

Application of eye movement tracking technology in web design

Chenyanzhe Wu

Information technology academy, Beijing Normal University, Zhuhai, 519087, China

Abstract: Eye movement tracking technology is an emerging technology in recent years and has been widely used in many fields. Tracking people’s eyeball movement can help to understand human’s emotion and behavior, reflect human’s subjective intention on things, and provide a basis for the research and development in many fields. This paper mainly reviewed the eyeball movement tracking technology, and made a brief analysis on its worldwide application, in order to lay a foundation for better understanding the research of eyeball movement tracking technology.

Keywords: Eye movement tracking; Movement trajectory; Key technology.

1. Introduction

Eyes are an important source of information for people. They can transfer 80% of external information to the brain and then get more information from the observed information. Due to the directness, uniqueness and variability of human eyes staring at things, the research on eye movement has never stopped. Regarding the early studies of eye movement, some scholars consider they can be traced back to Greek era, but until mediaeval times, people truly used eyeball device to test the movement of eyeball.

The idea of eyeball movement was firstly proposed in 1930, with its initial target at business level. But restricted by the development of computer and other technologies, electrooculogram (EOG) develops very slowly. As the computer image technology advances and the high-quality electron device springs up, many research and development institutions are devoting to eye movement tracking technology of various applications. Based on these, eye movement tracking technology has been improved, developed and then widely used.

By using the eyeball trajectory tracking technology, we can track the trajectories of eyeballs and obtain the eyeball movement parameters such as fixation trajectory, fixation time, fixation frequency, pupil size and so on. Meanwhile, by virtue of visual trajectory and fixation-focused image, it is feasible to get people’s most objective recognition of things and further acquire more accurate ways how people know the relation of things.

2. Principle of eye movement tracking technology

Electrooculogram (EOG) taking eyeball movement tracking technology as the basic principle has been widely used in every aspects of the society. Eyeball movement tracking is a vision-based tracking technology, which integrates eyeballs with camera to acquire the infrared light produced by eyeballs so as to continuously record the changes of eyeball movement and track the target. Eyeball movement tester uses infrared pupil camera to process eyeball images and determine the position of eyeballs. Since 1967, Yarbus had deemed eyeball movement as a comprehensive measurement method. He believed that every theme of the

objects could have an effect on eyeballs, and eyeball movement can reflect human’s ideological activities. The most frequently used eye movement of people are trace convergence, vestibular eye movement, saccade, fixation, look back, etc. Eyes can collect external information by these movements (As shown in figure1).

The acting characteristics of eyeballs are a critical window to understand how the brain processes messages. During reading, people always acquire the necessary message by fixed gaze. During book reading, sometimes when the eyes look at one place, they need to stop for a while letting the message being processed at a higher layer and then shift to other places. This may happen when your brain can’t think. Meanwhile, when the subjects are analyzing the meanings and think that the knowledge included can be used to predict the subsequent content, the saccade phenomenon may happen. When the subjects feel hard to understand the test statement, the saccade length of their eyeballs would be shortening and the gazing time would be lengthened.

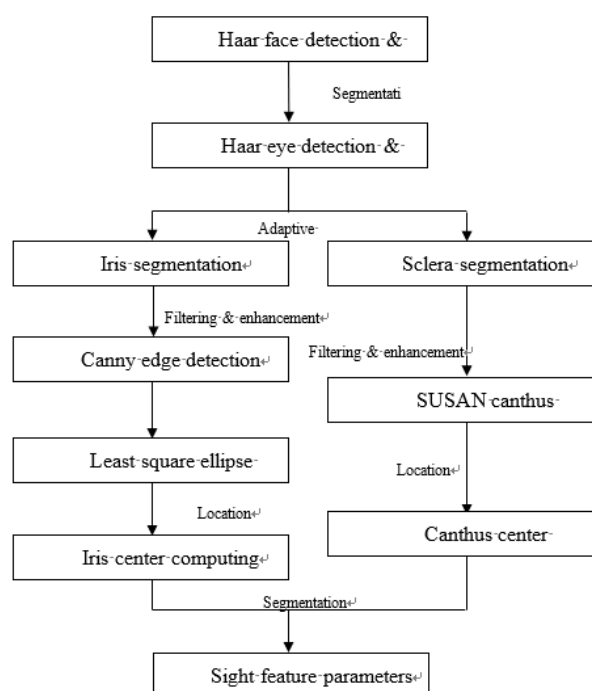


Fig.1 Extraction of sight feature parameters

3. Technical type and characteristics of eye movement tracking system

According to the professional approaches used, eyeball movement tracking system can be divided into mechanical, electromagnetic and optical systems; according to system structure and tracking means used, it can be divided into invasive and noninvasive systems; according to the wearing requirement of device, it can be divided into wearing and non-wearing systems.

In 1898, Delabarre used the convex lens characteristics of eyeballs for the first time, and transferred and measured the moving trajectories of human eyeballs during reading through a connecting rod. This is the first mechanical approach to track eyeball trajectory.

