Drowsiness Detection in Drivers: A Review

Pooja C. Rane
M.E. Student, Electronics and Telecommunication Department,
Saraswati College of Engineering, Mumbai University, India

Manjusha Deshmukh, Ph.D
Electronics and Telecommunication Department,
Saraswati College of Engineering
Mumbai University, India

ABSTRACT
Inattentiveness in drivers is the major contributing factor in road crashes. Inattention can be caused by several reasons and one amongst them is fatigue. Fatigue is the subjective feeling of tiredness which is distinct from weakness. Fatigue can be defined as the state of impairment that can include physical, mental or both the elements associated with lower alertness and reduced performance. Thus performing a physical activity becomes difficult with the increasing fatigue level. Fatigue can have physical or mental causes. Alertness of a person is typically characterized by the various visual cues like eyelid movement, gaze movement, head movement and facial expressions. They can also be deduced from the driver's behaviour with the vehicle like distance maintained between vehicles, lane deviation, steering wheel control, breaking and gearing of the vehicle. Mental state of the driver can best be determined from the Electroencephalogram signals. This paper gives a brief review of the various visual and non-visual cues to detect the inattentiveness in drivers and in turn helps in reducing the probabilities of mishaps caused due to the fatigue

Keywords
Fatigue, Electroencephalogram, PERCLOS, Template matching.

1. INTRODUCTION
Driver is highly responsible for watching the road and taking accurate decisions in response to other drivers' actions in the complex task of driving. The driver is said to be vigilant if he is in the state of wakefulness and is able to respond to the external stimuli effectively and is very essential when it comes to safe driving. Drowsy driving was reportedly involved in 2.2 to 2.6 percent of total fatal crashes annually during the period 2005 – 2009, nationwide [1]. Out of the total road accidents, 70% road crashes are due to the drowsiness or inattentiveness in drivers.

- Few warning signs of drowsiness and fatigue are given by NHTSA:
- Can't remember the last few miles driven.
- Have wandering or disconnected thoughts.
- Experience difficulty focusing or keeping eyes open.
- Have trouble keeping head up.
- Drift from lanes or hit a rumble strip
- Yawn repeatedly
- Tailgate or miss traffic signals
- Find yourself jerking your vehicle back into lane.
- Continuing to drive in this condition puts one at serious risk of being involved in a fatigue related.

Detecting this fatigue at earlier stage is very important to avoid accidents, however is equally difficult. Self-reported fatigue detection is the most accurate way to detect drowsiness. However, it sometimes happens that the inattentiveness of driver is persists in an unconscious state of the driver rendering him to report it to avoid mishaps. Thus a lot of computer vision techniques have been researched, developed and implemented to curb the damage caused by the inattentiveness of the drivers. These methods can be either intrusive or non-intrusive. The intrusive techniques are seen to give better results compared to the non-intrusive techniques. However, they are a little disturbing to the drivers. This paper gives an overview of some of the intrusive as well as the non-intrusive methods that can be used to detect the earlier fatigue in drivers to avoid the accidental damages. These techniques can be further developed for advanced fatigue detection. In this paper we will be concentrating only on the review of the drowsiness detection methods based on driver's movements.

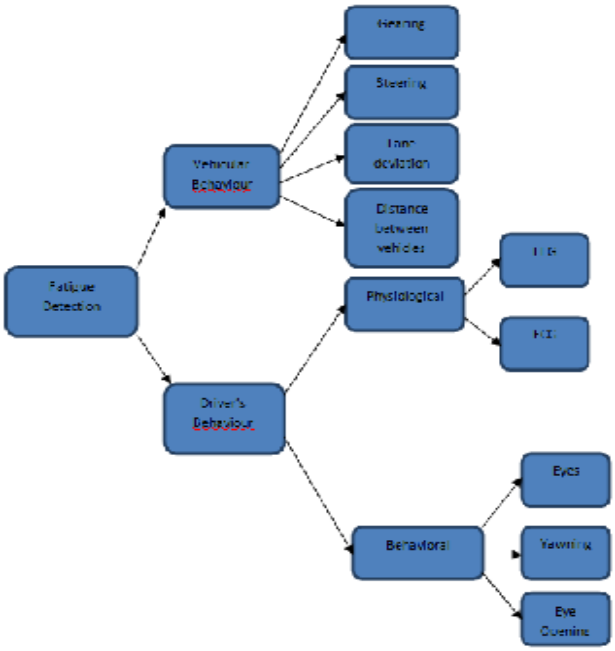

Fig. Classification of drowsiness detection techniques

2. METHODS FOR MEASURING DROWSINESS

2.1 Physiological
Psychological methods are those that are related with the brain. Thus in this method we use the brainwaves to infer the mental state of the driver.

