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Enhancing Reading Advancement Using Eye Gaze Tracking

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Abstract
This research aims to understand the enhancing reading advancement using eye gaze tracking in regards to pull the increase of time interacting with such devices along. In order to realize that, user should have a good understanding of the reading process and of the eye gaze tracking systems; as well as a good understanding of the issues existing while using eye gaze tracking system for reading process. Some issues are very common, so our proposed implementation algorithm compensate these issues. To obtain the best results possible, two mains algorithm have been implemented: the baseline algorithm and the algorithm to smooth the data. The tracking error rate is calculated based on changing points and missed changing points. In [21], a previous implementation on the same data was done and the final tracking error rate value was of 126%. The tracking error rate value seems to be abnormally high but this value is actually useful as described in [21]. For this system, all the algorithms used give a final tracking error rate value of 114.6%. Three main origins of the accuracy of the eye gaze reading were normal fixation, regression, skip fixation; and accuracies are displayed by the tracking rate value obtained. The three main sources of errors are the calibration drift, the quality of the setup and the physical characteristics of the eyes. For the tests, the graphical interface uses characters with an average height of 24 pixels for the text. By considering that the subject was approximately at 60 centimeters of the tracker. The character on the screen represents an angle of ±0.88◦; which is just above the threshold of ±0.5◦ imposed by the physical characteristics of the eyeball for the advancement of reading using eye gaze tracking.

Keywords: User interface, human computer interaction, detection and tracking, reading, models, intelligent systems

I. INTRODUCTION

Using eye gaze interaction for reading advancement, it would allow to free the hands and by consequence not to overstress the hand muscles. Plus, it would not add some load to the eye muscles because eyes move anyway without any interaction constraint. A simple example shows that when using the mouse to click on a button, the eyes follow the movement of the mouse on the screen in any case. Eye movements are fast and using them to interact would be fast as well. But nowadays most of the interactions with eye gaze, as eye typing systems for instance, is slower than with ordinary inputs (keyboard for example). Combining eye gaze and another modality would allow to speed-up the interaction and reading process.

There has been a point by point survey of works on visualization made over the final few a long time such as [17], [18] and [19] that tended to later improvements in following strategies, comparing distinctive procedures of estimation, setup, application and challenges included utilizing center as input factors. Hansen [18] gives an in-depth survey on diverse eye models, eye discovery methods and eye calibration models, and a rundown of eye utilize. To talk about mistakes within the follow of the highlights from the models of the eye show, jitter and redistribution due to the client wearing glasses. In any case, our work contrasts for a few reasons in this survey. To begin with, our survey is pointed particularly at highlighting issues that influence the evaluation of the execution of perceptual following frameworks, such as measurements and exactness precision and the sources of blunder checks. In [11], a study is made on measuring and improving the parent-child joint attention for reading. It is really important for social learning activities. The study is made on one of these social learning activities that is storybook reading. The point of this study is to give to the mother a feedback of where the child looks and to give to the child a feedback of where the mother looks. Most of the time, when reading storybook, the child and the mother are not paying attention to the same things at the same time. The mother is reading the text and the child is mostly looking at images. Learning print-related skills is done when there is a real joint attention. Giving them real-time

feedbacks allows the mother to know what the child is looking at and to adapt her reading; it also allows the child to know which word his mother is reading and the pronunciation of the word.

Inquire about on eye tracking created by the 1960s and follow-up observing was begun within the 1970s with a specific center on making strides exactness and decreasing issues for clients. The application's center on accomplishing the common purpose of human-computer interaction implied small. This changed within the 1990s as the optical eye obtained the input and computer applications [23]. Post 2000, the fast improvement of computer speed, advanced video processing and moo taken a toll has brought us following apparatuses closer to clients, utilizing gaming, virtual reality and web promoting [24].

