USING EYE TRACKING TECHNOLOGY IN PRODUCT DESIGN EVALUATION

Gojko VLADIĆ 1, Nemanja KAŠIKOVIĆ 1, Magdolna PAL 1, Ivan PINČJER 1, Mladen STANČIĆ 2, Ivana TOMIĆ 1
1 University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia
2 University of Banja Luka, Faculty of Technology, Banja Luka, Bosnia and Herzegovina

Received (04.05.2018); Revised (04.06.2018); Accepted (06.06.2018)

Abstract: A Visual sense occupy a 30 to 40 percent of the human cerebral cortex, and more than 70% of information is collected by vision, leaving less than 30 % for other senses. Having this in mind it is obvious that vision is the most important sensor and special attention must be attributed do research of its role in product design evaluation process. Eye tracking technology gives opportunity for recording the gaze positions and eye movements, thus giving the information about what the person is looking at. Pairing of eye tracking data with survey data can give valuable information to the designers. This paper offers short overview of the eye tracking technology and possibilities of its use in the design process.

Key words: eye tracking technology, product design evaluation.

1. INTRODUCTION

Human interaction with the environment is defined by the quantity of the information they get from that environment as an input. Products that surround us are considered our environment. Holistic approach to the product design takes in to consideration engagement of all user senses. But not all human senses are equal. Considering dominance of the vision it must be taken in to consideration when determining design priorities. It is well established fact that interpretation of visual information acquired by the human eyes occupy a 30 to 40 percent of the cerebral cortex. More important is the fact that more than 70% of all information is collected by vision, leaving less than 30 % for other senses shown in Figure 1 [1].

Evaluation of the design in the early stage of the product development is one of the most efficient ways to shorten product development time, reduce cost and orient the resources on the worthy ideas. Having this in mind, importance of objective design judgment is imperative. While very important, dealing with extraction of objective data about human perception of the product design is a great problem. There are numerous techniques for gathering data about product visual perception and almost all of them are dealing with subjective judgment gathered through surveys. Eye tracking technology is one of rear objective ways to judge design performance regarding visual characteristics of the product. Compared to EEG and other brain imaging technologies, which are also able to objectively measure response to visual stimuli, eye tracking is inexpensive and widely affordable.

2. EYE TRACKING TECHNOLOGY

Eye tracking is a research methodology that can provide insight in to visual attention of individual. In other words eye tracking gives the information about where the user is looking at any point in time, how long they look at that point, and the path their gaze taking from one point to the next one. Thus, providing valuable information about what the user was drawn to and how the user perceived and interpreted whatever was the subject of the research. Eye tracking technology has been applied to numerous fields including human factors, cognitive psychology, marketing, user experience research, and the broad field of human–computer interaction [2]. Not only does eye-tracking assist in research, but it also can be used a computer input device, making it possible for disabled people to communicate with the computes through on-screen keyboards [3]. Lately the examples of this technology can be also seen in control of cell phones with eyes, by using front-facing cameras on the phones to track the movement of the user’s eyes [4].

Fig.1. Hierarchy of human senses

It is obvious that vision is the most important human sensor. Special attention must be attributed to research of its role in product design evaluation process.

*Correspondence Author’s Address: University of Novi Sad, Faculty of Technical Sciences, Department of Graphic Engineering and Design, Trg Dostieja Obradovica 6, 21000 Novi Sad, Serbia, vladicg@uns.ac.rs
2.1. Eye Tracking Equipment

Eye tracking is not novel idea, it has been used since 19th century in research of reading habits. Firstly just by observation, best known research of physiological optics by Louis Émile Javal. By the beginning of 20th century first eye tracking devices were constructed. These devices were quite intrusive, and required participants to wear lenses that had a small opening with a pointer attached to it. Which allowed researcher to observe where the participant was looking while reading. Advancements in usability and improvement comfort arrived when camera was introduced in the eye movement research. Non-intrusive eye-tracking device that recorded motions of eyes on film allowing detailed study of eye motion but still participants head was fixed to the device. During 1980’s eye tracking begun to be used in marketing research, mainly concentrated on printed ads in magazines. In 1990’s expansion of World Wide Web required research in differences of print and screen design. Since 2000 till present day eye tracking technology showed its usefulness in many different fields both scientific and non-scientific.

