III.International Conference on
Theoretical and Applied Computer Science and Engineering
(ICTACSE, 2018)
Ankara, Turkey, November 23-24, 2018

Analysis of Driver's Cognitive Behavior on Driving Performance Using Reaction Test Simulation and EEG Frequency Spindles

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***Abstract*— Driver's drowsiness becomes a prominent factor that causes the growing number of road accident in the past few years and turns out to be perturbing for Malaysian road safety. Driving a vehicle under drowsy circumstance will affect driving performance and alertness deficiency, which ultimately give rise to a higher chance of collision. This research presents approaches for fatigue and alertness detection based on the electroencephalography (EEG) and power spectrum to evaluate driver's vigilance level in a static driving simulator. The EEG databases are validated using the Karolinska Sleepiness Scale (KSS). The acquired EEG signals are pre-processed and segregated into six frequency range signals. Frequency-domain power spectral density (PSD) feature extraction techniques were evaluated (specifically periodogram, Lomb-Scargle, multitaper, and Welch) with supervised learning classifiers (MLNN, SVM, and KNN) were used to estimate the performance of all the extracted features. Ten-fold cross-validation method was used for validating and testing the reliability of the classifier model. The highest accuracy is obtained from MLNN using Lomb-Scargle PSD with 96.3% and the minimum accuracy is attained from QSVM and KNN with both 62.2% using periodogram and Welch PSD features set respectively.**

Keywords— alertness; KSS; reaction time (RT); PSD; EEG

I. INTRODUCTION

Fatigue and sleepiness while driving were common among the heavy vehicle and car drivers in Malaysia, with various possible causes: acute and chronic sleep deprivation, driving the vehicle for long hours and at different driving patterns, irregular schedule changes, and sleep disorders due to the driver's working conditions, especially at monotonous driving environment. Driving a vehicle under the influences of fatigue/drowsiness will cause longer response time, vigilance reduction and deficits in communication and information processing, which may lead to higher risk of collision and lacks correctness in decision-making, especially at high speeds. Statistics on fatal or injury-causing traffic accidents by Malaysian Institute of Road Safety Research (MIROS) shows that the death-to-population ratio stands at 23.8 to 100,000 Malaysian people, 80% of fatal accidents are due to human errors.

The available technologies for monitoring the driver's cognitive state are still in its infancy and the knowledge of understanding government policies (JPJ, PDRM, JKJR, MIROS, JKR) focusing on 4E (Engineering, Enforcement, Education and Environment) and vehicle manufacturer's strategies are yet not sufficient to prevent from fatal road accidents. In recent years, a variety of methods and approaches have been proposed by researchers for detecting driver fatigue/drowsiness based on eye movements, head movements, and biosignals. Among the various psychophysiological based approaches as an indicative measure, EEG perhaps being the most promising indicators of driver fatigue. However, there are some challenges in developing EEG based driver alertness systems, which includes, lack of a significant index for detecting fatigue and pervasive noise interferences while acquiring the EEG signals in a static driving environment.

Furthermore, driver fatigue may also cause due to task-induced factors such as a high density of traffic, body posture and under exposure to vibration and noise that may not relate to sleepiness. At present, there are no adaptive models to discriminate the correlation between the physical and cognitive consequences of fatigue that relates to driver alertness. Hence, it

This work is supported by the Ministry of Higher Education (MoHE), Malaysia, under grant FRGS/1/2016/TK04/UNIKL/01/1.