

## BENEFITS OF USING EYE TRACKING TECHNOLOGY

Željko Gavrić<sup>1</sup>, Miroslav Minović<sup>1</sup>, Vanja Mišković<sup>2</sup>

<sup>1</sup>Faculty of Organizational Sciences, University of Belgrade, Serbia

<sup>2</sup>Faculty of information technology, Slobomir P University, Republic of Srpska

### Abstract

*The use of eye tracking system is in constant expansion. The field of eye tracking research is interdisciplinary and requires an assistance of experts from various aspects in order to design an efficient system. The eye tracking systems are used in various fields such as safety improvement, helping people with disabilities as well as disease detection, etc. This paper presents a review on technologies used for eye tracking such as electrooculography, infrared oculography, scleral search coil method and video oculography. The paper also includes systems used for various purposes related to real-time eye tracking.*

**Keywords:** Eye tracking system, Help for people with disabilities, Detection of Disease, Detection of Attention.

### INTRODUCTION

Eye tracking system has been steadily expanding in the last years, originally due to the development and availability of technology, but also because of the possibility of their use without influencing the person who performs certain activities and whose eye movements are being tracked.

The first eye tracking systems emerged out of the need to enable human computer interaction for people with disabilities. One of the first systems that allows text to be input without using hands, i.e. using eyes movements only is described in the paper [1].

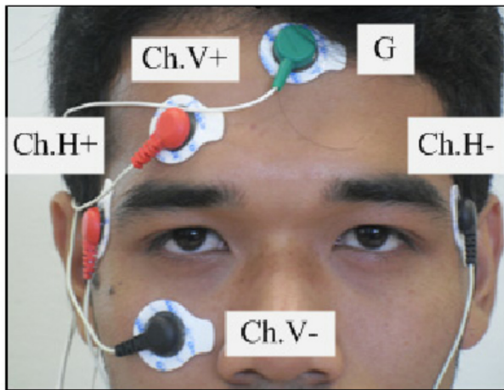
Eye tracking technology can be applied in various fields and for different purposes. One of the applications is the use of eye tracking for safety improvement. Safety improvement is needed in various fields both at work and in everyday activities. Safety improvement is based upon detection of attention. Most of the accidents happen while performing work-related or daily activities and are caused by reduction of attention. There are two approaches to this problem solving. The first approach requires the use of eye tracking system in order to prevent the accident directly. This approach involves real-time algorithm which can decide and turn off the device or a potentially dangerous part of the

device by using certain electronic circuits. These systems require a constant use of eye tracking techniques. Another approach to safety improvement requires the use of eye tracking system for a certain period of time after which the collected data is analyzed and irregularities in the performance of working and daily tasks which can cause accidents are observed.

### EYE TRACKING TECHNOLOGIES

There are a couple of eye tracking technologies that use different approaches. Technologies such as electrooculography, infrared oculography, scleral search coil method and video oculography are describes in this paper [2].

**Electrooculography** represents a simple method which requires a system of electrodes placed on a person's head. Eye movement manifests itself as a difference between the standing corneal retinal potential which varies depending on the eye position. Electrodes detect the difference between potentials, i.e. voltage based upon which is possible to determine the eye movement. The signal induced by electrodes is called the EOG signal. The Figure 1 illustrates the placement of electrodes for EOG recording.



**Fig. 1.** Placement of electrodes on the head [3].

**Infrared oculography** is contactless technology designed to measure the eye movement. The main components needed for the utilization of this technology are infrared transmitter and infrared receiver. The receiver and transmitter need to be fixed usually for the glasses. The eye movement detection is based upon the principal that when transmitter diffuses infrared light reflected from the eye and depending on the amount of the light received in the receiver the eye movement is detected. Figure 2 shows glasses with infrared transmitter and receiver attached.