Different techniques can provide precise eye tracking. In general, there are two types of eye movement monitoring techniques: those that measure the position of the eye relative to the head, and those that measure the orientation of the eye in space, or the “point of regard” [5]. The latter measurement is typically used when the concern is the identification of elements in a visual scene, such as design judgment.

There are four broad categories of eye movement measurement methodologies involving the use or measurement of: Electro-OculoGraphy (EOG), scleral contact lens/search coil, Video-OculoGraphy (VOG), and video-based combined pupil and corneal reflection.

Electrooculography (EOG/E.O.G.), shown in figure 3, is a technique for measuring the corneo-retinal standing potential that exists between the front and the back of the human eye.

To measure eye movement, pairs of electrodes are typically placed either above and below the eye or to the left and right of the eye. If the eye moves from centre position toward one of the two electrodes, this electrode "sees" the positive side of the retina and the opposite electrode "sees" the negative side of the retina. Consequently, a potential difference occurs between the electrodes. Assuming that the resting potential is constant, the recorded potential is a measure of the eye's position.

Scleral contact lens/search coil is technique, shown in figure 4, uses magnet wire sandwiched between two soft contact lenses as a magnetic search coil to measure horizontal and vertical eye movements in humans. This technique is quite uncomfortable for the participants and requires highly trained personnel for placing the lens and conducting the experiment, as shown in figure 5.

Video-OculoGraphy (VOG), shown in figure 6, is a non-invasive, video-based method of measuring horizontal, vertical and torsional position components of the movements of both eyes (eye tracking) using a head-mounted mask that is equipped with small cameras.
All of these techniques are not suitable for design research as they measure movement of the eye in relation to the head and they often do not provide point of regard measurement. To provide this measurement, either the head must be fixed so that the eye’s position relative to the head and point of regard coincide. Also discomfort of the electrodes glued to the head, wearing lenses or a mask can influence behaviour of the user.

When the concern is the identification of elements in a visual scene, and intrusiveness must be minimal in order to reduce influence on the user video-based combined pupil and corneal reflection technique offers the most potential. Video-based combined pupil and corneal reflection technique measures multiple ocular features in order to disambiguate head movement from eye rotation. Two such features are the corneal reflection (of a light source, usually infra-red) and the pupil centre. The positional difference between the pupil centre and corneal reflection changes with pure eye rotation, but remains relatively constant with minor head movements. Video-based trackers utilize relatively inexpensive cameras and image processing hardware to compute the point of regard in real-time. The apparatus may be table mounted, or worn on the head. These devices, which are becoming increasingly available, are most suitable for use in interactive systems [6]. Software, that is usually device specific, calculates the eye gaze from the features in a process called gaze estimation.

Today in its infancy is technology of using regular cameras for recording eye gaze. One of which is EyeSee which developed web cam based platform for tracking and recording respondents’ eye gaze for online eye tracking and facial coding of responses to printed ad, TV commercial, website, etc. EyeSee’s studies are cost-effective (2-3 times more than the conventional studies), provide fast results and can be conducted all over the world [7].

There are four functions that are key to most eye tracking devices [6]:

- Connection establishes a link with the eye tracker device, then calibration determines where the user’s eyes are located and synchs the computer’s display with eye movement by displaying calibration points;
- Calibration would may be done by a dot moving around the screen and the user's eye following it to let the device know how the specific eye moves;
- Synchronization informs the application of the eye tracker device’s state, which is necessary for the final function, data streaming;
Data streaming allows the recording of the user data which provides real-time information about the fixations and saccades.

Fig. 7. Examples of video-based combined pupil and corneal reflection device a) desktop device, b) mobile device

2.2. Choosing Right Eye Tracking Technique

Most important factor when choosing adequate equipment is sample frequency of the device, or the number of images of the eye taken in one second. Minimal frequency for design judgment applications is 60 Hz. When judging design eye fixations are longer and there is no constant eye movement such as in case of reading. Devices with higher frequencies are usually used for reading and in specific psychology and psycho-physics experiments. In design evaluation it is very important to reduce the influence on the participant. This influence is usually greater in the artificial conditions, thus when choosing equipment it must be taken into consideration. Intrusive equipment can produce uncomfortable and unnatural experimental conditions, but at the same time it offers some advantages that can influence the decision regarding the equipment to be used. Intrusive technologies are usually more precise, more expensive, difficult to setup, offer possibility of mobile applications (wearable equipment), obstructive to users, usually used in psychology and medicine science. Non-intrusive technologies are usually less expensive, easy to setup, non-obstructive to subjects and used for marketing and design research. The structure and characteristics of participants in the experiments must be taken into consideration also. For example research done with children or people with disabilities can limit the choice of equipment. Example of eye tracking research done with children is shown in figure 8.

