VOL. 11, NO. 12, JUNE 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences


www.arpnjournals.com

DEVELOPMENT OF EYE TRACKING COMPUTERIZED TECHNIQUES FOR POST DATA ANALYSIS

W Mimi Diyana W Zaki[1], Mizhanim Mohamad Shahimin[2], Fadhilah Ismail[1] and Sayuthi Shokri[1]
[1]Departmental of Electric, Electronic & Systems Engineering, Faculty of Engineering & Built Environment, Universiti Kebangsaan Malaysia, UKM Bangi, Selangor, Malaysia
[2]Optometry and Vision Sciences Program, Faculty of Health Sciences, Universiti Kebangsaan Malaysia, Kuala Lumpur, Malaysia
E-Mail: wmdiyana@ukm.edu.my

ABSTRACT

Eye detection device or eye tracker is an instrument used to objectively observe the eye movement. The integration of this technology with the growing use of computers needs an automated data analysis. Most of the commercial eye tracker systems produce eye movement data in the form of graphic illustrations. The recorded raw data cannot be further analysed due to constraints in an existing eye tracking system, in which the data needs to be extracted manually and separately analysed. Thus, the development of a GUI as a platform and automated data processing techniques can help to expedite the post data processing and analysis, later may reduce the gaps in research using the eye tracker. This work aims to overcome the problem in processing and analysing the raw data that being collected from the eye tracking system known as the Tobii TX300**.**

Keywords: data analysis, tobii TX 300, graphic user interface, fixation and saccade.

INTRODUCTION

Information where a person is looking at that is based on the sequence of the eyes that shifting from one location to another at a given time can be captured by an eye tracker. Eye tracking is a technique of measuring the eye movements of an individual [1]. Using eye-tracking techniques, the linguistic researchers can study and investigate the human language development, language skills and reading behaviour. Eye movement can be associated with visual attention and cognitive, in which the information gained are useful in the development study of infant and children's' psychomotor skills [2].

The eye movements are fundamental to the development of the research in various fields such as science or literature, especially in the field of psychology, neurology, ophthalmology, linguistic as well as research marketing and arts. In addition, the eye movements can be a mechanism to promote the interaction between the inputs of the system as well as to understand the body language and lip reading. The movements can be acquired and used as a control signal by an individual to interact directly with the interfaces without using a mouse or any keyboard inputs. This can be a major advantage for disable users [1].

Various techniques had been used to track the eye movements using the eye tracking technology for reading research over hundreds years ago. For example, a technique using electro-oculographs evaluated the potential differences between electrodes mounted on the skin around the eyes to detect the eye movements [3]. The scleral search coil technique is another method in measuring eye movements. Duchowski detected an eye motion by measuring the fluctuations in an electromagnetic field when a metal coil was moved along the movement of the eyes. During the experimental work, a person had to wear big contact lenses that covered the cornea (clear membrane that cover the front eye) and sclera (white eye that can be seen from outside) with a metal coil embedded around the edge of lens [4].

Previous methods are quite invasive. However, most of modern eye-tracking systems use video images of the eye to determine the exact location where an individual is looking at (known as "point of regard"). There are many ocular distinguishing features that can be used to consider a point of regard, such as corneal reflections (known as Purkinje images), iris-sclera boundary, and apparent pupil shape [5]. In addition, this area of research is also conducted using direct or indirect observation. The observation technique is used to understand the reading patterns as a series of a short stop (fixation) and rapid changes (saccade).

Fixation is defined as a retaining of a visual focus at a specific location or word [6]. The eye fixation point is closely related to the ability of a person to visually code a space with information [7]. It also occurs within a short time due to the vision that will be extracted from the printed pages [8, 9]. Saccades are ballistic eye movements synchronising both eyes between two points of fixation in the same eye directions. Zhai *et al*. define saccade as the fast eye movements to obtain an image target and centre it on the fovea [10]. Nevertheless, some respondent may not be able to fixate when reading all words in a sentence. Respondents who are dyslexic may have longer fixation period than normal subjects. Thus, it can be concluded that the dyslexic respondents have problems in extracting information [8, 11, 12].

Eye detection device is a current technology used to objectively observe the eye movements. Integration of this technology with the usage of advanced computer system allows the eye motion to be collected and analysed in real-time. Most of the commercial devices display the motion data in the form of graphic illustrations. The recorded output data cannot be further analysed due to the constraints of the existing eye tracking system. Hence, the

development of an automated software system to analyse data of the eye movement can help to expedite the data processing, generate the graphical data analysis and lessen the gaps of conducting a research using the eye detection device.

