Focus Loss While Driving Detection by Using Prior Stage ERP as Baseline

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Abstract—**Driving demands a full focus on the road to avoid any kind of unfortunate events. However, it is common for the driver to lose focus especially on the road with less traffic and for a long journey. Studies have shown that quite number of accidents happened due to loss of focus. Hence, this on-going study is to develop a device to detect focus loss signs while driving. The preliminary papers have shown that the loss of focus is associated to the declining of evoked response potential (erp) amplitude over time. However, to determine the significant decline of amplitude is challenging due to inter-variability of individuals. Hence, this paper proposes a novelty detection approach by using prior stage of recording as baseline to extract focus loss in a single trials of erp of respective individuals. Erps of 20 subjects were recorded while driving a simulator car. The obtained results suggested that the proposed approach successfully detects the loss attention but with a delay as few seconds are needed to obtain the baseline. Novelty detection by using prior stage of recording as baseline is promising but the improvement is needed to be done to apply it in real time.**

Keywords—prior stage baseline; focus loss; erp;

I. INTRODUCTION

DATA from the World Health Organization published in July 2017 [1] has reported that road accidents had caused 20 and 50 million injuries every year. Among the risk factors identified by WHO are speeding, driving while intoxicated and distracted driving due to the use of mobile phones. However, there is one factor that is hard to be proven in the accidental reports and most of the doers did not aware when it has happened. A study from the University of Bordeaux as reported in [2] in France stated that of nearly 1000 drivers injured in the accident, 52% reported losing their attention before crashing their cars. He et al in 2011 [3] revealed more than a fifth of drivers (21%) switch to autopilot when on familiar routes, putting themselves and other road users at risk. Such phenomenon is also known as white line syndrome which arises to those behind the wheel in great distance journey, responding to external events in the expected, safe and correct manner with no recollection of having consciously done so [4].

Devices and methods to overcome focus loss behind the wheel have become a fashionable study among researchers. There are several methods have been proposed for instances, Plessey Semiconductor [5] has developed a new heart rate-based driver alertness monitoring system which provides early warning of drowsiness or health issue and Volvo [6] Developed Driver Alert System to detect the deteriorating driving ability die to distraction or sleepiness. However, those methods are meant to detect loss of focus due to drowsiness and health issue, not specifically detect focus loss or white line syndrome. For this, several studies have shown that electroencephalogram (eeg) is able to detect the focus loss due mind wandering [7]-[9] and microsleep [10]-[11] phenomenon. There are three types of eeg feature that can be extracted for analysis purpose such as event related potential (erp), spectral power and multiscale entropy (mse). Woodman provides the introduction of EEG measurement in perception, sensation, cognition and attention. The researcher revealed

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that the erp techniques to study about the attention is increased which prove that erp is the technique that easy to handle to analyze the brain information [12]. Kayser in his research reveals that erp contribute to the new insight on assessing attention and cognitive control in the development of neuropsychiatric disorders such as schizophrenia [13]. Ahirwal and D Iondhe presented in their paper that power spectrum analysis is able to estimate the visual attention which corresponds to the brain cognitive process [14]. Liu et. al use spectral power analysis to classify the state of attentiveness [15]. However, using this technique there are such difficulties to identify the inattentiveness due to an additional information that extracted together during the classification.

Another technique that able to measure the attention is MSE by discriminating the different attention states in curing the attention deficit hyperactivity disorder (ADHD) and Alzheimer's disease [14]. Chu et. al provides the brief summary on the use of MSE for neuropsychiatric disease such as autism, ADHD Tourette and epilepsy in children [15]. However, this technique is frequently used to detect the attention abnormality among the neuro-psychiatry patient and not proven to the health person.

In our previous prior study [7]-[9], we have shown that focus loss is significantly observed by using habituation (amplitude decline) approach of N100 wave. In each subject, the amplitude declining of N100 wave could differentiate between focus and loss of focus erp wave by using simply averaging method but in a group evaluation, the significant value of amplitude decrements to differentiate between focus and loss of focus erp is variety. Hence, the prior findings were not ready to develop the device yet. Thus, this subsequent study is to overcome the problem variability between subjects by suggesting novelty detection approach to extract amplitude decrements. The early state of the driver (assumed as the driver is very attentive and free from fatigue or drowsiness) will be the baseline and the degrading of the consecutive responses compared to the baseline is detected as attention loss. The following sections will discuss the methodology in detail.