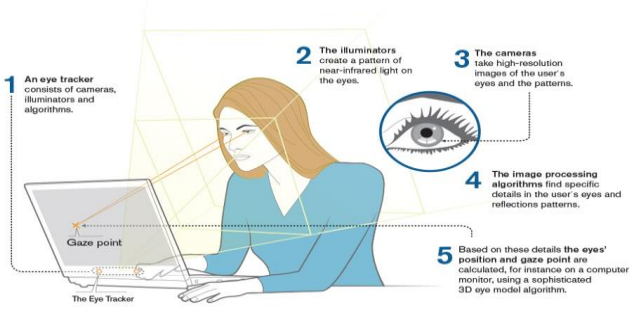

Fig.1: Relation between head front and gaze path

Real-time tracking and tracking of traffic on vehicle platforms are utilized in driver bolster programs to screen caution and driving levels. These set up an eye-tracking setup that is placed on the car dashboard in conjunction with the computer algorithms of the computer using algorithms. On handheld gadgets such as phones or tablets, the front camera is utilized to screen user's consideration to perform assignments such as locking / opening phones, visual present, raise lights, or impede sensors [15] [16]

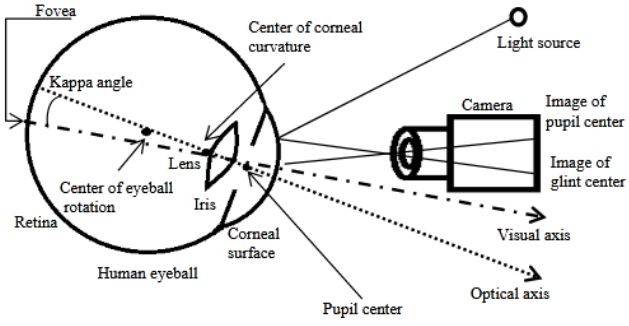

Fig.2: A. Human eye ball model

Eye parameters and setup resources used in 3D eye tracking [21] [22]. The light axis is exposed as a line combination the center of the mass decomposition and the center of student. The vertical axis passes during the fovea and the medial area of the corneal curvature. Kappa angle is the angular deviation between the visual and visual axis.

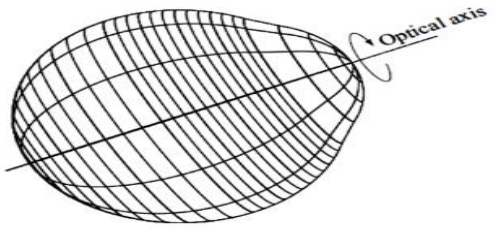

Fig.2: B. aspherical form of the corner

An aspherical model of the cornea, as a surface of revolution about the optical axis of the eye [20]

A. **Hygienic interaction:** Another advantage of eye gaze tracking system is their hygienic interface. Because of the absence of contact needed with such systems, it would fit perfectly in environments with high hygienic requirements [8]. For example, in an operation room for surgery, eye gaze systems would fill the requirements; there is indeed no need of touch interaction with the systems. It can also be useful for public interfaces when there is epidemic menace and when there is a need for hygienic interaction.

B. **Remote control**: Nowadays, with the technology, it is possible to have remote control with eye gaze tracking systems. Detecting the eyes over meters of distance is now possible with the lenses of the camera and its high resolution. It is even possible to detect the eyes at one meter with low cost eye gaze tracking systems [11].

C. **Interaction certified**: Using eye gaze interaction certifies the presence of a user in front of the webcam as well as the attention of this user. Eye gaze interaction can require some specific behavior of the user; for instance, for the user to go on with further features, it can be asked to read a warning text [4].

D. **User's activity detailed**: The eyes reveal a lot about someone activities; tracking them gives useful information about what the user is doing. Without further data analysis, an eye gaze tracking system provides information about what the eyes are looking at, and this is already of big potential for context-aware systems. With simple data analysis, it is possible to detect whether a user is reading or doing other activities for example. With further data analysis, it is possible to detect emotional or physical condition of the user, as their level of literacy and their age [9].

II. METHODOLOGY

The usability testing is another field of commercial interest for eye gaze tracking. As seen previously, the first use of eye gaze trackers has been for military research to find out the best location of instruments in aircraft cockpits. It is an advantage to be able to track the direction of the eye when

introducing a new device to someone. This way, it is possible to see where the user is looking when searching for the control to solve a specific task. Nowadays, internet is also a commercial platform and it is important to find out the usability of web pages as in [2].

