A Survey on Automatic Drowsy Driver Detection System in Image Processing
Dr. Amitabh Wahi, Prof. S. Sundaramurthy, Ms. P. Abinaya

Abstract— Due to the increasing growth in population, the occurrence of vehicle accidents has also seen an increase. A detailed analysis shows that, around half million accidents occur in a year, in India alone. Drowsiness and sleeping while driving are now identified as one of the reasons behind fatal crashes and highway accidents caused by drivers. Various drowsiness detection techniques researched are discussed in this paper. These techniques are classified and then compared using their features. Computer vision based image processing techniques is one of them. This uses various images of driver to detect drowsiness states using his/her eyes states, facial expressions and head poses. This technique is on the focus of this survey paper.

Keywords— Driver fatigue, Drowsiness detection techniques, Image processing, Facial expressions, Eye states, Head poses, Accidents

I. INTRODUCTION

Driver drowsiness is one of the significant factor in a large number of traffic accidents. Safe driving is a major concern of societies all over the world. Thousands of people are killed or seriously injured due to drivers falling asleep at the wheels each year. Fletcher et al. in [6] has mentioned that 30% of traffic accidents have been caused by drowsiness. It was demonstrated that driving performance declines with increased drowsiness with resulting crashes constituting more than 20% of all vehicle accidents [7]. Traditionally transportation system is no longer sufficient. It is essential to develop a real time safety system for drowsiness related road accident prevention. There are many methods for detecting the driver drowsiness. The signs of the driver drowsiness are:

- Driver may be yawn frequently
- Driver is unable to keep eyes open
- Driver catches him nodding off and has trouble keeping head up
- The thoughts of the person wander and take focus off from the road
- The driver can’t remember driving the last few miles
- Driver is impatient, in a hurry, and grouchy
- The person ends up too close to cars in front of you
- The person misses road signs or drive past your turn
- Drift into the other lane or onto the shoulder of the road

It includes the measurements of physiological features like EEG, heart rate, pulse rate, eyelid movement, gaze, head movement and behaviors of the vehicle, lane deviations and steering movements. After long hours of driving or in absent of alert mental state, the eyelids of driver will become heavy due to fatigue. The attention of driver starts to lose focus and that creates risks for accidents. These are typical reactions of fatigue, which is very dangerous. Recent statistics estimate that annually 1,200 deaths and 76,000 injuries can be attributed to fatigue related crashes. These accidents can be controlled by development of technologies for detecting or preventing drowsiness. The drowsiness detection fatigue involves sequence of images of a face. The analysis of face images is a popular research area with applications such as face recognition, virtual tools, and human identification security systems.

There are number of different techniques available for analyzing driver’s drowsiness. These techniques are Image Processing based techniques, Electroencephalograph based techniques, Electrooculogram based techniques, Electrocardiogram based techniques, and artificial neural network based techniques. The image processing based techniques can be divided in three categories. These categories are template matching technique, eye blinking technique, yawning based technique, and head pose based technique. These techniques are based on computer vision using image processing. In the computer vision technique, facial expressions of the driver like eyes blinking and head movements are generally used by the researchers to detect driver drowsiness. Various drowsiness detection techniques researched are discussed in this paper.

II. VARIOUS DROWSINESS DETECTION TECHNIQUES

There are various techniques being used by researchers to detect driver drowsiness (shown in fig.1) i) Image processing based techniques ii) EEG (electroencephalograph) based detection iii) Electrooculogram (EOG) based detection
iv) Electrocardiogram (ECG) based detection v) Artificial neural network based techniques.

Image processing is a form of signal processing where the input of an image includes picture or video frame is given and the output of image is an image or a set of features or factors related to the copy. Most image-processing methods involve considering the image as a two-dimensional signal and applying standard signal-processing procedures to it. Image processing can be called as digital image processing, but visual and correspondent image processing also are possible. This paper discuss about overall methods that apply to all of them. The procurement of images (generating the input image in the initial place) is stated to as imaging.

Fig 1: Various Drowsiness Detection Techniques

A. Image Processing Based Technique

In image processing based technique, drivers face images are used for processing so that one can find its states. From the face image one can see that driver is awake or sleeping. Using same images, they can define drowsiness of driver because in face image if driver is sleeping or dozing then his/her eyes are closed in image. And also we can predict their drowsiness with the help of the symptoms like yawning, blinking and head position like nodding, tilting and shaking. And other symptoms of drowsiness can also detected from the face image. We can classify these techniques in four sub-categories.