II. METHODOLOGY

A. *Participants*

20 healthy subjects of age between 18 to 30 years with driving license were participating in this experiment. They were all student of Universiti Teknikal Malaysia Melaka and participated on voluntary basis. Prior to the experiment, all subjects are required to sign the informed consent.

B. *Stimuli and Experimental Paradigm*

The experiment was conducted on a high fidelity in-lab driving simulator based on virtual reality technology to build the 3D highway driving scene in a sound proof room. The subject was seated about the distance of 90cm from the display of driving simulator and three surface electrodes (AG/AgCl) of EEG measurement are attached on the scalp of the subject. The EEG recording system (BIOPAC Inc framework) was applied for real time EEG data acquisition throughout the experiment.

The impedance of the BIOPAC is guaranteed underneath 5kΩ and the responses will be filtered using bandpass digital filter between 1 to 15Hz. The recordings were done with the sampling frequency of 500Hz. The recorded EEG data was segmented into response extending from 0 to 1s post-trigger stimulus. These responses were filtered using a digital filter (bandpass 1-15Hz). Each segment of response will be referred to as trial along this paper.

The eeg recording is done only during early daytime (between 9 a.m and 3 p.m) as to avoid any unwanted event that might influence the result such as sleepy, tiring, fatigue. Subjects were seated comfortably in front of the driving simulator as in driving the real car. 10 minutes training course was given to each participant prior to the experiment in order to get used to the driving simulator. Two sessions of recording were held (10 minutes each), first driving while listening to radio and second without any other stimulation. The driving scenario is a long monotonous driving in highway scenario around twenty minutes respectively. As the

analysis is erp, a trigger sound of 1kHz tone was played throughout the experiment. The subjects are required to take 5 minutes rest between sessions to avoid fatigue and drowsiness due to the experiment.

The analysis of the erp began 1 minutes after recording. This action is taken as to ensure the driver and the erp are in stable condition. Based on previous study [10], focus loss during driving could happens after 6 minutes of the task. Based on that report, in this study, the first 5 minutes of recording is used as baseline for the analysis. The baseline is produced by averaging the amplitude of the erps. The analysis is done by comparing the amplitude of consecutive response to the baseline amplitude. As the biological signal is not steady and rigid [7]-[9], the significant decline is based on if the current consecutive erp amplitude is less more than 50% from the baseline, the attention condition will denote as 0 (loss of focus), and other than that will denote as 2 (focus).

III. RESULTS AND DISCUSSION

The results from driving while listening to radio is denoted as focus ON group and the results from driving without given any stimulation is denoted as focus OFF group. Only results from 10 subjects were shown here due to limitation of maximum pages. As shown in Fig. 1 to Fig. 20, response is corresponding to time in second as stated in methodology part (sampling frequency is 500 Hz). Only 8 minutes 33 seconds recording were presented here for homogeneous presentation as some of the erps of the subjects must be discarded due to artifact. The baseline is obtained from the earlier 5 minutes recording which is 300 responses. Hence, the novelty detection start at response 301.

From our previous studies [7]-[9], we have shown that our minds will be focus on driving better if we listening to the radio program compared to just listen to music or quiet. As previous findings, current results showed similar observation. With respect to the left side of Fig. 1 to Fig. 10 (focus OFF) showed the amplitude of N100 wave decline overtime compared to focus ON results (Fig. 11 to Fig. 20).

