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REVIEW OF DRIVER PERFORMANCE ANALYSIS FOR DETECTING FATIGUE

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Abstract

Around the world, road accidents and fatalities are frequently caused by driver fatigue. As a result, there has been an increase in interest in creating efficient systems for detecting driver drowsiness. Performance based approaches have become a promising strategy since they rely on tracking changes in driving behaviour or physiological markers. To identify indicators of fatigue, it depends on monitoring the driver's physical and mental performance. Performance-based techniques have the benefits of being non-invasive, inexpensive, and implementable in real-time. The most recent performance based approaches for detecting driver weariness are reviewed in this paper.

Keywords – driver fatigue, detection methods, performance analysis

I. Introduction

Road accidents result in a large number of injuries and fatalities. Drowsy driving, the leading cause of traffic fatalities, is one of the key causes among them. Fatigue is one of the biggest factors in serious car accidents. When physical fatigue occurs, efficiency and capacity to do a task declines. Physical fatigue severely affects physical coordination. During the condition of fatigue, the motor nerves take longer time to react than under normal conditions. Mental fatigue normally follows after severe physical fatigue. The common symptoms of mental fatigue are less desire to do work, absence of concentration and decline of work efficiency. Driving is not only physical, but also a visual and mental task. Drivers under fatigue experiences declination in perception, decision making capability and vehicle control, which leads to serious problems. Fatigue slows reaction time, situational awareness, judgment time which are very crucial for driving job (Körber et al., 2015) (Tamrin et al., 2014). As a result, we should recognise fatigue early on, and this is currently one of the popular subjects for studies.

Performance measurement method of driver fatigue assessment monitors the behaviour of the driver using the vehicle by identifying any change in the normal driving course. These methods rely on the principle that vehicle control will be reduced while driving on fatigue. These methods are non-intrusive in nature and is a direct measure of the performance of the driver who controls the vehicle.

The various performance measurement parameters which provide information regarding driver fatigue are

1. Speed of the vehicle
2. Steering wheel angle
3. Distance from the vehicle in front
4. Lane position
5. Deviation from mean position of road
6. Vehicle trajectory

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II. Steering error and lateral position on road based detection method

During the course of driving, the drivers assess the ahead situation on road and executes steering controls in small increments which are smooth and predictable in nature. This action involuntarily happens during driving. While under distraction of any means, the effectiveness in monitoring the surroundings diminishes and the vehicle deviates laterally. This results in large and irregular steering manoeuvres to correct the error occurred in vehicle mean path. The predictive nature of steering decreases when the corrective manoeuvres increase. This results in steering error. Steering error can be identified using a magnetic sensor. (Boer et al., 2005)

Lateral position is the relative position of the vehicle on the lane with respect to the lane central line. During normal driving situations, the driver follows the centre of the lane. Deviation occurs when the driver is inattentive or performing any special manoeuvres like overtaking, change of direction and cornering. It is generally identified by lane markings at centre line or shoulders using a video camera. (Enache et al., 2009) In this method, mean and standard deviation of steering error along with the number of crossings of standard deviation of lateral position on lane are measured. The measurements are done using a driving simulator in a driving course of 13.9 km for 40 minutes. The data set was divided into one minute long sub interval duration. Analysis was performed using mixed effects model (A mixed model is a statistical model containing both fixed effects and random effects) to identify negative influences in driver performance. (Rossi et al., 2011)

III. Vehicle trajectory based detection method

Vehicle trajectory is the path that a vehicle follows on the road. Vehicle trajectory depends on certain parameters. They include lane deviation, standard deviation of lane position, maximum lane deviation and mean square of lane deviation. Mean square of lane deviation is a reliable measure of driver fatigue. (Havlikova and Sediva, 2016)

In this method, trajectory of the vehicle is assessed using the data received from various sensors placed on the vehicle. The sensors used are steering wheel angle sensor, vehicle speed sensor and sensor of travelled distance. A camera is also used for identifying the change of position of vehicle from the central reference line. (Havlikova and Sediva, 2016)

Actual vehicle trajectory is compared with the ideal geometrical path. Ideal path is obtained by capturing the central line of the road. Statistical analysis, probability analysis and spectral analysis are done on the trajectory data. When the driver is under the influence of fatigue, the dynamic behaviour of the vehicle changes significantly. The vehicle running out of the ideal trajectory was noticeable during the instances when the driver is under fatigue. (Havlikova and Sediva, 2016)

IV. Steering behaviour based detection method

Steering behaviour is considered as the general response of a driver to the steering requirement demanded by input and interferences of driving action. Steering behaviour is part of the overall drivability of the vehicle. Fatigue and micro-sleep at steering often alters normal steering behaviour. Fatigue induces changes in driver's steering behaviour and response time. It causes the steering action to be less precise. Typical indication of steering behaviour change includes less frequent steering movements followed by quick and abrupt movements to correct the vehicle track. On the basis of the frequency of these movements, fatigue can be identified. (Denton, 2014) (Harrer and Pfeffer, 2016)

Steering behaviour is influenced by the following factors.