METHODOLOGY

Tobii TX300 system is an eye tracking device used in this project. This system is user-friendly and emphasizes on the freedom of movement in which an individual eye tracking will not interfere with the carefully researched natural behaviour. The embedded algorithm allows large head movement during the eye tracking recording while simultaneously maintaining the accuracy and precision at a sampling frequency of 300Hz [13].

By determining the relationship between the pupil and corneal reflection, a camera-based eye tracker device can calculate the gaze together with head direction. If an individual is out of the monitor box, i.e. within the eye sensor, and then back into it, the eye tracking will be resumed tracking almost immediately. Eye tracking studies with accurate and appropriate length can be done without the individual experiencing any fatigue. This means that the eye movement parameters such as saccade and fixation can be studied even without using any chinrest.

In this research, the development of the graphical user interface (GUI) generally involves four main stages. The first stage is to collect the raw data from the Tobii TX300. Then, the raw data are filtered to identify the eye parameters as fixation or saccade. The unwanted data or noise data known as 'unclassified' are cleaned from the raw data occurred when an individual might be blinking or looking at other direction (not at the monitor box). Thirdly, using the extracted eye parameters (fixation and saccade), the clean data can be plotted. Lastly, the new cleaned data can be generated. The working principle of this device is shown in Figure-1 and Figure-2 describes how the gaze data is collected from the Tobii TX300.

Fourteen respondents (3 normals, 11 dyslexic) have been examined to get their reading patterns and the data collected from Tobii eye tracker system are analysed. Each respondent starts the experiment with the standard 9-point calibration process to ensure the eye movement made is accurately tracked. Next, the respondent would have to read a set of text with normal spacing (text default) and an expended-spacing text. Figure-3 shows the example of the words and sentences need to be read by each respondent. The Tobii TX300 system only allows visualisation of the data with limited quantitative outputs. For further analysis, the raw data (.tsv file) need to be extracted and manually plotted, resulting in thousands of data for each respondent.

The raw data would then be processed using the Matlab program developed for this application.

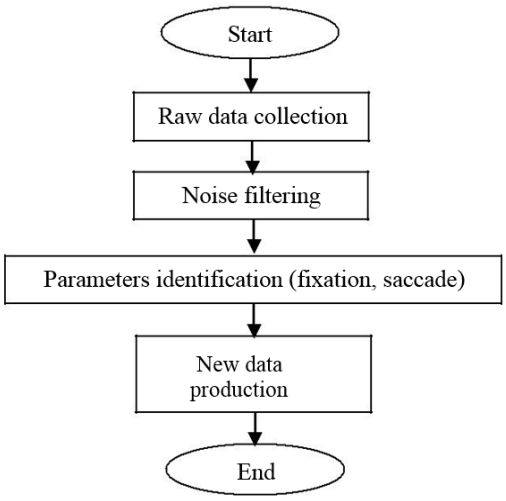

Figure-1. Step-by-step automated techniques for post data analysis.

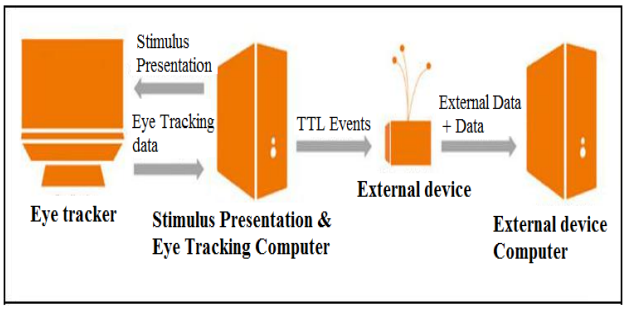

Figure-2. Eye tracker gaze sample processing in which the gaze data is processed externally from the eye tracker.

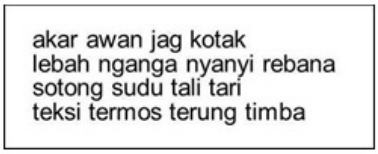

Figure-3. Example of text used.

RESULTS AND DISCUSSIONS

The fixation period is collected from the Tobii TX300 while the saccade amplitude is calculated using the equation (1) [14].

$$y = \sqrt{(a1 - a2)^2 + (b2 - b1)^2} \quad (1)$$

The saccade amplitude is calculated in pixel; a1 is the fixation of the first X; a2 is the fixation of the second X; b1 is the fixation of the first Y; and b2 is the fixation of the second Y.

Based on the texts read by each respondent, the average frequency (in percentage) of the saccade, fixation and unclassified (noise) can be shown as in Table-1.

Table-1. Tabulation of average frequency (%) of data type.

