Journal of Korea Multimedia Society Vol. 25, No. 2, February 2022(pp. 421-431)
https://doi.org/10.9717/kmms.2022.25.2.421

Designing Real-time Observation System to Evaluate Driving Pattern through Eye Tracker

Kwekam Tchomdji Luther. Oberlin[†], Euitay, Jung[††]

ABSTRACT

The purpose of this research is to determine the point of fixation of the driver during the process of driving. Based on the results of this research, the driving instructor can make a judgement on what the trainee stare on the most. Traffic accidents have become a serious concern in modern society. Especially, the traffic accidents among unskilled and elderly drivers are at issue. A driver should put attention on the vehicles around, traffic signs, passersby, passengers, road situation and its dashboard. An eye-tracking-based application was developed to analyze the driver's gaze behavior. It is a prototype for real-time eye tracking for monitoring the point of interest of drivers in driving practice. In this study, the driver's attention was measured by capturing the movement of the eyes in real road driving conditions using these tools. As a result, dwelling duration time, entry time and the average of fixation of the eye gaze are leading parameters that could help us prove the idea of this study.

Key words: Eye Tracking, Gaze Analysis, Driver's Behavior, Driving Patterns

1. INTRODUCTION

1.1 Background

The increase in traffic accidents has become a serious concern to modern society. Especially, the traffic accidents among unskilled and elderly drivers are issued. Drivers with a diminished vigilance level suffer from a marked decline in their abilities of perception, recognition, and vehicle control; therefore pose a serious danger to their own lives and the lives of other people. Statistics show that one of the leading causes of fatal or injury-causing traffic accidents is due to drivers with a diminished vigilance level [1]. Many studies show that accidents can be due to drivers' lack of concentration on the road [2]. That is, many drivers cannot read or interpret a particular signal properly within a limited time during operation. With the ever-growing traffic conditions, this problem will further deteriorate.

For this reason, with the help of an eye tracker, we monitored the driver's level of vigilance and any insecure driving conditions to prevent accidents. This system could be used to test in driving school before issuing or renewing them a driving license. Studying the driver's gaze behavior is important to improve driving safety conditions and consequently to enhance general traffic safety. Gaze control may involve movements of eyes, head, and trunk, and these are coordinated in a way that can be translated, more or less directly, into motor control signals for the arms [3].

The following three reasons motivated our research:

※ Corresponding Author : Euitay Jung, Address: (15588) 55 Hanyangdeahak-ro, Sangnok-gu, Ansan, Gyeonggi, Korea, TEL : +82-31-400-5701, FAX : +82-31-400-5681, E-mail : jungjet@gmail.com
Receipt date : Feb. 16, 2022, Approval date : Feb. 22, 2022

[†] U Design Department, Graduate School, Inje University (E-mail: oberlinkwekam@gmail.com)
[††] Dept. of Communication Design, College of Design, Hanyang University
※ This work has supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT)(No. 2021S1A5A8069884).

1) Most 'common' drivers have a short and narrow field of vision, meaning that they do not far enough ahead, nor they broadly look enough all around. This behavior to focus one's gaze on a 'tunnel vision' just in front of the car is intrinsically unsafe, and can be avoided through specific training to:

a) Exploit the full potential of the visual system, especially the wide angle of visual sensitivity offered by peripheral vision;

b) Avoid distractions that drastically reduce the angle of peripheral vision;

c) Recognize and exploit the correct visual target;

d) Examine the surrounding environment (scanning).

2) Since driver's distractions can be characterized as activities that take a driver's attention away from the task of driving [4], safe driving training can help both inexperienced and also experienced drivers to increase, by means of experimental measurements, their awareness about the different categories of distractions, i.e. visual, auditory, biomechanical and cognitive.

3) The specific training of a professional driver (a pilot or professional tester) allows to achieve the maximum performance on the track or to develop the vehicle dynamics of prototype or pre-production cars. This system will be used in a driving test.

This study is a basic study for observing and databaseizing driver's driving habits. This research has innovative applications as follows. The increasing driving ability of elderly drivers can be judged by eye gazing when driving in a simulator capable of eye tracking. It can also be used to judge driving ability during driving training for first-time drivers. Pre-judgment using this simulator will help reduce accidents by judging whether this person actually has the minimum ability to acquire a driver's license.

