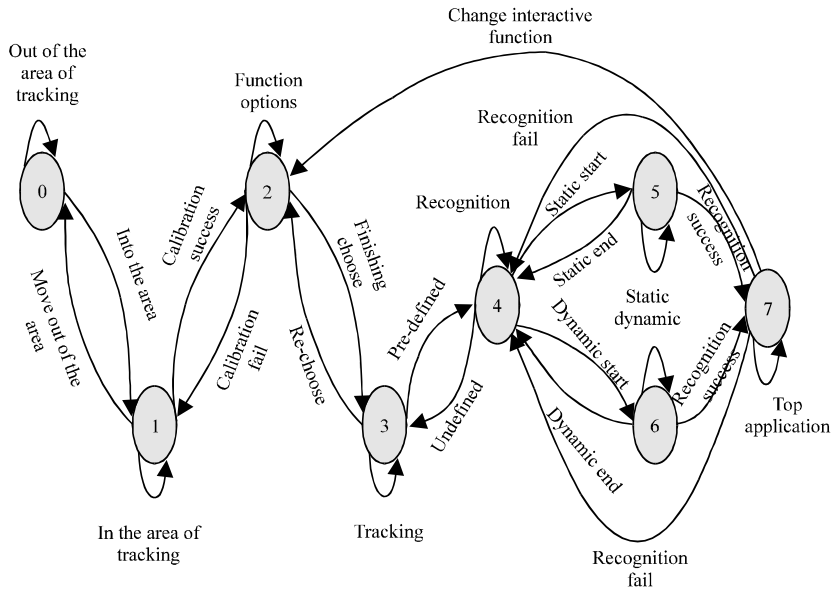

Fig. 3: Eye movement interactive state transition model

initial eye movement then goes into the state 5, or into the state 6. Only the eye movement type has been defined then interacts with the top application. It can be chosen other interactive function in the interaction process at any time, such as the "click" into "amplification". The state transition model provides a standard software development process for the eye control programming, the detail eye movement interface examples can develop software flow chart in this state transfer model basis easily.

EYE MOVEMENT INTERACTIVE INTERFACE EXAMPLE EYEHUD

In order to improve the driver's user experience in vehicle with such various equipments, automobile manufacturers have begun to shorten the time of user's access to information and operating equipment. The driver may lower the head to watch instrument display or regulation floor console audio air conditioning equipment vehicle at high speed, especially the night high-speed traffic, it may cause accidents in case of an emergency (Ting, 2008). More and more high-grade vehicle assembly a HUD (Head Up Display car looked Up Display) system to reduce the line of sight sloshing, so as to avoid dangerous situation happen. It will display the information about the car in front wind shield and its display position, display brightness are adjustable, so it can avoid looking down at instrument or adjusting the equipment by body rotation while driving, also shorten the time that the eye to the visual blind area ahead. It has a great application value to reduce the traffic accident (Hao, 2009).

At present HUD which most of the cars used is located in instrument desk back end projection screen, it display important information (such as vehicle speed, navigation remind, etc.) onto the bottom of the front windshield for drivers to watch (Kumar *et al*., 2007). As is known to all, when people are driving a car, they can not use their hands for any other thing, if they can obtain information through the eye at the same time with the use of visual operation in the HUD of information. It can be regarded as a kind of alternative touch screen or function key, as a method to solve information saturation.

Due to the line of sight is uncertain and also everybody's eye movement process is not the same, so it is necessary to study the advantages and disadvantages and the application range of the total line of sight control and the combination of the line of sight and key control. Which needs to explain is that eye control interface is not a traditional way which uses button to open or close a electronic equipment but needs a special key which has an effect to any equipment in any interface (Tullis and Albert, 2009). At present the