2.1.1 Electroencephalograph(EEG)
EEG signals are the most reliable data signals to interpret the behavior or mental state of a person. A lot of studies have been put forth that investigate the association of the brain

waves and its electrical nature using EEG with the fatigue symptoms. An increased level of alpha activity refers to the decreased cortical arousal whereas the increased level of beta activity associates with the increased cortical arousal. Thus the maximum studies reflect that high frequency waves such as beta (14-32Hz) is observed in alertness and low frequency EEG waves such as alpha (8-13Hz), theta (4-7.5Hz) and delta (0.5-3.5) are observed in the inattentive state of mind[7]. Generally 32 channel EEG data is collected using International 10-20 electrode montage. The signal captured is then pre-processed to remove the artefacts. 20s duration segments are selected from each alert and fatigue state from which the first 20s with the least artefact movement is taken for analysis. Sampling rate is taken as 256 Hz and 2 seconds epochs are spectrally analyzed into four frequency bands for analyzing alpha, beta, theta, delta. Relative power can be calculated by dividing each band by the total power. A total of 2496 vectors are collected to test alert versus fatigue in neural networks [6]. Various network architectures that can be used are Multilayer Perceptrons (MLP), Radial Basis Function networks (RBF), Probabilistic Neural Networks (PNN) using Bayesian statistics and Linear Networks.

2.1.2 Electrocardiography (ECG)

This technique involves determining the percentage of drowsiness based on the rate at which the heart beats. This technique involves placing the sensors on the chest against heart and recording the heart beats. The pulse rate of a person at alert state is observed to be 80-90pulses/sec. However this rate ebbs to a great extent if the person is drowsy [4,5].

2.2 Behavioral

Behavioral methods include those that relate fatigue with the physical movements. Movement or behavior of eyes, head, mouth, heart and pulse is usually observed to detect the drowsiness in drivers.

2.2.1 Fatigue detection through eye blinks

A live video is first captured through a webcam. The video is then divided into frames, where each frame is pre-processed for further analysis. Segmentation is performed on the image to find the area of interest. Eyes are then analyzed for their state. They are continuously scanned to check for the span between two blinks which is usually around 0.45 seconds [8]. If the duration increases then it can be concluded that some fatigue exists. Thus this method works for tracking the occurrence of the features to deduce the drowsiness in drivers.

2.2.2 PERCLOS

PERCLOS is another technique that works for the drowsiness detection based on the ocular status. This method measures the percentage of eye closure. Using Singular Value Decomposition Eigen-eye spaces are created for fully open, partially open and fully closed eyes in the training phase from eye images. These Eigen spaces are used to categorize test eye images to one of these three categories for calculating PERCLOS. Experimental results show nearly 98% accuracy for offline as well as for online categorization of eyes for calculating PERCLOS and level of drowsiness [4].

2.2.3 Template Matching

Template matching is a technique wherein a database is made of the various reference images of the different states of the region of interest. Template itself is an Image. However it is a smaller part of the image which is being considered. The target region of interest is obtained from the target image and then is compared with the reference images from the database to deduce the various states of the eyes. The highest percentage of the matching between the target and reference image gives the state of the driver's eyes. This template matching is generally performed on the HIS model rather than the RGB color model to incorporate the shadowing of the face in the images. This is a very simple technique and gives results up to 95% [9].

2.2.4 Yawning

Yawning is another important symptom of fatigue. It has been observed that the percentage of mouth opening is greater in case of yawning compared to that of speaking [3]. Hence fatigue can be detected by measuring the percentage of mouth opening. This can be done either by template matching or by the corner point detection as explained in [2]. The yawning state of the mouth can also be determined by finding the largest non-skin area in the face area. The three available no-skin areas in the face can be eyes mouth and open mouth. However out of all the three, open mouth will have the largest non-skin pixels [12].