There was only one paper related to road driving and eye tracking among studies in Korea.[5] This paper studied the driver's staring rate in the central area according to the type of road, and it was different from the study on the staring rate by POIs in this paper. Also, only one study has been published on eye tracking in the Journal of the Korean Multimedia Society. The study was a study on the gaze of an advertisement poster.[6] Therefore, it was judged that the progress of this study was justified in terms of originality."

1.2 Eye Gaze Tracking Fundamentals

Several types of eye movements are studied in eye gaze research and applications to collect information about user intent, cognitive processes, behavior and attention analysis [7,8]. These are broadly classified as follows:

1. Fixations: These are phases when the eyes are stationary between movements and visual input occurs. Fixation related measurement variables include total fixation duration, mean fixation duration, fixation spatial density, number of areas fixated, fixation sequences and fixation rate.

2. Saccades: These are rapid and involuntary eye movements that occur between fixations. Measurable saccade related parameters include saccade number, amplitude and fixation-saccade ratio.

3. Scanpath: This includes a series of short fixations and saccades alternating before the eyes reach a target location on the screen. Movement measures derived from scanpath include scanpath direction, duration, length and area covered.

4. Gaze duration: It refers to the sum of all fixations made in an area of interest before the eyes leave that area and also the proportion of time spent in each area.

5. Pupil size and blink: Pupil size and blink rate are measures used to study cognitive workload. Table 1 presents the characteristics of different eye movements and their applications.

Table 1. Eye movement's classification.

Eye movement type	Movement rate	Latency/duration of occurrence	Functionality/ Significance	Applications in Human Computer interaction
Fixation	< 15 - 100 deg/ms	180 - 275 ms	Acquiring information, Cognitive processing, attention	Browsing information, reading, scene perception
Saccade	100 - 700 deg/sec	Latency - 200 ms, duration: 20 - 200 ms	Moving between targets	Visual search
Smooth pursuit	< 100 deg/sec based on target speed	100 ms	Following moving targets	Gaze based drawing, steering
Scanpath	--	--	Scanning, direct search	Assessing user behavior, user interface and layout quality
Gaze duration	--	--	Cognitive processing, conveying intent	Item selection, text/number entry
Blink	12 - 15 per min	300 ms	Indicates behavioral states, stress	Eye liveliness detection, activate command/control
Pupil size change	4 - 7 mm/sec	140 ms	Cognitive effort, representing micro emotions	Assessing cognitive workload, user fatigue, command/control

1.3 Related Works

In the past few years, many researchers have been working on the development of safety systems using different techniques. Many efforts have been reported in the literature for developing active safety systems intended for reducing the number of automobile accidents due to reduced vigilance.

H. Saito et al. described the information communication system and the detector for the driver's physical or mental conditions such as fatigue, drowsiness, etc. which are closely related to the occurrence of traffic accidents [9]. H. Ueno et al. described a technique for detecting sleepiness in a driver and a technique for arousing the driver from that sleepy condition. For that, an image processing technique to recognize the open or closed state of the driver's eyes was a result of detecting drowsiness at the wheel [10]. S. Boverie et al. presented the result obtained on driving vigilance monitoring and the working directions for occupant nature and position analysis [11]. M. Kaneda et al. argued that preventing drowsiness during driving requires a method for accurately detecting a decline in driver alertness and a method for alerting and refreshing the driver [12]. R. Onken et al. presented intelligent monitoring and warning aid for the driver on German motorways. Haptic warning messages are generated and initiated on the basis of comprehensive system knowledge about the driving situation including the behavioral state and the condition of the driver [13].

Meanwhile, J. Feraric et al. all used the statistical versus neural bet approach for the driver behavior description and adaptive warning. Automatic recognition of driver's facial expression by image analysis was one of the techniques that were studied to come out with the result which helps to reduce traffic accidents [14].

Vision systems are of great interest in monitoring driver's vigilance and occupant's nature and position. The use of such systems can also provide meaningful information for increasing vehicle occupant's comfort and security. This global approach has been initiated within Siemens Automotive (SA) by the development of a real-time prototype for loss of vigilance detection. Work is now going on for occupant sensing. Among different techniques, the best detection accuracy was achieved with techniques that measure physiological conditions like brain waves, heart rate, and pulse rate [15]. P. Smith et al. described a system for analyzing human driver alertness. It relies on optical flow and color predicates to robustly track a person's head and facial features. This system classifies rotation in all viewing directions, detects eye/mouth occlusion, detects eye blinking, and recovers the 3D gaze of the eyes [16]. The study by C. Ahlstrom et al. described the processed eye tracking data in large-scale naturalistic driving data sets, involving 13 vehicles equipped with sophisticated eye tracking devices [17]. And from the observation that complex and dangerous driving situations often arise because of a delayed perception of traffic objects, the investigation by E. Tafaj et al. exploited an advanced driving simulation system, equipped with eye tracking technology, to analyze the driver's visual behavior based on an adaptive online algorithm [18].