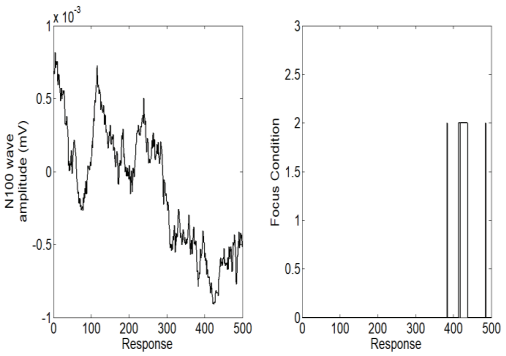

Fig. 1. Subject 1 (Focus OFF)

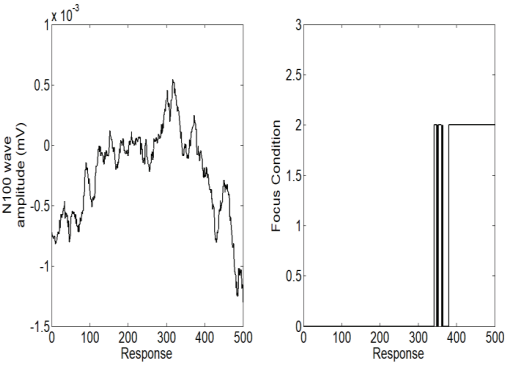

Fig. 2. Subject 2 (Focus OFF)

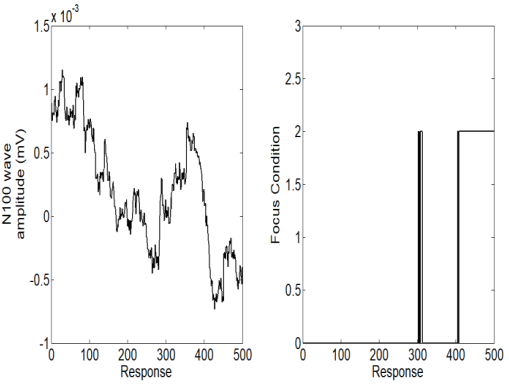

Fig. 3. Subject 3 (Focus OFF)

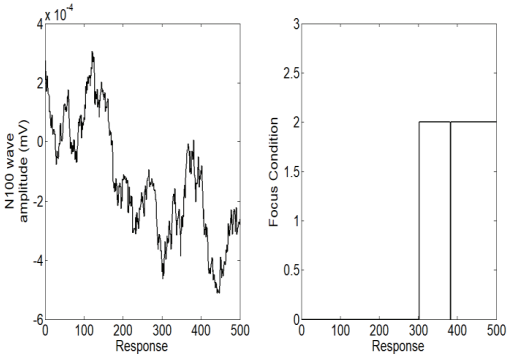

Fig. 4. Subject 4 (Focus OFF)

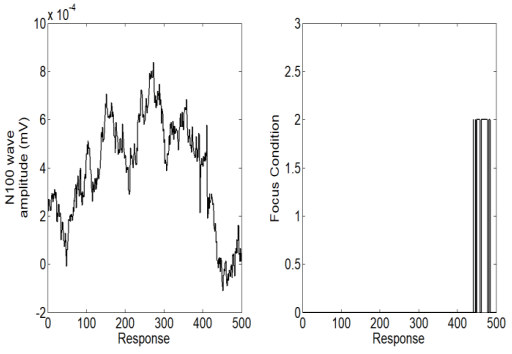

Fig. 5. Subject 5 (Focus OFF)

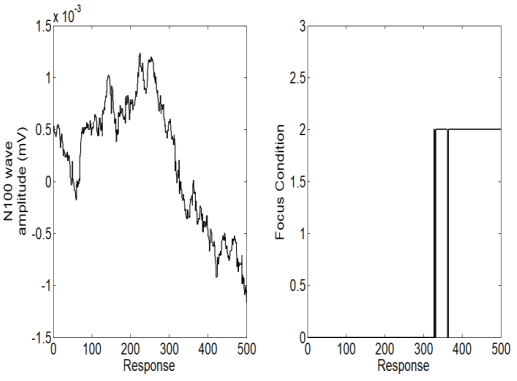

Fig. 6. Subject 6 (Focus OFF)