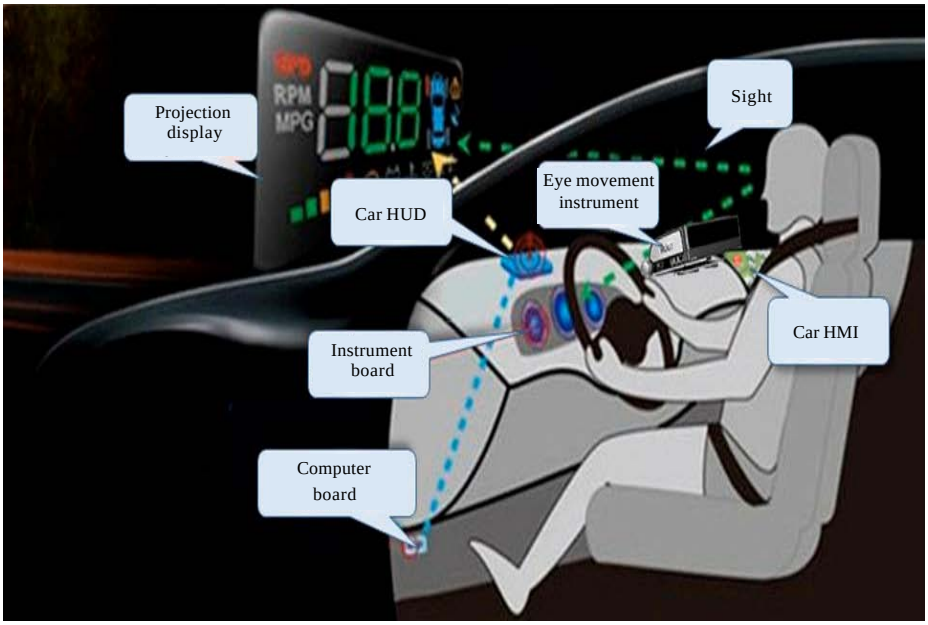

Fig. 4: EyeHUD conceptual model

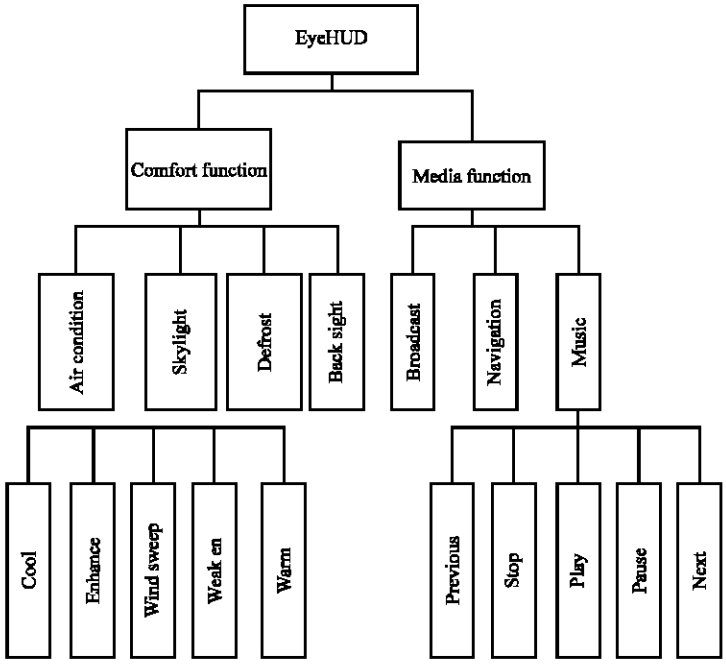

Fig. 5: Hierarchy block diagram of EyeHUD

laboratory has the development of Eye movement interaction prototype system software and hardware conditions, according to the above proposed Eye movement interaction system model, this study will develop an eye control interface which is applicative in automobile.

According to the above mentioned, the concept of EyeHUD models such as Fig. 4 shows. In the development of the prototype system, there needs two block screens to simulate the real driving environment, one of them simulates the first block glass vision, another one simulates the car HMI (Human Machine Interface) operation interface.

EyeHUD is developed as an interactive interface of sight for driving environment. Vehicle electronic equipment which is commonly used can be divided into safety equipment, comfortable model equipment and recreational equipment according to the function (Zhuang, 2009), as shown in Table 1. Because the influence of eye control on the traffic safety haven't got evaluation and its original purpose is assisting the driver controlling car HMI to reduce head-down operation. It is about 0.8s between two blink, in car environment eye movement is not suitable for controlling functions which needs rapid reaction, such as brake accelerator pedal, light system, etc., (Li, 2009).