Good results have also been reported with techniques that monitor eyelid movement and gaze with a head-mounted eye tracker or special contact lens. The results from monitoring head movement with a head-mount device are also encouraging [13]. These techniques, though less intrusive, are still not practically acceptable. A driver's state of vigilance can also be characterized by the behaviors of the vehicle he/she operates. Vehicle behaviors including speed, lateral position, turning angle, and moving course are good indicators of driver's alertness level. While these techniques may be implemented non-intrusively, they are, nevertheless, subject to several limitations including the vehicle type, driver experiences, and driving conditions.

This paper describes a real-time prototype system based on computer vision for monitoring driver's vigilance by the use of an eye tracker and a camera placed on the car dashboard. We have employed this technique because our goal is to monitor the driver in real conditions (vehicle moving).

2. TEST SETUP

2.1 Basic Setup and Method Used for Eye Gaze Estimation

Video based eye gaze tracking systems comprise fundamentally of one or more digital cameras, near infra-red (NIR) LEDs and a computer with screen displaying a user interface where the user gaze is tracked. A typical eye gaze tracking setup is shown in Fig. 1. The steps commonly involved in passive video based eye tracking include user calibration, capturing video frames of the face and eye regions of user, eye detection and mapping with gaze coordinates on screen. The common methodology (called Pupil Center Corneal Reflection or PCCR method) involves using NIR LEDs

(a) (b) (c)

Fig. 1. Experiment Environment. (a) The eye tracker positioned on the dashboard, (b) side view, and (c) wide view

to produce glints on the eye cornea surface and then capturing images/videos of the eye region [19, 20]. Gaze is estimated from the relative movement between the pupil center and glint positions. External NIR illumination with single/multiple LEDs (wavelengths typically in the range 850+/- 30 nm with some works such as [21] using 940 nm) is often used to achieve better contrast and avoid effects due to variations induced by natural light. Webcams are mostly used; those operate at 30/60 fps frame rate and have infrared (IR) transmission filters to block out the visible light. The user-interface for gaze tracking can be active or passive, single or multimodal [22,23]. In an active user interface, the user's gaze can be tracked to activate a function and gaze information can be used as an input modality. A passive interface is a non-command interface where eye gaze data is collected to understand user interest or attention. Single modal gaze tracking interfaces use gaze as the only input variable whereas a multimodal interface combines gaze input along with mouse, keyboard, touch, or blink inputs for command.

2.2 Systems

The purpose of this experiment is to determine the point of fixation of the driver during the process of driving and from there, the driving instructor can determine whether the driver may drive or not. The driver-system interaction was designed to be as simple as possible. In the implemented prototype, the only action required for the driver is to focus on his driving applying all that he studied during the driving class. During this process the Instructor will be seated by his side on the passage area with a computer used to study his driving actions.

The car employed for the tests was equipped with:

1) "An SMI(Senso Motoric Instruments) eye tracker is placed on the top of the dashboard at the central position with respect to the driver's seat(Fig. 1, (a)). An eye tracker is a device that detects the user's eye gaze, thus finds what is being observed, by the use of a screen. An eye tracker must be able to record the user's gaze coordinates at certain number of times per second (sampling rates), and to indirectly detect, through proper algorithms, fixations and saccades. Infrared or near-infrared light is normally used to illuminate the user's eyes.

2) "A web camera, positioned at the top of the windshield (Fig. 1, (b))."

3) "A laptop computer, equipped with a USB3 port for the eye tracker and a USB2 port for the web camera, running the whole application (Fig. 1, (c))." It also records the measurement data and movie clips.