**Fig. 2.** Glasses for infrared oculography [4].

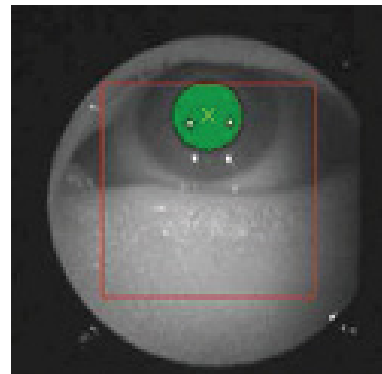
Scleral search coil method is a very precise and invasive technology which requires the placement of the search coil in the eye. The coil is incorporated into the silicone rubber that adheres to the eye and it doesn't damage the eye. The coil is inserted into the eye after local anesthetic has been introduced. A magnetic field is generated with the help of the larger coils placed either side of the head and on the top and in the back of the head as well. There is a change in the magnetic field in the

outer coils due to the movement of the eye, therefore it is possible to detect the direction in the movement. Figure 3 represents scleral search coil method.



**Fig. 3.** Scleral search coil method [5].

Video oculography is the most widely used eye tracking technology. This technology requires a camera that captures the eye and a computer capable of quickly executing algorithms responsible for image analysis. Some systems require the use of a light diode that illuminates the eye to produce a reflection of the light on the eye. A camera that can create a quality and focused image in different lighting and background conditions is required for more precise eye movement. Figure 4 shows an eye illuminated by a light diode.



**Fig. 4.** Eye illuminated by a light diode [6].

Eye tracking methods based upon video oculography can be divided into two basic groups, i.e. the method based upon the appearance and method based upon characteristics. Appearance based methods use the eye shape and calculate the position as the relative relationship between the pupils and the corners of the eyes, while characteristics-based methods use various eye characteristics such as contours, eye corners, reflection caused by infrared light, etc. [7].

## EYE TRACKING IN REAL TIME

The term eye tracking means recording eye movements in relation to the head, and in some respects, it involves gaze tracking. In addition to the eye and gaze tracking, an eye blink is also an important criterion for safety [8].

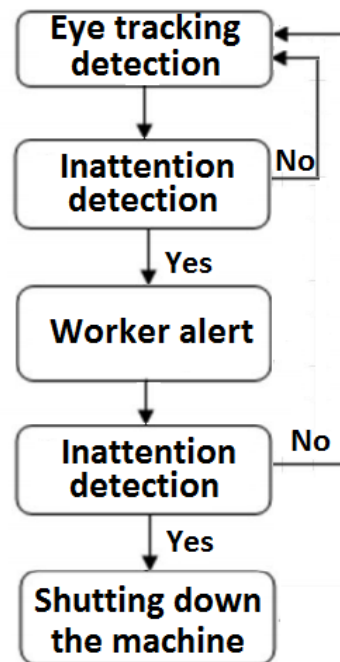
Real-time eye tracking systems are applied to detect the dangers manifested by an unexpected eye movement. Such systems can be used in cars and workplaces, but also when performing different everyday activities. Industry is the most common sector where the eye tracking application is required. According to [9], 5147 workers died at work in the USA during 2017. Human error is responsible for about 80% of these accidents. Apart from the mortal outcome, a significant number of workers experiences an accident at work every day. A certain percent of these accidents could be prevented by using a real-time eye tracking system.

### Eye tracking in industry

The largest number of workers in the world is employed in industrial and manufacturing sector. Industrial workplaces mainly require workers to use dangerous machines which in a fraction of a second may kill or hurt the workers due to negligence. The main cause of accidents at work is lack of attention due to various factors such as fatigue, drowsiness and so on.

Eye movement systems can monitor the workers' eye movement at the workplace and detect occurrences that may cause adverse effects. These systems can detect the distraction of workers gaze during the operation where they need the gaze to be directed at the work, and to effectively warn the workers or prevent the execution of potentially dangerous operation. Eye movement systems can detect an eye blink as well. If a worker blinks more than expected during the observed period or the blink lasts longer than the expected, the system should warn the worker in the right way to focus on his work. The warning can include light, sound or vibration and, in certain cases, it is possible to automatically switch off the machine. Figure 5 illustrates a proposal for a global

negligence detection model in the industrial workplace.