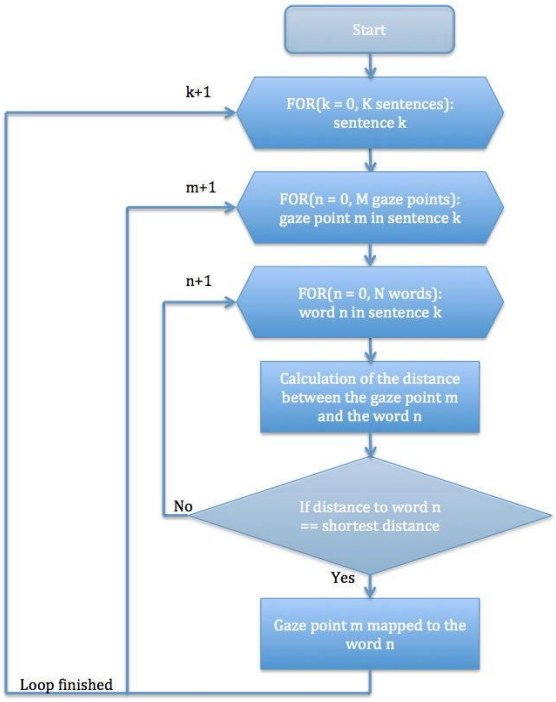

Fig. 3: Implementation flowchart.

We look at the gaze points in the list containing the gaze information. And we check if for a gaze point, the previous gaze point is equal to the following and if the time elapsed is less than 200 milliseconds. If for a gaze point all the conditions are gathered, the gaze point is removed from the list.

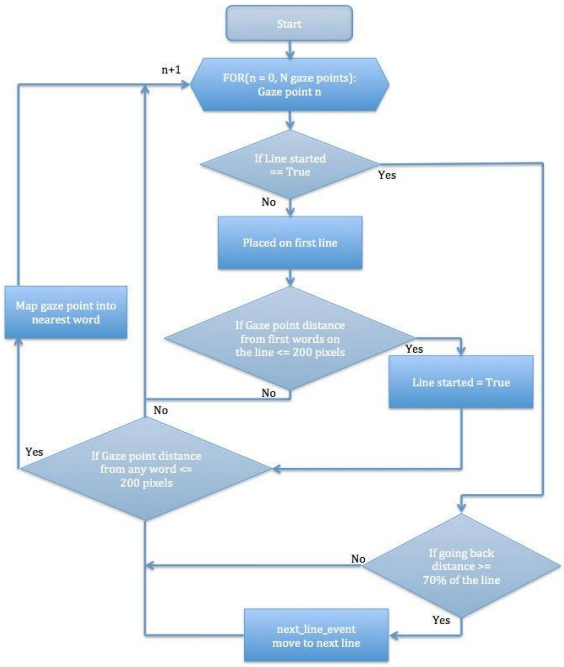

Fig. 4: Baseline algorithm flowchart.

The other kind of contact lenses is the magnetic one. The contact lenses have a coal that is integrated in it. This coal allows to detect the change in the magnetic field. It is very useful because when eyes rotate, an electric field is produced.

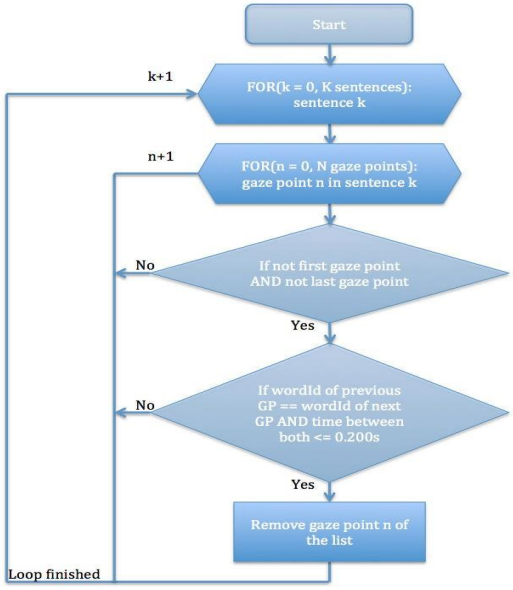

Fig. 5: Smoothing algorithm flowchart.