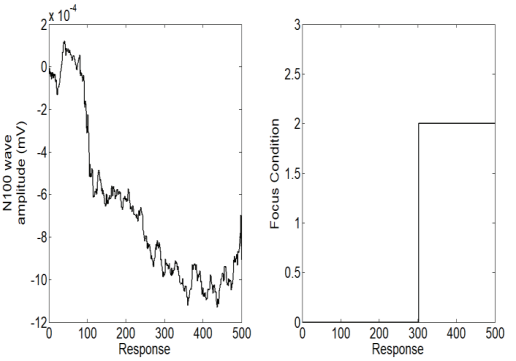

Fig. 7. Subject 7 (Focus OFF)

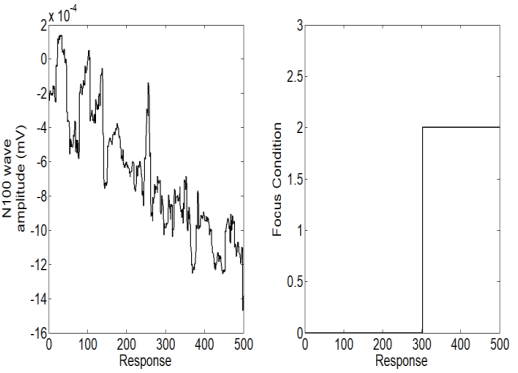

Fig. 8. Subject 8 (Focus OFF)

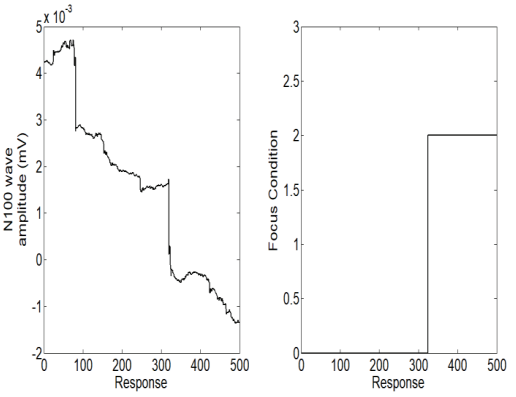

Fig. 9. Subject 9 (Focus OFF)

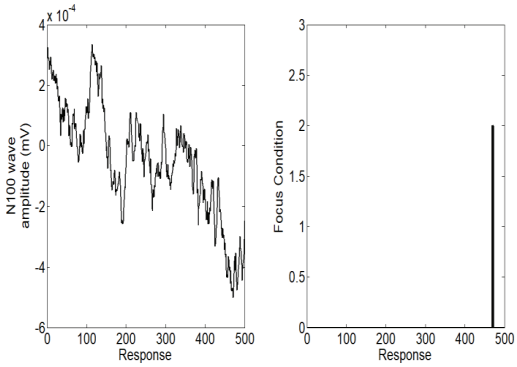

Fig. 10. Subject 10 (Focus OFF)

The morphology of erps could demonstrate one has loss focus by observing the decline of its amplitude and increases or horizontal pattern of erps amplitude over time denotes that the subject focus increases or maintain. However, as shown in Fig. 1 to Fig. 20, the amplitude value of each subject is different which is correspond to the statement of each person has unique erps [16]. A threshold which indicates the significance decline correspond to focus loss is important to be determined in order to develop an alertness device.

The proposed approach is able to detect the decline of amplitude regardless the value of amplitude. This is due to the novelty detection is based on individuals erps. Focus Condition indicates 2 when the erps amplitude declines over time as shown in Fig. 1 to Fig. 2. Where as, "0" was elicited when the erps increasing or horizontal as shown in focus ON group (Fig. 11 to Fig. 20). Based on these results, the proposed approach answers the problem of inter-variability between subjects. However, as shown in Fig. 3, Fig. 4, Fig. 7 and Fig. 8, the decline of amplitude has started after 1 to 2 minutes of recording began. This suggest that some subjects began to have focus loss less than 5 minutes and accidents could happen within this length of time Another observation (refer to Fig.3, Fig.6 and Fig. 10), the amplitude of N100 wave increases again after dramatically drop within the baseline period. This suggests that 5 minutes for baseline determination is quite lengthy and the physiological of the subject may varied within that period. Hence, the information of the significance amplitude decline would be eliminated by averaging method (to determine the baseline) and caused the detection delayed as shown in Fig. 10, the dropping of erps amplitude is clearly seen from the second of 300 but only detected by the system at 470 seconds. Therefore, the length of time for baseline has becomes the next problem need to be solved. If too short, probably not enough information and if too long, to many information of amplitude decrement could be eliminated. Determination of appropriate length of baseline extraction would be next problem to be look into in the future study to improve the method.