Type of data	Fixation	Saccade	Noise
Normal	82.739	10.198	7.062
Dyslexic (Text default)	91.348	4.679	3.973
Dyslexic (Text Expanded)	87.709	7.757	4.534

By tabulating the frequency, we can see that the average frequency of fixation for dyslexic patient is higher than the normal patient. In addition, by expanding the sample text, the average frequency can be further reduced and these findings are also supported by previous research [14]. It is shown that by increasing the distance between the characters (in the text as Figure-3), the dyslexic patient can recognize the characters easier, hence, the reading period and reading rate can be shorten and increased, respectively.

Figure-4 is a snapshot of the developed system showing the collected raw data of a respondent that is plotted using the Matlab, whereas, Figure-5 shows its corresponding graph that has been cleaned without the noise. The unclassified can be considered as unwanted data or noise as

a) an individual might be blinking,
b) an individual turns away completely from the system so the eyes are lost,
c) an individual might move the head rapidly that the system has difficulty in finding the individual's eyes,
d) there is something between the eyes and Tobii eye tracker (eye scratching, eye rubbing).

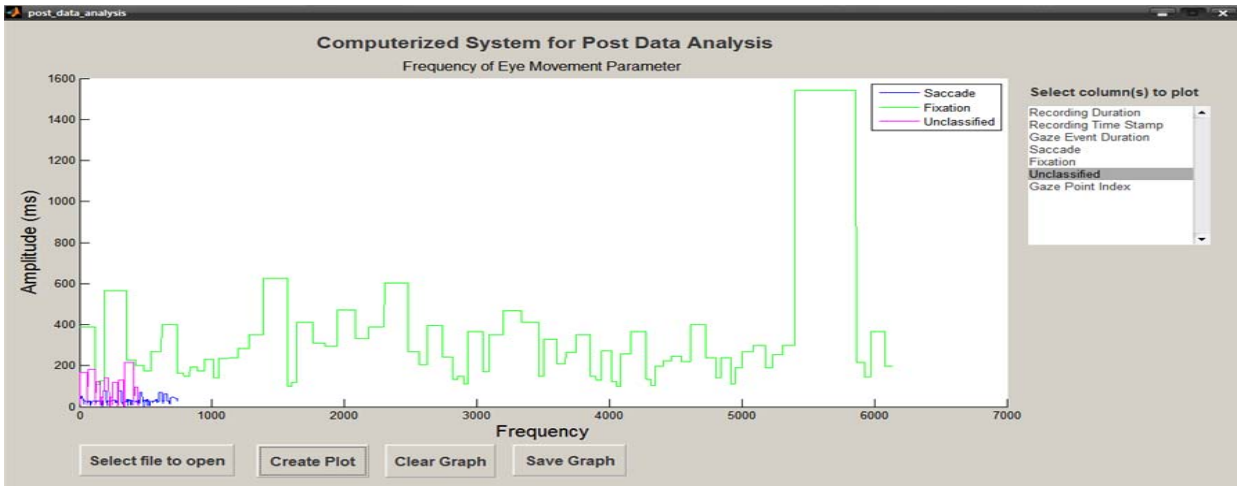

Figure-4. Raw data.

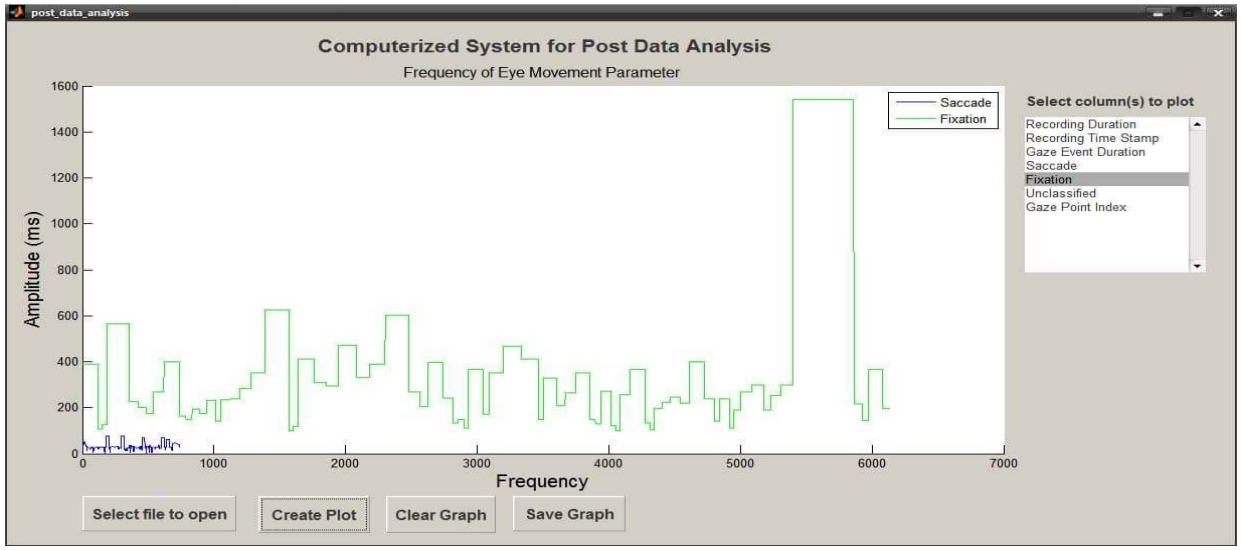

Figure-5. Clean data.