For each gaze point, we look if the line is started; it means that we look at the gaze point to see if it is mapped onto one of the first words of the line. If it is, we consider the line started and we can follow the reading path to detect the next line event. Then we map the gaze points into the corresponding words on the first line. It uses the same principle. First, we check if the gaze point falls directly onto a word and if not, we calculate the nearest distance to the word. The gaze point is mapped only if the distance is less than 200 pixels.

The data from the lenses, there is a thin wire connected to the measuring device that is uncomfortable for the user [7]. This method is used anyway because it has a really high accuracy and a nearly unlimited resolution. Magnetic contact lenses are found in the field of psychological and medical researches [2]. The principle of video-based eye gaze tracking is to detect the eye and the pupil from video sequences to find out the gaze direction. Because the method is unobtrusive, it is the one that is the most used. The purpose of video-based eye gaze tracking is to estimate the gaze direction based on video sequences [6]. One way of doing this is to detect the iris using the contrast between the white of the eyeball and the dark of the iris. Concerning the horizontal estimation of the gaze direction [10].

All the video-based methods require the detection of the pupil. To do that, image processing is mandatory. In image processing, what is called edge detection is typically what is needed to detect the elliptical contour of the pupil [13]. A method is to calculate the characteristics of the ellipse formed by the shape of the pupil to estimate the gaze direction. Another method tracks the rotational movements of the eyes but this kind of systems are not very spread. The eye gaze tracking systems based on video do not need

interaction or contact: that is why maintenance is not mandatory. Unlike mice and keyboards, the eye tracking devices do not need to be cleaned, which becomes a real problem for mice and keyboards. The camera centered eye positioning system is focusing on the center axis is shown in fig. 6.

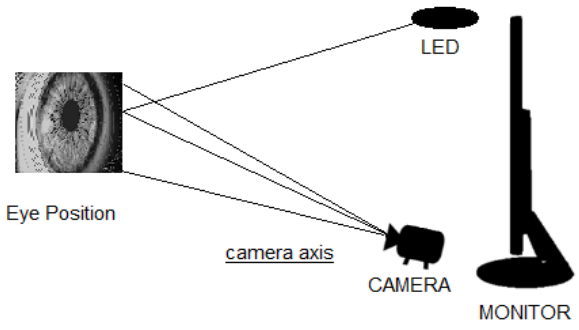

Fig. 6: Image projection plane [12]

III. RESULTS

A. Results with no processing

The results obtained in this section are obtained directly from the raw data. The tracking error rate is calculated directly from the data with no processing and algorithms. These results are presented in the Table 1.

TABLE 1:
No processing results.

Subjects	Tracking error rate
Subject 01	1.288
Subject 02	1.387
Subject 03	1.383
Subject 04	1.522
Average	***1.395***

B. Results with the baseline processing

The results obtained in this section are obtained by extracting information from the raw data. The tracking error rate is calculated on the processed data. The baseline algorithm presented in methodology. These results are presented in the Table 2.

Subjects	Tracking error rate	Improvement
Subject 01	1.317	−2.21%
Subject 02	1.246	10.15%
Subject 03	1.233	10.83%
Subject 04	0.935	38.57%
Average	***1.183***	***14.33 %***

Table 2: Baseline processing results

C. Results with the processing to smooth the data

The results obtained in this section are obtained by applying the smoothing algorithm to the previous processed data. The tracking error rate is calculated on this new processed data. The smoothing algorithm presented methodology is applied. These results are presented in the Table 3.

TABLE 3:
Smoothing processing results.

Subjects	Tracking error rate	Improvement (basic processing)	Improvement (raw data)
Subject 01	1.260	4.48%	2.21%
Subject 02	1.211	2.76%	12.69%
Subject 03	1.195	3.40%	13.60%
Subject 04	0.918	3.72%	39.69%
Average	***1.146***	***3.02%***	***17.05 %***

The tracking errors have been clustered based on the type of the fixations of the errors. Three groups have been made: normal fixation, regression and skip fixation (between the previous fixation and the actual fixation, one or more words have been skipped). The corresponding percentages are given in the Table 4.

