Introduction & Comparison of Driver Drowsiness Detection System

Nikita G Prajapati[1] Asst. Prof. Pooja M Bhatt[2]
[1]Student [2]Assistant Professor
[1,2]Department of Computer Engineering
[1,2]IIET-Dharmaj

Abstract— In recent years, driver drowsiness has been one of the major causes of road accidents and can lead to severe physical injuries, deaths and significant economic losses. So there is a need of a reliable driver drowsiness detection system which could alert the driver before a mishap happens. There are two methods for drowsiness detection. The first one is intrusive methods and the second one is non-intrusive methods. The intrusive methods include measurement of heartbeat rate, mind wave monitoring etc. It is most accurate, but it is not realistic, because sensing electrodes would have to be attached directly onto the user's body, and hence it would be annoying and distracting the user. while the non-intrusive methods include the yawn detection, eye closure, eye blinking rate, head pose etc. It is realistic because it does not irritate the user while driving because no sensing electrodes would be attached to user's body. In this paper, various methods are included by which the drowsiness can be detected and warning can be issued to the driver while driving. And also compared different parameters for different methods.

Key words: Driver Drowsiness Detection, Driver Fatigue, Vehicle Accident Warning, Advanced Vehicle Safety

I. INTRODUCTION

Drowsiness is a process in which one level of awareness is reduced due to lacking of sleep or fatigue and it may cause the driver fall into sleep quietly. When the driver is suffering from drowsiness driver loses the control of the car, so driver might be suddenly deviated from the road and hit an obstacle or a car to overturn. According to available statistical data, over 1.3 million people die each year on the road and 20 to 50 million people suffer non-fatal injuries due to road accidents [6]. Based on police reports, the US National Highway Traffic Safety Administration (NHTSA) conservatively estimated that a total of 100,000 vehicle crashes each year are the direct result of driver drowsiness. These crashes resulted in approximately 1,550 deaths, 71,000 injuries and $12.5 billion in monetary losses. In the year 2009, the US National Sleep Foundation (NSF) reported that 54% of adult drivers have driven a vehicle while feeling drowsy and 28% of them actually fell asleep. The German Road Safety Council (DVR) claims that one in four highway traffic fatalities are a result of momentary driver drowsiness. These statistics suggest that driver drowsiness is one of the main causes of road accidents. In Australia [2] close to 6 percent of accidents is caused by driver fatigue and drowsiness. These statistics in the UK are 16 to 20 percent of accidents reported by police. Legal Medicine Organization of Iran's research shows that most road accidents statistics in the world happen in Iran. The financial costs inflicted in Iran road due to road accidents are estimated about 4000 million dollars (more than 3.5 percent of GDP). According to Iran's Police department in 2006 and 2007, 23% of accidents are caused by driver's fatigue and drowsiness. Considering the available statistics, importance of drowsiness detection systems is unavoidable.

II. DEFINING DROWSINESS

The term "drowsy" is synonymous with sleepy, which simply means an inclination to fall asleep. The stages of sleep can be categorized as awake, non-rapid eye movement sleep (NREM), and rapid eye movement sleep (REM). The second stage, NREM, can be subdivided into the following three stages [6],

- Stage I: transition from awake to asleep (drowsy)
- Stage II: light sleep
- Stages III: deep sleep

In order to analyse driver drowsiness, researchers have mostly studied Stage I, which is the drowsiness phase. Signs of Drowsiness can be categorised as below,

- Difficulty focusing, frequent blinking, or heavy eyelids
- Daydreaming; wandering/disconnected thoughts
- Trouble remembering the last few miles driven
- missing exits or traffic signs
- Yawning repeatedly or rubbing your eyes
- Trouble keeping your head up
- Drifting from your lane, tailgating, or hitting a shoulder rumble strip
- Feeling restless and irritable

A driver who falls asleep at the wheel loses control of the vehicle, an action which often results in a crash with either another vehicle or stationary objects. In order to prevent these devastating accidents, the state of drowsiness of the driver should be monitored.

