Perspective and the Use of Eye Tracking in Human-Computer Interaction

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Abstract. With the increasing demand for information technology, the traditional human-computer interaction (HCI) mode using keyboard and mouse cannot meet the need, which has inspired the research of multi-channel interface based on new interaction technologies such as eye tracking. The direction of human eye contains the information of current task status, so eye gaze is one of the convenient input channels for HCI. To make eye tracking technology more comprehensive and widely used, it is constantly improved. With the development of eye tracking technology, it has been scientifically explored in HCI to record eye movements. The main purpose of this paper is to summarize the update of eye tracking technology currently used for HCI, summarize the development direction and shortcomings of the current technology, and help new researchers to study various methods and algorithms of eye tracking. This paper will briefly introduce the eye tracking technology, summarizes the current application of eye tracking technology in HCI, and discusses the future direction.

Keywords: Eye Tracking; Human-Computer Interaction; Gaze Tracking.

1. Introduction

One effective and trustworthy HCI technique is eye tracking and detection [1]. According to research, more than 80% of people's external information comes from visual sources [2]. In HCI, eyes are used as nonverbal communicators [3] to input or identify user emotions. Eye tracking system is very useful in indicating the level of cognitive load, providing a basis for HCI and as a tool for interface design [4]. The expression of a person's desire, aspirations, and emotional condition heavily relies on the eyes and how they move. Eye motions offer a wealth of insight into people's intents and ideas. In several applications, including biometric security and attention monitoring, the mobility and geometrical properties of the eye make pupil localization, gaze estimation, and eye tracking crucial [1]. Therefore, reliable eye detection and eye tracking are thought to be essential to the advancement of HCI [5].

Technology HCI is used to examine how people and computers interact. The goal of the research is to improve the effectiveness and naturalness of contact by utilizing all available information for human-computer communication. In recent years, HCI has an increasing impact on all applications [3]. The interest in developing human-computer interaction has been growing, computers are a member of our daily life. The use of keyboard and mouse limits human-computer communication. Many systems that replace the mouse have appeared, but because of the accuracy, cost and throughput of the system, these systems are not feasible [6]. Nonverbal communication plays a crucial role in interpersonal communication, and they can also be used as the input of HCI [3]. Therefore, the research on these technologies has increased.

Eye tracking is a technology that can track features of the eye to provide real-time coordinates of the user's sight. Because eye movements are usually considered involuntary, eye tracking provides object data for visual interaction between users and the system. Eye tracking system can also use as a control signal, so users could directly interact with system interface without keyboard or mouse, providing an analysis tool for HCI. Four steps make up the eye tracking detection process: face detection, eye region detection, pupil detection, and eye tracking. Different techniques and algorithms are used in each step.

In the related work will mainly introduce the existing new eye movement tracking technology or the integration of eye movement technology and other technologies and the current problems. The discussion will discuss the current overall problems, needs and development direction. The conclusion will summarize the conclusions of this paper based on literature research.

2. Related Work

2.1 Eye Tracking Technology of Mobile Decices

Users who have impairments in sports or who are performing specialized tasks like cooking or driving may not be able to utilize the mobile device [7]. As a result, eye tracking has emerged as a possible method of interacting with portable electronic gadgets. Mobile device eye tracking technology has advanced significantly.

Traditional feature-based eye tracking algorithms cannot, however, determine the precise quantitative mapping between feature vectors and eye movement data or maintain high accuracy and stability on mobile devices due to the limits of mobile devices and numerous external circumstances.

A novel approach to eye tracking that Shiwei Cheng proposed combines appearance- and feature-based techniques and shows impressive effectiveness and viability [8].

2.2 Gaze Tracking Technology of Fixed Head

A person's current line of sight or glance is determined by their gaze. The meeting point of the line of sight and the surface of the object being observed is referred to as a fixed point. Staring can be utilized to realize adjustability and dynamic focus depth as well as to clarify the user's non-command interaction purpose. There are a variety of advantages to incorporating eye movements into human-computer interaction. For instance, by seeing the user's gaze, the computer may be able to better understand the user's request and maybe ascertain the user's mental condition, such as perplexity or exhaustion. So, for HCI and intelligent graphics, gaze tracking is crucial. Two issues matter a person's gaze: facial expression and eye direction.