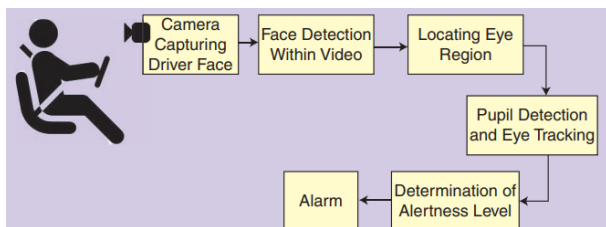
*Fig. 5. The proposal for a global safety improvement model in industry by using a real-time eye tracking system*

### Eye tracking system in a car

The automotive industry is investing large sums of money in order to increase security. Since the appearance of the first cars, much has been improved in order to increase security for drivers and passengers. Mainly, there used to be devices that reduce damage from car accidents, such as various types of airbags, self-adhesive seat belts, reinforcement of the most often damaged car parts.

Nowadays, it is striven to increase security through application of various technologies to avoid traffic accidents. The biggest reason for traffic accidents is the human error. A large part of these accidents happens because of careless driving, i.e. low attention levels during driving. Eye tracking systems can be applied for the purpose of monitoring the driver's attention while driving [10]. These systems have the task to detect drowsiness and other kind of distractions and warn the driver of the detected irregularities. This paper describes one such system.

Figure 6 represents a schematic for tracking the driver's attention.



**Fig. 6.** A schematic for tracking driver's attention[7]

## Assistive technology for people with disabilities

The human side of eye tracking application is the assistive technology for people with disabilities. There are numerous examples of people who couldn't communicate with the surrounding environment until the appearance of assistive technology especially intended for people with disabilities.

These systems are designed for people suffering from autism, cerebral palsy, muscular dystrophy and similar disabilities. For those people, the eye tracking systems represent the link with the surrounding environment. The link is represented through the computer interaction regardless of whether they are browsing the Internet, use social networks or communicate with the environment using specialized software that allows users to select an option only by using their gaze as well as to select the mouse click option.

Additionally, there are also systems which can pronounce a desired activity chosen by directing the gaze at it. One of the frequently used systems for this purpose is Tobii Communicator. Tobii Communicator was developed by the Tobii company, and in addition to the hardware device that is in the form of a tablet, it also comes with specialized software.

Tobii works by using forward and rearward-facing infrared cameras that are mounted on a screen. The cameras pick up the activity of the cornea, which allows a user to stare at a phrase or a symbol and "activate" it much like a mouse click would activate a computer screen. The user can then spell words, string together phrases, and express ideas that allow them to take part in conversations, build relationships, participate in educational and recreational activities and

take part in aspects of life that other people enjoy. [11]

Tobii Communicator is shown in Figure 7.



**Fig. 7.** Tobii Communicator [12].

## Help in diagnosing diseases and disorders

The application of eye tracking systems is used in early detection of children's autism. This paper [13] shows such a system designed to show specific videos, and the eye tracking system records and analyzes the visual characteristic of eyes during the video playback. Thanks to the appropriate algorithm, the system is capable to detect characteristic eye movements indicating autism.

Apart from autism, eye tracking systems are also used in diagnosing obsessive-compulsive disorder, Parkinson's and Alzheimer's disease [14].

Eye tracking systems are frequently used in psychological research, mostly among children, where the collected data can help in detecting the retention and attention level. These tests are performed by requesting the reading of the text while eyes movements are being monitored, i.e. for how long the gaze is directed at the observed subject and which way the eye is moving through the text. [15]

## CONCLUSION

The use of eye tracking system is in constant expansion lately. These systems can be used in different fields and they contribute to improving the quality of life, comfort and safety.

The first part of this paper shows technologies used for eye tracking. Furthermore, the paper describes the application of eye tracking systems. The paper also describes a certain field of their application, such as assistive technology for disabled people, where these systems are particularly valuable in increasing the quality of life for children who have a certain level of disability.

It is expected that a technological advancement can result in better accuracy and lower prices of eye tracking systems. In that case, they could be applied to the previously inapplicable fields, thus becoming available to those people who needed it the most- people with disabilities. Unfortunately, because of the high price, these systems are still unavailable to most of the people which need them the most.