2.2.5 Eye tracking and Detection

Tracking the movement of eyes in the video is the most popular and successful technique. In this technique the center of the eye is detected in the first frame and the center of mass of the eye region pixels is found. Then a 5x5 window is searched around the center of mass to find the darkest pixel which is considered to be the pupil. The eye centers that are analyzed are seen to have the shortest distance to the lips corners. This is how the eyes and lips can be determined and then can further be analyzed for the open or closed state. However this technique fails during occlusion. Hence better system proposed was including blinks of the eyes. This is done by creating a difference image of the frame and its previous frame and then calculating threshold which results in binary image which shows the regions of movements. A recursive labelling procedure is applied to recover the connected components. Hence only few components are obtained. However in case where a large number of connected components are resulted the image is directly discarded. It then waits for the next involuntary blink to locate eye [10].

2.2.6 Eye Detection using Edge Detector

In this novel method, the detected region of eye is subjected to edge detector. The different types of edge detectors available are Canny Edge Detector and Sobel Edge Detector. The canny edge detector has more noise compared to Sobel Edge Detector. As a result, output of Canny Detector has many unwanted edges. Eye status detection is done by performing the sum of the binary output image of the detector. It is obvious that the sum of the image having an open eye will be more as it has more number of edges compared to that of the closed eye. However a problem arises when the lighting conditions in the background interferes with the image [11].

3. CONCLUSION

Some of the methods discussed above are related to the drowsiness detection. However some are intrusive while the other are non-intrusive methods. EEG concept is the most reliable method, however it becomes intrusive for the driver to drive with all the sensors placed around the head. ECG concept also comes with the same limitations. The system becomes irritating to the user. Out of the various systems discussed above template matching is the technique that is used on a large scale since it utilizes image processing making the system n0on-intrusive to the driver. The system is also seen to give the results upto 80% with some of the advanced versions of templates.

4. REFERENCES

[1] Knipling, R., & Wang, J. (1994). "Crashes and fatalities related to driver drowsiness/fatigue". Washington, DC: National Highway Traffic Safety Administration.NHTSA. July, 2008.

[2] Behnoosh Hariri 1, Shabnam Abtahi, "A Yawning Measurement Method to Detect Driver Drowsiness," Distributed and Collaborative Virtual Environments Research Laboratory, University of Ottawa, Ottawa, Canada.

[3] A. Benoit, A. Caplier, " Hypovigilence analysis: open or closed eyes or mouth? Blinking or yawning frequency?", Proc. IEEE Conference onadvanced videoe and signal based surveillance, 2005, pp.207-2122 CogniVue Corporation,Gatineau, Quebec, Canada.

[4] Dinges, D. F., & Grace, R. , "PERCLOS: A Valid sychophysiological Measure of Alertness As Assessed by Psychomotor Vigilance", US Department of Transportation, Federal Highway Administration. Publication Number FHWA-MCRT-98- 006.

[5] Yuan J., Sun D., Lin M., "Changes in physiological parameters induced by indoor simulated driving: Effect of lower body exercise at mid-term break". Sensors. 2009;9:6913–6933.

[6] Kawanaka H., Oguri K. "Driver's Cognitive Distraction Detection Using Physiological Features by the Adaboost", Proceedings of the 12th International IEEE Conference on Intelligent Transportation Systems; St.Louis, MO, USA. 3–7 October 2009; pp. 1–6.

[7] Chin T.L., Che J.C., Bor S.L., Shao H.H., Chih F.C., Wang I.J. " A real-time wireless brain-computer interface system for drowsiness detection", IEEE Trans. Biomed. Circ. Syst. 2010;4:214–222.

[8] Artem A. Lenskiy and Jong-Soo Lee., " Driver's Eye Blinking Detection Using Novel Color and Texture Segmentation Algorithms". In:International Journal of Control, Automation and Systems (2012) 10(2):317-327 DOI 10.1007/s12555-012-0212-0 ISSN:1598-6446 eISSN:2005-4092.

[9] Sunita Roy, Samir Kumar Bandyopadhyay, " Extraction of Facial Features Using a Simple Template Based Method" , IJEST, Vol. 5, July 2013, 1528-1531.

[10] Richa Mehta, Manish Shrivastava "An Automatic Approach for Eye Tracking and Blink Detection in Real Time", IJEIT Vol.1, Issue 5, May 2012.

[11] Kusuma Kumari B.M., " Real Time Detecting Driver's Drowsiness using Computer Vision", IJERT, Vol. 3, Issue 3, May 2014.

[12] Monali V. Rajput, J.W. Bakal, "Execution Scheme for Driver Drowsiness Detection using Yawning Features", International Journal of Computer Applications, Vol.62 Issue 6, January 2013.