2.3 Calibration

It must be ensured that the eye tracker is accurately tracking the driver's eye movements. To confirm this, the driver's eyes have to be calibrated to ensure that he is seated at the right position where his eyes can be tracked by the system and this procedure is called calibration. The process of calibration of test subject to the eye tracker is an essential aspect of precise data collection. Each test subject that is participating in the experiment had to be individually calibrated to the system. Individual calibration is necessary as the eye ball is varying in terms of shape and radius up to 10% (Percent)[24]. The calibration process itself has always to be conducted in the same light conditions as the experiment. First as it is said by [26] it is essential that test subjects were seated at an appropriate distance and level from the eye tracker. The participants must be enabled to take sufficient time to find a convenient seating position. The SMI eye tracker provides a tracker status window which displays in real time the detection of participant's eyes. The purpose of this tool is to verify that the test subject is correctly positioned in front of the eye tracker. Calibration is performed by showing the user a set of specific targets distributed over the front screen (as shown in Fig. 4) and the user is asked to gaze at them for a certain amount of time[25]. The tracker camera captures the various eye positions for each target point which are then mapped to the corresponding gaze coordinates and thus the tracker learns this mapping function. Calibration routines differ in the number and layout of target points, user fixation duration at each point and type of mapping algorithm used. The 5 calibration points were covering the complete area of the computer monitor representing extrema of the desired visual stimulus. Test subject were asked to manually press the space bar when fixing the calibration points. According to [27],this calibration method is superior compared to both the operator controlled approach and the automatic calibration method.

After calibration, we can start the actual recording of the driver's gaze where the eye gaze is recorded by the eye tracker and the road video is recorded by the web camera. Once acquired, the fixation and road video files are provided to the Gaze Replay application developed for this project, which (offline) produces the final video file with fixations superimposed on the road scene.

3. EXPERIMENTS

3.1 Conducting Experiments

The purpose of the experiment is to show that eye tracking can identify what the driver is more focusing on. The eye tracking used for this experiment will produce some data which would help us to prove this idea. The experiment was carried out in a urban road: a scenario with several targets that the driver had to look at explicitly during the road. "The set of targets included street sign boards (Fig. 2, (a)) and traffic light indicators(Fig. 2, (b))".

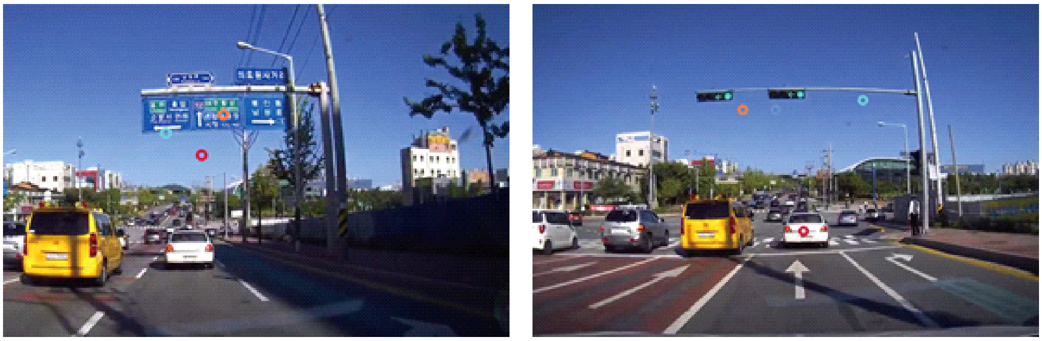
Each frame was then processed to identify 'AOIs (Areas of Interest)' that fall into predefined semantic categories indicated in Fig. 3(a).

The next thing is to figure out the recruitment and selection process of the participants. In total 30 people participated in this study. First of all, before carrying on our experiment, we interviewed the participants. After that, we collected various answers from them and the majority answered: First, the vehicles in front and beside them; second, the traffic light which indicates to them whether to stop or not; lastly the sign board which indicates what to do at that point.

After taking into consideration these answers from the drivers, we used it as a reference to run our experiment. In this experiment, we created AOIs that would help us to see the movements of the driver's eyes. All this is shown in the Fig. 3 (b).

1) The box number 3 indicates the cars beside and in front of our car.

2) The box number 1 and 2 indicate the traffic



(a) (b)

Fig. 2. The Set of Targets. (a) The route sign boards and (b) Traffic Light Indicators for Pedestrians.

(a) (b)

Fig. 3. AOIs. (a) Allocating area of interest and (b) AOI result display

light.

3) The box number 4, 5, 6 and 7 indicate the sign board.

After the experiment some few participant results were used to explain the idea of this paper. This is because the data produce by them was reliable and matching with what they said during the interview.