## ACKNOWLEDGMENT

This article was supported by the Ministry of Education, Science and Technological Development of Serbia under the project TR-32013.

## REFERENCES

- [1] Hutchinson T. E., White K. P., Martin W. N., Reichert K. C., Frey L. A., Human-computer interaction using eye-gaze input, IEEE Transactions on systems, man, and cybernetics, 19(6), 1527-1534, 1989.
- [2] Gavrić Ž., Minović M., Tehnologije praćenja pokreta oka, SYM-OP-IS 2017, 25-28 septembar 2017, Zlatibor.
- [3] Aungsakun S., Phinyomark A., Phukpattaranont P., Limsakul C., Robust eye movement recognition using EOG signal for human-computer interface, In International Conference on Software Engineering and Computer Systems, Springer-Berlin, pp. 714-723, 2011, Heidelberg.
- [4] Objective assessment of drowsiness and reaction time during intermittent Ramadan fasting in young men: A case-crossover study - Scientific Figure on ResearchGate. Available: [https://www.researchgate.net/figure/Optalert-glasses-with-infrared-oculography-in-the-arm-attached-to-the-frame-The\\_fig2\\_255788553](https://www.researchgate.net/figure/Optalert-glasses-with-infrared-oculography-in-the-arm-attached-to-the-frame-The_fig2_255788553) [Accessed on: 28.09.2019]
- [5] Chronos Vision, Scleral Search Coils 2D/3D, available at: [http://www.chronos-vision.de/downloads/CV\\_Product\\_SSC.pdf](http://www.chronos-vision.de/downloads/CV_Product_SSC.pdf) (Accessed on: 28.09.2019)
- [6] Hammoud R. I. (Ed), Passive eye monitoring: Algorithms, applications and experiments, Springer Science & Business Media, 2008.
- [7] Bazrafkan S., Kar A., Costache C., Eye Gaze for Consumer Electronics: Controlling and commanding intelligent systems, IEEE Consumer Electronics Magazine, 4(4), 65-71, 2015.
- [8] Polatsek P., Eye Blink Detection, Slovak University of Technology in Bratislava, Faculty of Informatics and Information Technologies. IIT. SRC, 18, 2013.
- [9] Bureau of Labor Statistics, U.S. Department of Labor, The Economics Daily, Fatal occupational injuries to foreign-born workers on the Internet at <https://www.bls.gov/opub/ted/2018/fatal-occupational-injuries-to-foreign-born-workers.htm> (Accessed on: 28.09.2019)
- [10] Tayibnapi I. R., Koo D. Y., Choi M. K., Kwon S., A novel driver fatigue monitoring using optical imaging of face on safe driving system. In Control, Electronics, Renewable Energy and Communications (ICCEREC), International Conference on (pp. 115-120), IEEE, 2016.
- [11] Jo J., Lee S. J., Kim J., Jung H. G., Park K. R., Vision-based method for detecting driver drowsiness and distraction in driver monitoring system, Optical Engineering, 50(12), 127202, 2011.
- [12] Tobii, Eye Tracking Communication for Individuals that are Non-Verbal, available at: <https://www.cerebralpalsy.org/inspiration/technology/eye-tracking> (Accessed on: 25.10.2019)
- [13] Tobii, Speech generating device with the world's #1 eye tracker, available at: <https://www.tobiidynavox.com/devices/eye-gaze-devices/I-12/> (Accessed on: 05.10.2019)
- [14] Vargas-Cuentas I., Hidalgo D., Roman-Gonzalez A., Power M., Gilman R. H., Zimic M., Diagnosis of autism using an eye tracking system, IEEE Global Humanitarian Technology Conference (GHTC), Seattle, WA, pp. 624-627, 2016.
- [15] IMotions, Top 8 Eye Tracking Applications in Research, available at: <https://imotions.com/blog/top-8-applications-eye-tracking-research/> (Accessed on: 05.10.2019)
- [16] Inoue A., Paracha S., Identifying reading disorders via eye-tracking technology, In Advanced Materials for Science and Engineering (ICAMSE), International Conference, IEEE, (pp. 607-610), 2016.