is necessary to develop an adaptive driver fatigue identification model considering various environmental and behavioral aspects of the driver and evaluate the level of alertness. The Event-related potentials (ERP) observed from the drivers can be used to identify the cognitive state and fatigue index that may improve the driver's performance capacity and prevents a catastrophic incident. However, there is limited information on the correlation between driver fatigues due to task-induced factors and attitude/behavior. Therefore, understanding the psychology of fatigue may lead to better fatigue-alertness model.

II. Literature Review

Currently, there is a worldwide trend of humanization of criminal legislation and the practice of its application. Western countries tend to move away from punitive, repressive criminal proceedings. Heavy vehicles (E-class license) driver fatigue is a major exogenous cause of road accidents and has implications for Malaysian road safety [1]–[3]. Statistics on fatal road accidents by Malaysian Institute of Road Safety Research (MIROS) shows that the death-to-population ratio stands at 23.8 to 100,000 people (10.3% (lorry) and 1.59% (bus)), compared to the world average of 18 to 100,000 people, human errors is 80% [4]. The major aspect that causes human errors are fatigue or drowsiness due to personality and temperament, lack of sleep, consumption of alcohol, long driving hours and driving patterns such as driving at midnight, early dawn, mid-afternoon hours and especially in the monotonous driving environment, personality and temperament may also influence fatigue [5], [6]. Therefore, preventing such catastrophic accidents is thus a major focus of government policies, vehicle manufactures strategies and research efforts in the field of automotive and safety research [2], [7], [8].

In recent years, there are number of techniques and approaches have been proposed to recognize vigilance changes in the past such as physical changes during fatigue and measuring physiological changes of drivers, such as eye activity measurement, heartbeat rate, skin electric potential, and especially, brain wave activities as a means of detecting the cognitive states [9]–[11]. Therefore, monitoring EEG signals during driver fatigue may be a promising variable for use in fatigue/drowsiness countermeasure systems. EEG based identification of alertness levels have the advantages of making an accurate and quantitative assessment and relatively shorter one to track second-to-second fluctuations in the driver's performance. However, EEG based monitoring fatigue and evaluating the significant index level are still in its infancy and there is lot to explore such as the EEG frequency spindles correlates of fatigue and drowsiness, as well as to evaluate what extent these cognitive-state related EEG activities can be efficiently incorporated into a real-time fatigue monitoring system [1], [7], [12], [13]. Also, there are challenges in processing the EEG signals, which contains pervasive noise interferences while recording the brain responses in a realistic and dynamic driving environment [14].

Therefore, in this research work, it is proposed to develop an adaptive heavy vehicle driver fatigue and alertness model based on EEG frequency bands by combining signal processing algorithms and soft computing techniques such as a neuro-fuzzy algorithm to estimate the driver cognitive state while driving a vehicle in a virtual-based static simulator under monotonous driving environment. To minimize the computational time, the features used for modeling should be minimal. Thus, in this research, it is proposed to minimize the number of features using soft computing techniques and classification using non-linear supervised classification algorithms. The proposed adaptive model identifies the discrimination between the driver's level of fatigue by recognizing whether the driver is fatigue due to task-induced factors or attitude/ behavior using the brain responses, then the level of fatigue is related with sleepiness (i.e. the level of alertness towards driving).

Further, the adaptive model can be utilized to alert drivers and regulators in optimizing the properties of the interface systems in identifying potential catastrophe. The proposed system alerts the driver during fatigue/drowsiness according to the recognition of cognitive state and produces the fatigue index and level of alertness. The proposed system also helps the driver to be more attentive and intuitive to prevent fatal road accidents.

III. Methodology

A. Data Acquisition and Experimental Setup

This research work involves acquiring EEG data from a number of subjects with a specifically designed protocol for Alert Driving (AD) and Fatigue Driving (FD) simulations. In order to acquire drivers' EEG database, two specifics driving simulation procedures were developed. The first procedure is an alert driving session which is recorded in the morning for AD database and the second procedure is fatigue/drowsiness driving session which is recorded in the afternoon for FD database. The developed EEG databases for AD and FD were collected from 10 normal subjects in two different driving procedures. The proposed methodologies involve classification of driver's vigilance level (alert and fatigue) through exclusive mode (subject wise analysis), as illustrated in Fig. 1.

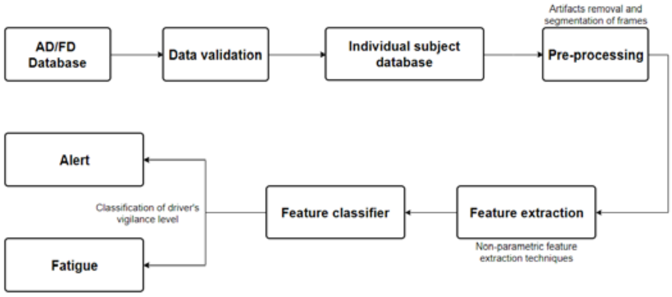

Fig. 1. Block diagram for fatigue and alertness detection model

B. Driving Simulation

The Reaction Test (RT) driving task from OpenDS is selected to be used for the alert and fatigue data acquisition. In RT driving task, there are two sub-tasks that the subjects need to execute during the driving, which are "Slow Down" (X), as shown in Fig. 2, and "Change Lane" (arrow), as shown in Fig. 3. There is a total of 20 sub-tasks need to be completed (10 tasks for "X" and 10 tasks for "arrow") throughout a driving session. The subjects were needed to react as fast as possible on