3.1 Result

The result shows that many drivers stare more at the car beside and in front of them followed by the traffic light and lastly sign board. This can be explained by the dwell time and entry time found in each box. The tables below show the results obtained during the experiment of each driver.

- The dwell time: is the total amount of time spent looking within an AOI. This includes all fixations and saccades within the AOI, including revisits. Dwell time is an excellent metric that conveys the level of interest with a certain AOI. Obviously, the greater the dwell time, the greater the level of interest in the AOI.

- The average of fixation: tells you how long the average fixation lasted for, and can be determined for either individuals or for groups. If one image leads to much higher average fixation duration than another, then it could be worthwhile exploring the reasons why. Furthermore, comparisons across AOIs allow you to determine which areas were actually focused on more than others.

- The entry time: is the time the driver started looking into an area of interest. That is the order in which the driver view a particular area.

From all the explanation of time above we can know the order in which the drive view objects when driving.

We use Table 2 and Table 5 which are the best and worst result experiment respectively. Table 2 is the best because what was said during the interview by drivers is what he did meanwhile in Table 5 there are some of the objects that the driver did

Table 2. The Result Experiment of driver 1.

Area of Interests	Dwell Time (mille seconds ms)	Dwell Time (%)	Average Fixation (mille seconds ms)	Entry Time (mille seconds ms)
Cars in Front and Beside	12962.8	24.3	362.5	4278.5
Traffic Light	632.0	1.2	632.0	49241.6
First Sign Board	733.4	1.4	244.5	20843.6
Second Sign Board	396.9	0.8	199.4	4046.0
Third Sign Board	302.0	0.6	151.0	21677.2

Table 3. The Result Experiment of driver 2.

Area of Interests	Dwell Time (mille seconds ms)	Dwell Time (%)	Average Fixation (mille seconds ms)	Entry Time (mille seconds ms)
Cars in Front and Beside	9000.3	17.4	316.1	57077.0
Traffic Light	3999.9	7.7	327.7	24271.9
First Sign Board	1466.3	2.8	488.8	23306.5
Second Sign Board	233.2	0.5	233..2	20206.6
Third Sign Board	3833.3	7.4	403.7	19172.3

Table 4. The Result Experiment of driver 3.

Area of Interests	Dwell Time (mille seconds ms)	Dwell Time (%)	Average Fixation (mille seconds ms)	Entry Time (mille seconds ms)
Cars in Front and Beside	2099.2	4.1	399.7	4262.0
Traffic Light	4332.3	8.4	344.4	22960.7
First Sign Board	3632.4	7.0	303.0	20627.3
Second Sign Board	2265.8	4.4	323.7	826.9
Third Sign Board	99.9	0.2	346.6	14296.3

Table 5. The Result Experiment of driver 4.

Area of Interests	Dwell Time (mille seconds ms)	Dwell Time (%)	Average Fixation (mille seconds ms)	Entry Time (mille seconds ms)
Cars in Front and Beside	30462.0	58.9	496.0	34160.0
Traffic Light	400.0	0.8	400.0	48578.0
First Sign Board	0	0	0	0
Second Sign Board	0	0	0	0
Third Sign Board	1099.8	2.1	355.5	20181.0

not look at. The meaning of first, second and third sign board as shown in the table 2 to tell us that there were many of them and that only three of them was viewed by the driver at a different time according to entry time.

From the result of this experiment, we can determine the objects that the driver stares at by using the dwell time. That is the higher the dwell time the higher the point of interest. To know the object that was stared first by the driver can be determined by the use of entry time. That is the first object viewed should have less time respectively.

We can now use the values in the table 2 to explain this. We can see that the driver stared more at the car in front and beside him followed by the traffic light and finally the sign board due to their dwell time which marked 12962.8 ms, 733.4 ms, 632.0 ms, 396.9 ms and 302.0 respectively. The entry time can show that all these objects were not in the same area. This applied for the rest of the tables. If we look into the tables we can see that the dwell time of cars in front and beside is higher. This is to tell us that we are able to determine which sign was viewed first by the driver. From this, we can determine the driver's order of focus.

4. CONCLUSIONS

In this study, we have shown a method used to determine the point of focus of the driver during the process of driving. We have shown that with our method we can use the dwell time and the entry time to show the object that was stare by the driver and also the place and time that object was viewed respectively. The main work presented in this paper was to show how implementing an eye tracking system in a car can help to detect and record the driver's gaze while driving.