Fig. 8. Example of eye tracking research done with children

Fig. 9. GazePoint GP3 eye tracking device

DISCUSSION ON EYE TRACKING TECHNOLOGY APPLICABILITY IN PRODUCT DESIGN EVALUATION

In this section applicability of eye tracking technology in product design evaluation will be discussed based on experiment conducted at the Department of Graphic Engineering and Design, Faculty of Technical Sciences as an example. Having in mind importance of packaging design in the marketing strategies, and costs involved with development of successful packaging importance of the consumer reaction research is obvious.

Eye tracking offers unique insight in the process of packaging judgment. This kind of research does not require capture of fast eye movement, like reading related research does. Equipment can have smaller sample rates as the longer eye fixations are expected and information about saccades is not useful for reaching conclusions. Samples of different packaging were prepared and photographed appropriately for the display on the screen as the experiment stimuli, shown in figure 11. The experiment was done using GazePoint GP3, 60 Hz eye tracking device based on video-based combined pupil and corneal reflection technique, shown in figure 9.

Stimuli was presented on 24” computer monitor, each of 20 participants went through device calibration process before the experiment. The aim of his experiment was to
determine influence of packaging shape on a price presumption, based on images of the packaging. Other part of the experiment aimed to determine interest points on the packaging based on which participants made the judgment about the price. Experiment was done using custom interactive application showing images of the packaging in random order accompanied with scale on which value was graded, all the while eye movement of the participant was recorded. After the experiment analysis was conducted to determine relation between assigned value and time spent observing the image of the packaging and the specific part of the packaging. Results of the experiments can be presented in two ways: graphically and numerically. Numerical data provides information about time and the gaze coordinates suitable for further statistical analysis. Figure 11. is showing visualization of eye tracking results which is usual outputted alongside time and gaze position numerical table [8].

Goals of the eye tracking part of experiment were partly achieved. The results concerning attention retaining time proven to be correlated with price evaluation as the packaging that was judged as most expensive retained the attention longest probably due to its novelty and complexity which were reports as the reasons for the higher price assigned. Expected results regarding specific details of the design that attracted participants attention were not obtained successfully. Size of the packaging images was adjusted to present them in real life size which could have presented a problem and one larger point of interest was observed for each of the packages. The interesting thing is that it was not always centre point, as it can be seen in figure 8. It might be advisable to present each packaging individually in full screen mode, disregarding real life size, in order to make distinction between different parts of the packaging.

Having in mind 60 Hz frequency of the device used eye movement trajectories (saccades) were also hard to track on the relatively small images. This could also be solved by displaying bigger images, thus increasing eye movement and overcoming the limitations of lower frequency equipment.

3. CONCLUSIONS

Importance of objective insight in to visual product design evaluation is evident, but still not enough attention is given to development of research equipment and methodologies in this area. Eye tracking technology offers some opportunities for affordable, objective examination of this problem. Overview of the available technologies guide us to the conclusion that only the video-based combined pupil and corneal reflection technique offers capabilities for application in the design evaluation area. Although limitations of desk top equipment is obvious when dealing with evaluation of real objects it is still only non-obstructive technique. On the other hand mobile (wearable) eye trackers offer participants interaction with real objects while recording their gaze, but obstructive nature of eye tracking glasses is constant reminder that they are part of the experiment, which could influence the outcome.

There are great expectations from the future technology development improvement of image analysis algorithms, which could improve accuracy and lower the cost of the equipment by introduction of regular cameras in the process of eye tracking. Practical example showed limited applicability of the technology and emphasised need for preliminary study in order to optimise stimuli and experimental conditions in order to overcome limitations of lower class equipment. Significant improvement could be achieved with optimization of the images used as stimuli, mainly with increasing space between areas of interest on the image. This would make the results more obvious and fixation points better differentiated for each area of interest.
ACKNOWLEDGMENTS

The research is supported by the Ministry of Education, Science and Technology Development of the Republic of Serbia, project number: 35027 “Development of software model for scientific and production improvement in graphic industry”.

REFERENCES