1. Characteristics of the driving task such as speed of the vehicle, curvature of lane and width of the lane.
2. Driving traits like driver experience.
3. Driver states like laxness, distraction and fatigue.

When driver is under the influence of fatigue, there will be less small and smooth steering adjustments. There will be more zig zag and slow oscillation. Steering entropy (Steering entropy is the measure of steering randomness) will be high and erratic steering movements will be larger. The driver will perform more large and fast steering corrections. (Krajewski et al., 2009)

In this method, a driving simulator is used for data extraction. Steering data extracted are steering angle variation, maximum amplitude of steering movement, steering entropy, zero crossing distance of steering wheel and the mean velocity of zero crossings. Feature extraction is done using brute force feature extraction method. Five dis- tinct machine learning algorithms (SVM-L, SVM-R, 5-NN, DT, LR) are used to predict the fatigue value of the driver. (Krajewski et al., 2009)

V. Driving error based detection method

Driving error is defined as any action or lack of action on the part of the driver which could require him or other road users to carry out corrective action or manoeuvres to make the situation safe (Shinar et al., 1978). Driving error can be measured on the basis of Running-of-the roads (RORI) index and Large Speed Variation (LSV) index. (Tamrin et al., 2014)

RORI index is calculated by identifying the driver's crossing over to the continuous white line at the edge of the passing lane for each second. When the stays on the traffic lanes, the value is zero. If the vehicle crosses the edges, RORI is measured as the distance between front wheel and the edge of the passing lane for each second. In this work, a RORI is calculated as the square root of the sum of the square of amplitudes for one minute duration. (Tamrin et al., 2014)

LSV is the absolute difference between the authorized speed at a particular lane and the vehicle's speed for each second. If the variation in speed is greater than 20km/hr, then LSV is calculated as sum of change in speed for a time of one minute. (Tamrin et al., 2014)

The data thus obtained was statistically analysed and found out that RORI and LSV are significantly related to driver fatigue. (Tamrin et al., 2014)

VI. Headway based detection method

Headway is the safe distance of a subject vehicle behind a leading vehicle in a transit system. When drivers are under the influence of fatigue, reaction time increases so that the corrective action in time of impact diminishes and rear end collision results. Rear end collision is normally because of lack of enough headway. (Zhang et al., 2016)

Headway can be expressed in time or distance. Time headway is defined as the time difference between any two successive vehicles when they cross a given point. Distance headway is defined as the distance between corresponding points of two successive vehicles at any given time. (Mathew and Krishna Rao, 2006)

In this work, a vision-based lane departure warning device is used to measure the time headway (THW). Subjective evaluation of fatigue is done simultaneously. Three parameters of THW are extracted from the data i.e. mean THW, standard deviation of THW and minimum THW. The extracted parameters are analysed and tested for correlation with the subjective measurement. The results showed that when the driver is under the influence of fatigue, the value of THW lowers. (Zhang et al., 2016)

VII. Steering wheel grip force based detection method

A driver under drowsy state will handle the steering wheel more slowly and erratically than on alert state. The steering grip force will be diminished while drowsiness or micro-sleep occurs. This situation may lead to the loosening of steering wheel fully, which will lead to an accident. (Lee et al., 2013)

Steering wheel grip force is measured using a distributed sensor network on the steering wheel. Each unit of this sensor network contains a micro-controller which senses and transmits the information to the network. Every sensor unit is assigned an address which is retrieved by the steering controller along with the information. The sensor element may be capacitive or piezoelectric type. Capacitive type sensor is very light weight and low cost. (Baronti et al., 2009) The sensor unit installed on the steering wheel measures the driver's grip force and send it to the controller unit for processing. The grip force data along with steering angle data and vehicle speed which are available on vehicle CAN network are simultaneously processed. Feature extraction and is done using fatigue detection algorithm (SVM classifier) to detect driver fatigue more accurately. (Baronti et al., 2009) (Lee et al., 2013)

VIII. Conclusion

Driver fatigue is a significant problem that affects millions of drivers each year. Performance based fatigue detection systems are an effective way to detect and prevent driver fatigue, and can help reduce the number of accidents caused by fatigue. Performance based methods rely on monitoring the driver's physical and mental performance to detect signs of fatigue. This approach involves monitoring various driver behavior metrics such as steering patterns and reaction times. While these systems are not foolproof, they can provide an additional layer of safety for drivers, and can help prevent accidents that may result in injury or death. As technology continues to advance, we can expect to see further improvements in performance based fatigue detection systems, making driving safer for everyone.

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