This study can be implemented in the driving school for the evaluation of student practice examinations. That is the trainer would teach the students the code of the road test them later practically. For example, the trainer would place different objects such as traffic light and sign board etc. on different places of the driving road path and expending to see their reaction during the process of driving. At the end of the driving process, the trainer can be able to determine the trainee that has to follow his instruction with the use of this study.

Since the employed eye tracker is a general device, not designed to work in a car, we had to solve several practical problems;

First, we have to find the best position of the driver inside the car.

Second, the main challenge that we had to face was the implementation of the calibration procedure, that could not be obtained using a screen, as usually occurs.

Third, finding the correct match between the eye tracker's coordinate space and that of the web camera used to shoot the road.

A partial drawback of the current implementation is the limited width of the virtual screen that constrains the usable windshield area within which the driver's gaze can be detected rightward glances are not sensed if the eyes are outside the eye tracker's range. The use of two eye trackers could extend the horizontal size of the virtual screen, although further challenges would need to be considered (e.g., the management of the two devices and their synchronization).

REFERENCE

[1] S.R. Sharran and G. Sivanesan, "Drowsy Driver Detection System," *International Journal of Science and Research*, Vol. 5, No. 2, pp, 2134 - 2137, 2016.

[2] S.P. McEvoy, M.R. Stevenson, and M. Woodward, "The Impact of Driver Distraction on Road Safety: Results from a Representative Survey in Two Australian States," *Injury Prevention*, Vol. 12, No. 4. pp. 242-247, 2006.

[3] V.M. Ciaramitaro, H.M. Chow, and L.G. Eglington, "Cross-Modal Attention Influences Auditory Contrast Sensitivity: Decreasing Visual Load Improves Auditory Thresholds for Amplitude- and Frequency-Modulated Sounds," *Journal of Vision*, Vol. 17, No. 3, pp.1-22, 2017.

[4] D.R. Mayhew, "Driver education and graduated licensing in North America: Past, present, and future," *Journal of Safety Research*, Vol. 38, No. 2, pp. 229 - 235, 2007.

[5] J, Park and H. Kim, "A Study on Driver's Gaze Area in Variable Road Characteristics Using Eye Tracking System," *The Korea Spatial Planning Review*, Vol. 77, pp. 83-101. 2013.

[6] M.K. Hwang, M.W. Kwon, M.H. Park, and C.Y. Kim, "A Study on the Visual Precautions of Soju Advertising Posters Using Eye Tracking," *Journal of Korea Multimedia Society*, Vol. 423, No. 2, pp. 368-375, 2020.

[7] J.C.R. Bergstrom, E.L. Olmsted-Hawala, and M.E. Jans, "Age-Related Differences in Eye Tracking and Usability Performance: Website Usability for Older Adults," *International Journal of Human-Computer Interaction*, Vol. 29, No. 8, pp.541 - 548. 2013.

[8] B.B. Velichkovsky, M.A. Rumyantsev, and M. A. Morozov, "New Solution to the Midas

Touch Problem - Identification of Visual Commands Via Extraction of Focal Fixations," *Procedia Computer Science*, Vol. 39, pp. 75-82, 2014.

[9] H. Saito, T. Ishiwaka, M. Sakata, and S. Okabayashi, "Applications of Driver's Line of Sight to Automobiles: What Can Driver's Eye Tell," *Proceedings of 1994 Vehicle Navigation and Information Systems Conference*, pp. 21-26, 1994.

[10] H. Ueno, M. Kaneda, and M. Tsukino, "Development of Drowsiness Detection System," *Proceedings of 1994 Vehicle Navigation and Information Systems Conference, Yokohama, Japan*, pp. 15-20, 1994.

[11] S. Boverie, J.M. Leqellec, and A. Hirl, "Intelligent Systems for Video Monitoring of Vehicle Cockpit," *International Congress and Exposition ITS: Advanced Controls and Vehicle Navigation Systems*, pp. 1-5, 1998.

[12] H. Ueno, M. Kaneda, and M. Tsukino, "Development of a Drowsiness Warning System," *Proceedings of VNIS'94 - 1994 Vehicle Navigation and Information Systems Conference*, 1994. pp. 15-22, 1994.