In this work, the spreadsheets collected from the Tobii TX300 system are being analysed using Matlab software. The command used is strcmp which is used to compare strings and it is a case sensitive. The command will select and plot the value of the strings that the user had chosen. After thorough investigation of the collected raw data, the noise filtering has been developed using a built-in Matlab commands. The fixation and saccade also can be plotted using the same command. This is due to the fact that the three types of data have been annotated in the raw files produced by the Tobii system. This finding is contradicted with previous work claimed by ROWA [15] in which the noise filtering algorithm was proposed for Tobii 1750 eye tracker. ROWA stands for Recursive Online Weight Average filter which acts as online filtering which can observe, remove and replace the unwanted data with better approximation and left the balanced signals untouched. For the online filtering, the algorithm used can only access the data that have been recorded while the offline filtering can access the recorded data before and after the data corruption. Thus, the offline filtering has more accurate estimation of the noise.

CONCLUSIONS

In this study, the GUI to analyse the raw data from the Tobii TX300 eye tracker device has been developed. An automated noise filtering of the eye movement data has been proposed and it is important for optimum movement point detection. The developed GUI is a useful platform to identify the eye movement parameters, thus facilitating the raw data management to calculate optimum amplitudes of abnormality detection in human reading patterns. Thus, this project can help the optometrists to simplify their daily routine in managing the raw data and saves a lot of time in constructing graphs to portray significant information from the data collected by the Tobii TX300 eye tracking system.

REFERENCES

[1] Poole A, Ball L. J. 2005. Eye tracking in human-computer interaction and usability research: current status and future prospects, 1st ed. Psychology Department, Lancaster University, UK.

[2] Tobii.com. 2014. Psycholinguistics & reading eye tracking. 2015. [Online]. Available: http://www.tobii.com/en/eye-tracking-research/global/research/linguistics/.

[3] Rayner K, Pollatsek A. 1989. The psychology of reading. Englewood Cliffs, NJ: Prentice Hall.

[4]Duchowski A. T. 2003. Eye tracking methodology: theory and practice. London: Springer-Verlag Ltd.

[5] Shahimin, M. M. and Shahimin M. M. 2013. Eye trackers in an oculary clinical setting. Proceeding SPIE 8923, Micro/Nano Materials, Devices and Systems; doi:10.1117/12.2033518.

[6] Raney G. E., Campbell S. J., Bovee J. C. 2014. Using eye movements to evaluate the cognitive processes involved in text comprehension, Journal of Visualized Experiments. 83(e50780).

[7] Just M. A, Carpenter P. A. 1976. Eye fixations and cognitive processes. Cognitive Psychology. 8, pp. 441-480.

[8] Reichle E. D., Rayner K, Pollatsek, A. 2003. The E-Z reader model of eye movement control in reading: Comparison to other models. Brain and Behavioral Sciences. 26. pp. 445–476.

[9] Vanderschantz, N. 2008. Reviewing the understanding of the effects of spacing on children's eye movements for on-screen reading. Department of Computer Science, University of Waikato, Hamilton, New Zealand.

[10] Zhai X, Ghahari A. Enderle, J.D. 2013. Parameter estimation of auditory saccades and visual saccades. In: Bioengineering Conference: 39th Annual Northeast. pp. 185-186.

[11] De Luca M., Di Pace E., Judica A., Spinelli D. Zoccolotti P. 1999. Eye movement patterns in linguistic a non-linguistic tasks in developmental surface dyslexia. Neuropsychologia. 37, 1407–1420.

[12] Starr M. S, Rayner K. 2001. Eye movements during reading: some current controversies. Trends in Cognitive Sciences. Ed ke-5. 4.

[13] Tobii Technology AB, Tobii TX300 eye tracker product description. 2010.5-6.Tobii Technology AB, Using Eye Tracking to Test Mobile Device. pp. 7-9.

[14] Madhavan I. 2014. Crowding effect on reading performance and eye movement among children with dyslexia in Klang Valley. Thesis dissertation. Fakulti Sains Kesihatan Universiti Kebangsaan Malaysia Kuala Lumpur.

[15] Chartier S, Renaud P. 2008. An online noise filter for eye tracker data recorded in a virtual environment. In Proceedings of the 2008 Symposium on Eye Tracking Research & Applications. pp. 153-156.