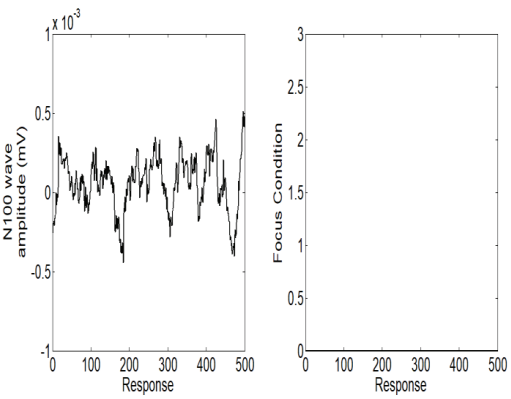

Fig. 11. Subject 1 (Focus ON)

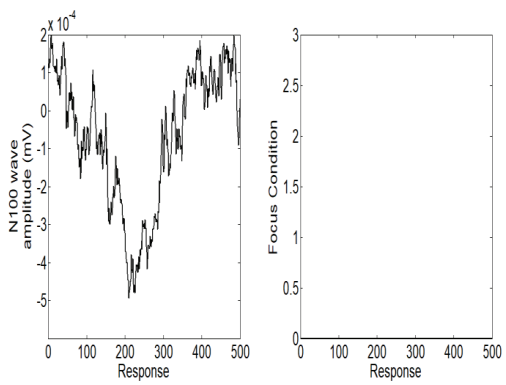

Fig. 12. Subject 2 (Focus ON)

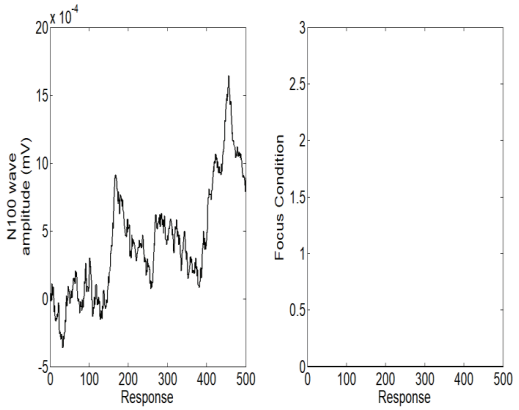

Fig. 13. Subject 3 (Focus ON)

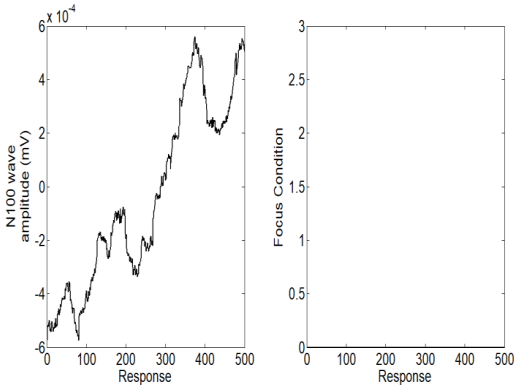

Fig. 14. Subject 4 (Focus ON)

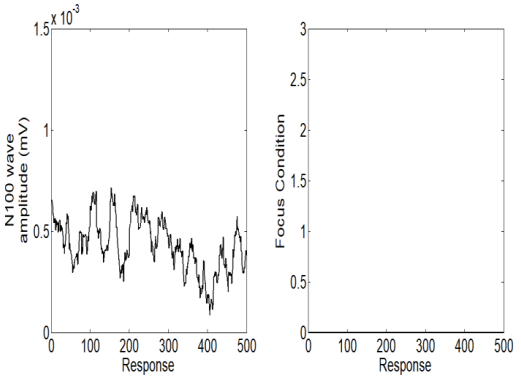

Fig. 15. Subject 5 (Focus ON)