Besides, some scholars track the movement of eyes according to the subcutaneous voltage difference of body surface during internal rotation of eyeballs. This measuring method is called Electrooculogram (EOG). After the 20th century, as light guide and photography techniques developed rapidly, Dodge and Cline firstly adopted corneal reflex and photography techniques to shoot the eyeball movement of the subjects in 1901, enabling this technology to be widely applied and developed.

In 1922, the world's first noninvasive eyeball movement tracking device "Guy Thomas Buswell in Chicago" came out in Chicago, USA. This product utilized eyes to refract the light on a thin film and then made records and determined their location. In the 1970s, with the blooming of eyeball movement tracking technology, it had been developed in reading and psychology fields. In the 1980s, as the eyeball movement tracking technology was universal, it was gradually used to solve the human-machine problems. A scientist from the University of Regensburg in German discovered a computer operated by "sight" in an investigation, which was an approach based on users' eye movement to assist the disabled to read and operate. Furthermore, Kumar et al. from the HCI team of Stanford University conducted an experiment named "EyeScrolling" which based on the control of document navigation and browsing behavior, thus, a specific "reading model" was created which can decide the rate of page viewed and the viewing scope for readers in the process of reading [10].

Therein, the mechanical method and electromagnetic method (invasive method) have been abandoned, because direct contact with eyes may result in injury and disturbance to human bodies. While, using camera to carry out nondestructive image collection on human body and extract eyeball characteristics from images produces little impact on the subjects and is easy to implement, so it is the most frequently used method at present.

4. Application scenarios of eye movement tracking system in web reading

Contributing to the development of virtual reality technology, computer technology and machine-aided design technology, eyeball tracking technology has been widely applied in electronic reading, information retrieval, human factor analysis and other fields. A great number of experimental results indicate that the effect of using eyeball tracking technology for virtual reading is better than finger interaction. In present digital and mobile phone reading,

eyeball tracking technology shows its important application and research value day by day.

4.1. Aided web e-reading

In the 2014 Android developers conference, Eye Tribe company released an only 20x1.9x1.9 cm accessory which can operate laptop by eye movement, making it the world's smallest eye tracking device at present. Though this software, the users could move eyes to control e-books and web browsing and achieve pull-down, flip-over, labeling, searching and other functions. Before this research result was published, the Eye Tribe accessories on Windows was also released in advance, covering all Windows devices including desktops, notebooks and laptops [11]. In the "FAC-TORY 2016 Fall", Tobii Technology displayed an intelligent eyeball movement tracking glasses named "Tobii Pro Glasses 2". Wearing these glasses, when the readers finish the last page, the interface will roll down and rebound back as expected. In addition, Samsung, Apple and Software have installed eye movement tracking in their IOS or Android system [11].

4.2. Web assessment and design

Eyeball movement tracking technology can effectively record users' eyeball movement on the web. By computing, the browsing sequence, attention allocation and readers' interested fields can be obtained. Finally, the map will label the "hot spot region" and point out which part of the page is the most attractive to readers. Owens (2008) and Nielsen (2006) had carried out a series of investigations on the access mode of Web sites, and the results demonstrated that: due to natural habits, the users' gazing center showed an E/F shape, while the hot spot was the upper right part of the web. This investigation put forward some suggestions on the content arrangement of websites, for example, a German company named EyeQuant utilized the above-mentioned principle to promote website design effect within a few minutes.

4.3. V-Learning deep learning

Since 2016, a new craze for computer deep learning had upsurged all over the world. The VR+ education based on eyeball movement tracking technology has attracted more discussion in the investment and education circles. The learning of artificial intelligence era should pay more attention to man-to-man interaction and emotional interaction. Though radio learning, Internet E-learning, MLearning, MOOCs and other courses have become popular, they don't have real situational penetration and should be improved in the interactions between teacher and students, between students and students, and between students and environment, in the teaching method and assessment method. However, V-Learning is a brand-new teaching method combining visual technology with virtual technology [12].

4.4. Reading psychology and reader study

During reading, the characteristics of human eye movement is a group of changes in eye movement and fixation points. Using eye movement tracking to match the eye movement information captured with the progress of reading and understanding at real time can help to make delicate evaluation on psychological activities. The researchers are attempting to conduct cognitive processing learning by virtue of electrophysiology/brain image technology and also discussing how to fuse the two. Taking ERP as an example, when eye movement and ERP

technologies are used to examine the reading comprehension process of Chinese, it is discovered that both of the methods can retain a certain consistency in the initial effect of Chinese reading comprehension. Russia's national commercial college announced in its official website on August 30th 2022 that, Russia and German co-built the first Russian-based eyeball movement database. This system can not only perform language retrieval but also timely check and rectify abnormal language functions. Thereby, using eyeball movement tracking language to retrieve language and literacy has become a new development direction.

5. Conclusion

With the continuous development and improvement of eye movement tracking technology, more studies on this technology have been started in other fields. Using eye movement tracking technology to capture human eyes and track eye movement can master people's reaction and interest in external factors under conscious or unconscious status to a certain extent. This paper mainly introduced the application and analysis of eye movement tracking technology in various fields at home and abroad. However, some relevant studies abroad are much earlier than those in China and have been applied into real operation, and their achievements are ahead of those in China. It is believed that as technological technology advances, eye movement tracking technology will be applied to real life and creates a more scientific and convenient life.

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