TABLE 4:
Errors cluster percentages.

Subjects	Normal fixation	Regression	Skip fixation
Subject 01	23.60%	11.80%	64.60%
Subject 02	11.41%	7.51%	81.08%
Subject 03	15.90%	10.70%	73.39%
Subject 04	20.89%	16.03%	62.98%
Average	***17.98 %***	***11.51 %***	***70.51 %***

The main source of errors is the skip fixation. Most of the time, we do not find hypothesis changes that correspond to reference changes. That is why this cluster has a high percentage. The percentage of the errors caused by the regressions is quite high. When reading, regressions happen but at a low frequency. Here, the percentage is close to the percentage of the errors caused by normal fixations, fixations which happen at a higher frequency.

D. Good tracking ability: The eye gaze trackers are able to enhance the advancement track of the gaze of any person, regardless of their ethnicity, the wear of glasses or contact lenses, and their age. There is also a good tolerance to lightning; the trackers are able to work even with large differences in light conditions.

E. Tracking optimization: The methods of dark and bright pupil are both used while tracking. The most suitable method is automatically calculated and used. Both methods are optimized; it is thus possible to get better tracking quality and better ability to track a wider range of population.

F. High accuracy: High accuracy of the trackers provides precise and reliable data about the position of the gaze of the user. The ability to move the head and the possibility of having changes in lightning allow to have a natural environment for the user.

H. Validity measures: The eye gaze trackers provide a tracking status meter and numerical validity measures for each data point, that are built-in and in real time. Thanks to it, it is possible to specify the correctness of the data that are recorded. With this validity information, it is possible to filter the data recorded in order to remove the corrupted one and to have a better data quality. Because the model can have a data rate of 120Hz, it is possible to use it for research in the field of neurological processes where it is valuable to have a higher quantity of detailed measures.

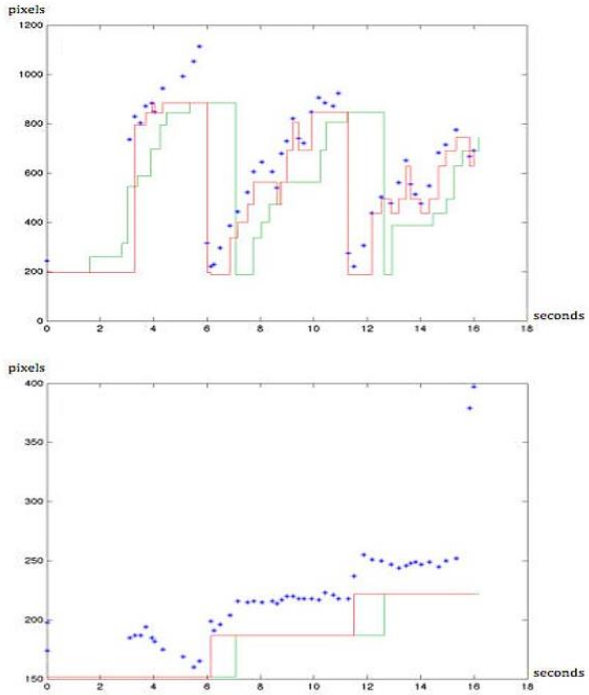

Fig. 7: Gaze data plots for sentence for all subjects.

IV. CONCLUSION

The purpose of this work is to understand reading process and enhance it in order to be able to follow this process with an eye gaze tracker. This way, mapping gaze points into corresponding words would be possible without too many errors. As a consequence, the fusion of eye gaze tracking and speech recognition would give better results than only speech recognition. During tests carried out to collect the data, an eye gaze tracker was used with different subjects. While recording the subjects reading the texts, the eye gaze tracker recorded the gaze point's location of the subjects. The information obtained from manual transcription are used as reference and the information from the eye gaze tracker are the hypothesis. The evaluation is performed by calculating the tracking error rate. The goal is to have the lowest tracking error rate while using only the hypothesis data.

CONFLICT OF INTEREST

The authors have no conflict of relevant interest to this article.

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