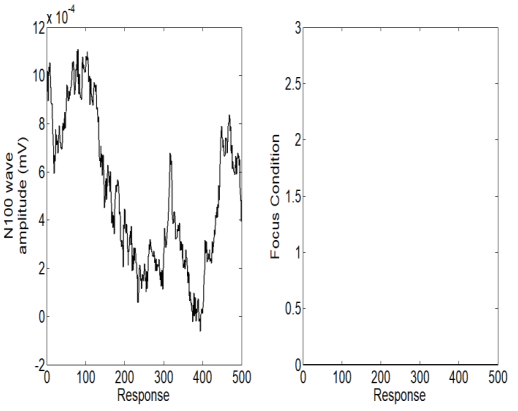

Fig. 16. Subject 6 (Focus ON)

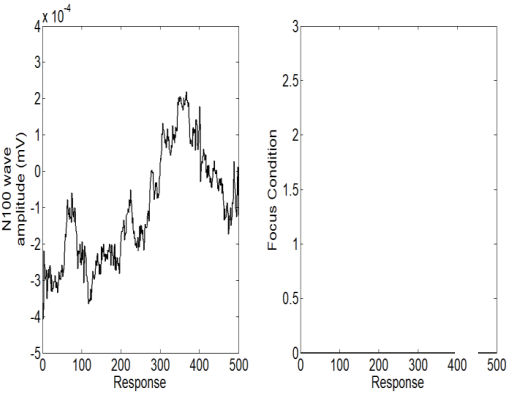

Fig. 17. Subject 7 (Focus ON)

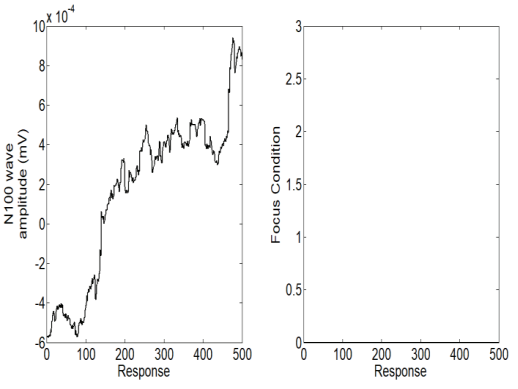

Fig. 18. Subject 8 (Focus ON)

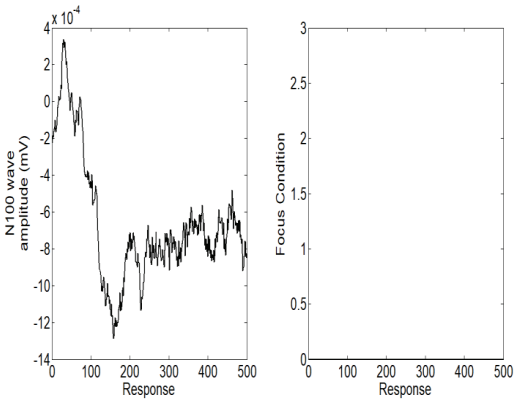

Fig. 19. Subject 9 (Focus ON)

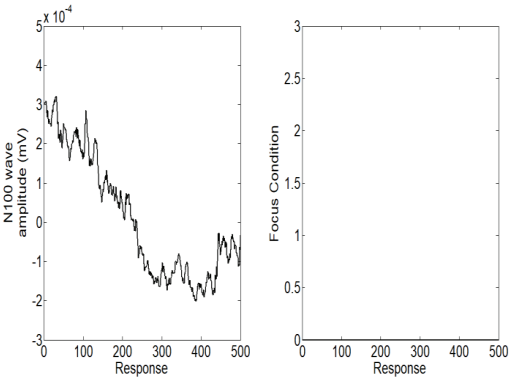

Fig. 20. Subject 10 (Focus ON)

IV. CONCLUSION

The obtained results suggested that the proposed approach detects the attention loss successfully but with a delay as few minutes are needed to obtain the baseline. Novelty detection by using prior stage of recording as baseline is promising but an improvement need to be done to apply it in real time.

ACKNOWLEDGMENT

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