Emotion recognition is an important part of efficient HCI, which plays a vital role in interactive communication and enables people to express themselves beyond the language field. By using SVD and HMM for eye tracking and emotion recognition, it could classify six different emotions, the correlation coefficient is small, and the accuracy is 77%. Recent research shows that the understanding and recognition of emotional expression play an important role in this work. However, the problem is that the camera is not calibrated, and head movement is not allowed [3].

2.3 Gaze Tracking Technology of Natural Head

Zhiwei Zhu et al. [9] proposed a new gaze tracking method which can make the head move naturally without calibration compared with the traditional gaze tracking methods. This method has a lower spatial gaze resolution and with the advantages of undisturbed and unobtrusive. At the same time, it can produce relatively stable and accurate line of sight tracking.

2.4 Eye Tracking Technology Integrated with EEG

A key goal of HCI intelligence [2] is to improve users' intention perception from HCI systems. At present, EEG or eye movement signals are primarily used in standard HCI intention recognition approaches. The benefits of these two physiological signals will be maximized through the combination of EEG and eye movements. Gather EEG and eye movement signals for feature extraction, feed them into a machine learning pattern recognition network for intention recognition, then use decision level fusion to get the final recognition result.

Many academics have been attempting to combine various physiological data in recent years to increase the accuracy of HCI detection. In order to discern intentions, Park U et al. [10] combined EEG and eye movement signals. They ultimately discovered that the combined signals' accuracy was

roughly 5% higher than that of a single physiological signal. Eye movement, EEG, and gesture data were merged by Postelnicu C et al. [11] to control a 6-DOF manipulator. The SUS score was greater than the national average, according to the data. In their summary of the techniques for detecting driver weariness in cars, Chowdhury et al. [12] discovered that numerous physiological signals were far more accurate than a single physiological signal for detecting driver fatigue. Mindui Zhao et al. [2] proposed a HCI intention recognition method based on EEG and eye movement fusion and decision level fusion, which can recognize users' intentions while they interact with each other.

3. Discussion

3.1 Development Trends

Because of the need for high efficiency and more natural interaction between human and computer, eye tracking technology is a feasible HCI method. With the increasing influence of HCI in applications [3], the application of eye movement tracking technology in HCI has gradually become complex and diversified. In general, the application of eye tracking technology mainly presents the following development trends.

3.1.1 Allow the Head to Move Naturally

Although the fixed head can achieve higher accuracy, it is of low significance in practical application, because it is unrealistic to require users to control the computer through their eyes without any movement, and users may need to use this interaction mode in mobile devices in the future. Therefore, there is a demand for high-precision eye movement tracking and gaze tracking technology. Zhiwei Zhu [9] and Shiwei Cheng [8] have conducted further research in this direction.

3.1.2 Integration with Other Technologies

Although eye tracking technology has gradually matured, it is only a single signal. If eye movement tracking technology can be integrated with one or more technologies to maximize the advantages of multiple physiological signals [2], the accuracy of human-computer interaction can be improved. Park U et al. [10], Postelnicu C et al. [11], Chowdhury et al. [12], and Mindui Zhao [2] all obtained through experiments that the recognition accuracy of multiple physiological signals is higher than that of a single physiological signal. Therefore, the integration of eye tracking and other technologies to complete HCI shows an application prospect. This paper focuses on the integration with EEG.

3.2 Problems

3.2.1 Complex Enviroments

If want to achieve high accuracy, there still need some conditions, such as lighting conditions and head fixation. Future work needs to simplify the calibration process and extract more feature points, so that users can still complete HCI through their eyes even in complex environments.

3.2.2 Portability

Because of the demand for high-resolution cameras, eye tracking technology usually requires highly demanding hardware, which is not conducive to the user's demand for portability.

3.2.3 Intergration

Different physiological signals may not be effectively fused, which is not conducive to maximizing the advantages of different physiological signals. Therefore, more and better fusion algorithms are one of the current development trends.

4. Conclusion

Eye tracking is considered as an efficient human-computer interaction method. This paper studies the existing methods and introduces the current situation and development direction of eye movement tracking technology. To make eye movement tracking technology could naturally use, relevant detection technologies have been updated to extract more feature points, or integrate with other technologies, so that the technology can remain reliable in complex situations. Therefore, more research work is needed to enable eye movement tracking technology to be used in a wider range of situations.

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