[13] D.R. Onken, "An Adaptive Knowledge- Based Driver Monitoring and Warning System," *Proceedings of 1994 Vehicle Navigation and Information Systems Conference*, pp. 3-10, 1994.

[14] J. Feraric, M. Kopf, and R. Onken, "Statistical versus Neural Bet Approach for Driver Behavior Description and Adaptive Warning," *The 11th European Annual Manual*, pp. 429-436, 1992.

[15] S. Saito, "Does Fatigue Exist in a Quantitative Measurement of Eye Movements?," *Ergonomics*, Vol. 35, No. 5-6, pp. 607-615, 1992.

[16] P. Smith, M. Shah, and N. Da Vitoria Lobo, "Monitoring Head/Eye Motion for Driver Alertness with One Camera," *Proc. - International Conference on Pattern Recognition*, Vol. 15, No. 4, pp. 636-642, 2000.

[17] C. Ahlstrom, T. Victor, C. Wege, and E. Steinmetz, "Processing of Eye/Head-Tracking Data in Large-Scale Naturalistic Driving Data Sets," *Transactions on Intelligent Transportation Systems*, Vol. 13, No. 2, pp. 553-564, 2012.

[18] E. Tafaj, T.C. Kubler, G. Kasneci, W. Rosenstiel, and M. Bogdan, "Online Classification of Eye Tracking Data for Automated Analysis of Traffic Hazard Perception," *International Conference on Artificial Neural Networks*, pp 442-450, 2013.

[19] D.W. Hansen and Q. Ji, "In the Eye of the Beholder: A Survey of Models for Eyes and Gaze," *IEEE Transactions on Pattern Analysis and Machine Intelligence.*, Vol. 32, No. 3, pp. 478-500, 2010.

[20] E.D. Guestrin and M. Eizenman, "General Theory of Remote Gaze Estimation Using the Pupil Center and Corneal Reflections," *IEEE Transactions on Biomedical Engineering*, Vol. 53, No. 6, pp. 1124- 1133, 2006.

[21] H.C. Lee, W.O. Lee, C.W. Cho, S.Y. Gwon, K.R. Park, H. Lee, and J. Cha, "Remote Gaze Tracking System on a Large Display," *Sensors*, Vol. 13, No. 10, pp. 13439-13463, 2013.

[22] O. Spakov and D. Miniotas, "Gaze-Based Selection of Standard-Size Menu Items," *Proceedings of the Seventh International Conference on Multimodal Interfaces*, pp. 124-128, 2005.

[23] Z. Zhu and Q. Ji, "Novel Eye Gaze Tracking Techniques Under Natural Head Movement," *IEEE Transactions on Biomedical Engineering*, Vol. 54, No. 12, pp. 2246-2260, 2007.

[24] K. Pernice and J. Nielsen, "Eye Tracking Methodology -How to conduct and Evaluate Usability Studies Using Eye Tracking," Technical Report, Nielsen Norman Group, Fremont, CA, USA, August 2009.

[25] A.T. Duchowski. K. Pernice and J. Nielsen.

"Eye Tracking Methodology -How to conduct and Evaluate Usability Studies Using Eye Tracking," Technical report, Nielsen Norman Group, Fremont, CA, USA, August 2009.

[26] K. Harezlak, P. Kasprowski, and M. Stasch, "Towards Accurate Eye Tracker Calibration -Methods and Procedures," *Procedia Computer Science*, Vol. 35, No. C, pp. 1073- 1081, 2014.

[27] K. Holmqvist, M. Nystrom, and R. Andersson, "Participants know best: Influence of calibration method on accuracy," *Journal of Vision*, Vol. 11, No. 11, pp. 503-503, 2011.

Kwekam Tchomdji Luther Oberlin

He received B.S. in Computer Software Engineering from National polytechnic Bamenda University, Cameroon in 2015, also received M.S. in Computer software engineering from Central South University, China in 2017, and a second M.S in Visual Design at Inje University, Korea in 2019. He is studying his PhD in Visual design at Inje University. Main research interests include the study on eye tracking device.

Euitay Jung

He received B.A. in Industrial Design from Seoul National University, in 1997 and M.A. in Interactive Media Systems from HS-Augsburg in Germany in 2008, Also he received his PhD. in Design from Kyungpook University in 2017. He joined Division of Multimedia Design, Inje University in 2009 and now he is in Department of Communication Design at Hanyang University. His interests includes multimedia, communication design and social innovation.