Table 1: Common car device classification

Type	Device name	Real-timing
Safety device	Accelerator, brake, car light, windshield wiper	High requirement
Comfort device	Seat, air condition, skylight back vision, defrost	Not high
Media device	Music, broadcast, blue tooth, navigation	Not high

Finally, with basis of eye movement control development and function analysis of automobile equipment, this topic selects seven commonly used equipment which make up the major element of function interactive interface, including navigation, radio, astern back sight, music, light, air conditioner and defrosting, the whole EyeHUD function hierarchy block diagram as shown in Fig. 5. Taking music as a representative, it has developed music function example interface longitudinal, interface element with the most commonly used music player function, other functional interface development may refer to the model.

According to the above Eye movement interaction system framework and EyeHUD conceptual model and the function requirement, the Eye Control prototype EyeHUD will include three main Interface: line of sight preliminary Settings Interface (Eye Preset Interface, EPI), Eye movement Control Interface (Eye Control Interface, ECI) and Virtual Car scene (Car Virtual Reality, CarVR). Three interface structure model as shown in

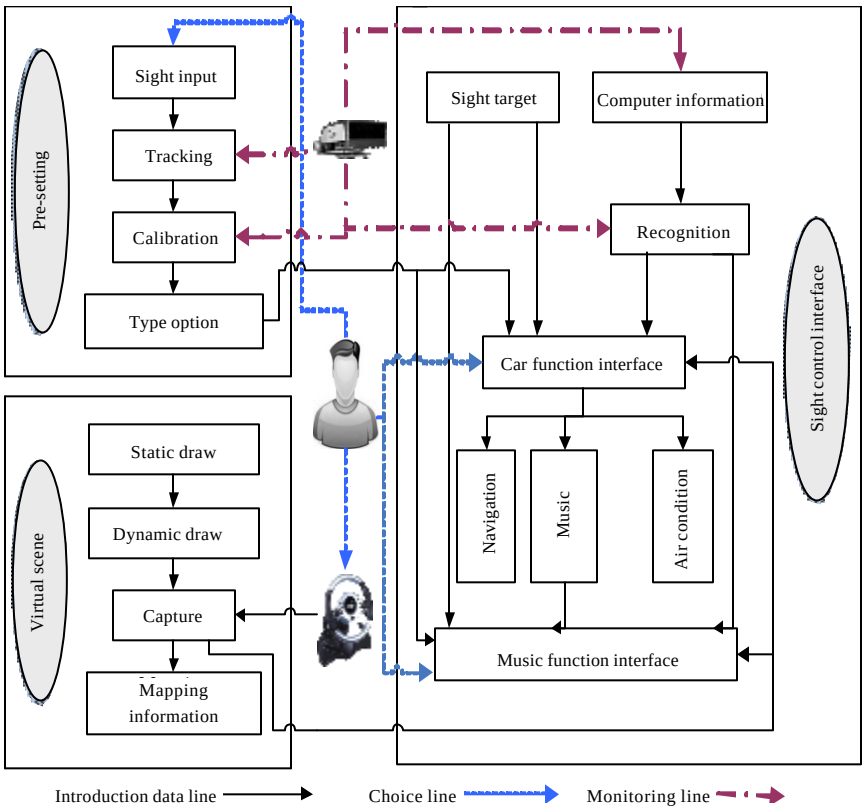

Fig. 6: EyeHUD structure model

Fig. 6. The user first completes eye tracking, check interactive function selection through the EPI and eye movement instrument. After the success of calibration, the users in the CarVR open the line of sight control interface ECI, then use the line of sight to open the function.

CONCLUSION

First, this study summarizes the research background of eye movement interactive. Then it puts forward the eye movement interaction design principles and extensible system framework with the basis of the advantages and disadvantages of the predecessor's eye control system. Finally, it designs an eye movement interactive state transition model on the basis of non-contact type interactive state transition model. For eye movement interaction system, it has been already developed the design principle and the interaction framework and developed the various kinds of functions of EyeHUD preliminary but there still exist some deficiency which needs to improve.

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