1) Eye Blink Measurement Technique

Tracking and blinking the eye parameters and detecting eye states are more difficult than just tracking and blinking the eye locations because the eyes occupy a small region of the face. Most eye hunters work well for exposed eyes. Nevertheless, blinking is a functional necessity for an individual. Also, for applications such as analysis of facial expression and driver fatigue alertness methods, it is a necessity to work more than tracing the locations of the individual’s eyes but obtain their complete sketch. We want to improve the state of the eyes (open/closed states), and the constraints of an eye model. We develop a model based method to track the features of an eye that uses convergent tracking methods that show how it can be used to detect either the eyes is open/closed, and to improve the considerations of the eye model. Eye tracking has established an abundant compact of consideration, that blinking is a functional necessity for persons. An example of such a system is the improvement of driver carefulness and accident reduction.

Fig 2: The Open State and the Close State of Eyelid

Fig 3: Flow Graph for Drowsy Driver Detection System Using Eye Blink Patterns

2) Template Based Technique

In this technique, one can use the states of eye i.e. if driver closes eye/s for some particular time then system will
generate the alarm. Because in this techniques system has both close and open eyes template of driver. This system can also be trained to get open and closed eye templates of driver. This method is simple and easy to implement because templates of both open and closed eye states shown in figure 4 are available to system. Researchers have used this technique [5].

3) **Yawning Based Technique**

Yawn is one of the symptoms of fatigue. The yawn is assumed to be modeled with a large vertical mouth opening. Mouth is wide open is larger in yawning compared to speaking. Using face tracking and then mouth tracking one can detect yawn. In paper [10], they detect yawning based on opening rate of mouth and the amount changes in mouth contour area as shown in figure 5. When yawn is detected by system then it alarms the driver.

4) **Head Pose Detection Technique**

Head pose is estimated by calculating optic flow of the facial features. Analysis of the driver’s head behavior leads to three moving components: nodding, shaking, and tilting. To track the gaze direction of the driver, we trace the center point of the pupil using CDF analysis and estimate the frequency of eye-movement. Head pose estimation is a good index that directly shows the current state of the driver. When drowsy, a person’s head is leaned forward due to the weight of the head. However, then, it becomes difficult to breath and the head tries to regain the normal state, which results in nodding. The direction of gaze can be recognized by observing pupil of the eye. Since the position of the pupil’s center indicates the gaze direction. When the calculation of the rotate vector is true then the alarm starts to prevent him from drowsiness.

**B. Electroencephalogram (EEG) Sensor**

The EEG electrode senses the EEG pulses. Then the signal is filtered and amplified by passing through the amplifier and Filter circuit. This analog signal is sampled and converted into Digital signal using the ADC converter. The EEG-signal can be classified on the basis of its amplitude and frequency Range. They are: beta waves (13-25 hz), alpha waves (8-12Hz), theta waves (5-7 hz), delta waves (0.5-4 hz). Ulrika Svensson et al [3]. When a driver gets drowsy a burst of alpha Activity can often be seen in the central regions of the brain (c3 and c4). An increase in alpha activity is thus the first Indicator of drowsiness. However, as mentioned before, some People do not show any alpha activity. As the driver gets Drowsier, alpha activity is replaced by theta activity [1]. When delta activity occurs in the EEG the driver is no longer awake; this is an indicator of deep sleep. In summary the transition from wakefulness to sleep can be described as a shift towards slower frequencies in the EEG. The process differs between individuals but seems to be consistent within the individual.
C. Electrooculogram (EOG) Sensor

Senses eyeball movement using IR sensors, comparators and potentiometers and location of iris is detected by two IR sensors and output is given to two comparators. The low power signal is augmented by the console amplifier and gesture is inverted by the upending amplifier. Analog signal is experimented and where it is transformed into digital signal by exhausting the correspondent to digital convertor. As drowsiness arises the blink duration gets longer, the blink amplitude smaller and the blinks occur more often. The delay in lid reopening increases and velocity of lid opening and closure decreases. These parameters can be detected by the EOG.

D. Electrocardiogram (ECG) Sensor

The sensor determines the Electro-Cardiograph using difference in electrical energy measured from the electrodes placed in driver’s seatback. The ECG pulse obtained is amplified and filtered by the signal conditioning unit and signal is inverted by the inverting amplifier. The analog signal is sampled and converted into digital signals by using the ADC. The frequency domain spectral analysis of HRV shows that typical HRV in human has three main frequency bands: high frequency band (HF) that lies in 0.15–0.4 Hz, low frequency band (LF) in 0.04–0.15 Hz, and very low frequency (VLF) in 0.003–0.04 Hz. Xun Yu et al. [5]. A number of psycho physiological researchers have found that the LF to HF power spectral density ratio (LF/HF ratio) decreases when a person changes from waking into drowsiness/sleep stage. In this proposed research, heart beat pulse signals will be measured by biosensors embedded in the driver’s seat.

F. Artificial Neural Networks (ANNs)

ANNs are computational representations encouraged by an animal's vital nervous schemes (particularly in brain) which are accomplished of machine learning as well as pattern acknowledgement.

Artificial neural networks are generally presented as systems of interconnected “neurons” which can compute values from inputs. A method for detecting drowsiness/sleepiness in drivers is developed. This technique is established on an artificial neural network. Steering angle signals are preprocessed and presented to the ANN which classifies them into drowsy and non-drowsy driving intervals. The method presented here relies on signals from the vehicle steering only (steering angle) and thus presents no obstruction to the driver. A feed forward ANN was trained using an error back-propagation algorithm and tested. The training and testing data were obtained from a previous experiment in a driving simulator driven by 12 drivers, each under different levels of sleep deprivation. The network classifies driving intervals into drowsy and non-drowsy intervals with high accuracy.

IV. REVIEW OF IMAGE PROCESSING BASED DROWSINESS DETECTION

The general model for drowsiness detection using vision based image processing techniques is shown in figure 9. First of all in these techniques they capture images by placing camera in vehicle and get images from video frames. From these video frames one can use face detection algorithms to detect face of driver. After that eyes detection algorithms is used to detect eyes and corner detection algorithm to detect head position. Than eyes and face tracking algorithms are used to track them. Using these various processed images one can detect drowsiness using various symptoms and
techniques which they defined in their systems. Researches carried using this technique is reviewed here. Researchers have attempted to determine driver drowsiness using the following measures: (1) vehicle-based measures (2) behavioral measures and (3) physiological measures. A detailed review on these measures will provide insight on the present systems, issues associated with them and the enhancements that need to be done to make a robust system. We review these three measures as to the sensors used and discuss the advantages and limitations of each methods [12].

Then the exact positions of driver’s eyes and mouth are located according to their geometric features respectively. The method of PATECP (Percentage and Time that Eyelids Cover the Pupils) and PATMIO (Percentage and Time that Mouth Is Open) as well as the new judge rule is used to estimate whether the driver is drowsy. The tests with actual driving video shows that our approach based on eye and mouth features makes the conditions of recognizing the driver’s drowsy state wider accurate[15].

A non-intrusive prototype computer vision system for monitoring a driver’s attention in real time is proposed [2]. The proposed technique uses an active IR illuminator based Hardware system to capture the driver’s Images in the real time environment. The visual behaviors of the driver’s attention level are observed using a software implementation. Images are taken using two cameras mounted inside and outside the test bed. We use a car as a test bed but this system is applicable to a wide range of vehicles like passenger buses, cargo trucks or any other conveyance of similar kind especially when the driving is long. The use of image processing in implementation of the system is, although less accurate, quite comfortable for the driver and easy to implement for long driving. Two webcams are used. These cameras take images after specified intervals of time and then these images are sent to a Laptop running MATLAB for their processing. Viola-Jones face detection algorithm is applied for face detection and tracking of the driver. Color Filtering in RGB space is used in MATLAB to monitor the traffic in front of our car which gives a signal if front vehicle is within a certain range. Moreover, another signal will be generated if the driver is found to be sleepy or if he closes his eyes for long interval of time.

V. CONCLUSION

Various Techniques for drowsiness detection has been reviewed with various conditions. The problem faced by many techniques is the accuracy in dim light condition. An enhancement algorithm is required to improve the quality of the image in dim light condition. Artificial Neural Network based technique with back propagation is assumed to be more efficient for classifying the opened and closed state of an eye to make the detection of drivers’ drowsiness. And the wavelet transform is used to detect the head poses which is mainly focused on efficiency and consistency of the system. Drowsiness of the driver wearing of spectacles also can be detected using Corner detection algorithm. Researches are undergoing some techniques to improve the accuracy. So there is a lot of scope in drowsiness detection using Image Processing.

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