III. DROWSINESS DETECTION METHODS

The following measures [6] have been used widely for monitoring drowsiness:

A. Vehicle-Based Measures

This method includes deviations from lane position, movement of the steering wheel, pressure on the acceleration pedal, etc., are constantly monitored and any change in these that crosses a specified threshold indicates a significantly increased probability that the driver is drowsy.

In most cases, these measurements are determined in a simulated environment by placing sensors on various vehicle components, including the steering wheel and the acceleration pedal; the signals sent by the sensors are then analysed to determine the level of drowsiness.

B. Behavioural Measures

The behaviour of the driver, including yawning, eye closure, eye blinking, head pose, etc., is monitored through a camera and the driver is alerted if any of these drowsiness symptoms are detected. This technique is well suited for real world conditions since it could be non-intrusive by using

optical sensors of video cameras to detect changes. A drowsy person displays a number of characteristic facial movements, including rapid and constant blinking, nodding or swinging their head, and frequent yawning. Computerized, non-intrusive, behavioural approaches are widely used for determining the drowsiness level of drivers by measuring their abnormal behaviours. Most of the published studies on using behavioural approaches to determine drowsiness, focus on blinking. PERCLOS (which is the percentage of eyelid closure over the pupil over time, reflecting slow eyelid closures, or "droops", rather than blinks) has been analysed in many studies. This measurement has been found to be a reliable measure to predict drowsiness and has been used in commercial products such as Seeing Machines and Lexus. Some researchers used multiple facial actions, including inner brow rise, outer brow rise, lip stretch, jaw drop and eye blink, to detect drowsiness. However, research on using other behavioural measures, such as yawning and head or eye position orientation, to determine the level of drowsiness.

C. Physiological Measures

This technique, is most accurate, but it is not realistic, since sensing electrodes would have to be attached directly onto the user's body, and hence be annoying and distracting to the user. In addition, long time usage would result in perspiration on the sensors, diminishing their ability to sense accurately. The correlation between physiological signals (electrocardiogram (ECG), electromyogram (EMG), electro Oculogram (EoG) and electroencephalogram (EEG)) and driver drowsiness has been studied by many researchers. As drivers become drowsy, their head begins to sway and the vehicle may wander away from the centre of the lane. The previously described vehicle-based and vision based measures become apparent only after the driver starts to sleep, which is often too late to prevent an accident. However, physiological signals start to change in earlier stages of drowsiness. Hence, physiological signals are more suitable to detect drowsiness with few false positives; making it possible to alert a drowsy driver in a timely manner and thereby prevent many road accidents.

IV. COMPARISON OF DIFFERENT PAPERS

	An Efficient System to Identify User Attentiveness Based On Fatigue Detection [1]	**Driver Drowsiness Detection Using Face Expression recognition [2]**	**Development of an Efficient System for Vehicle Accident Warning [3]**	**Development of a real-time drowsiness warning system based on an embedded system [4]**	**A physiological measures-based method for detecting inattention in drivers using machine learning approach [5]**
Implementation area	Image processing	Image processing	Image processing	Embedded system, brain wave	Machine learning
keywords	face detection, eye blinking rate, eye closer count, yawning, edge density, threshold value.	Face detection, face component detection, Infrared sources,	Vehicle Accident Warning, Advanced Vehicle Safety, Intelligent Vehicles, Driver Fatigue Warning, Eye Tracking System, Driver Assistance	mind wave, EEG, embedded system, real-time	ECG, EMG Physiological measures, Driver inattention, Driver distraction
Methodology	Eye Blink Rate, Yawning detection, Eye State Detection	Yawning detection, Eyebrow monitoring, Eye State Detection	Eye State Detection, Vehicle Distance measurement	data classification, Brain signal analysis, Data transfer	Heart rate, visual and cognitive inattention features
Resources used	Camera, Matlab, Laptop	Camera, Infrared Light, Matlab, Laptop	2 Camera, Laptop, Matlab, hardware alarm, vibration Alert	NeuroSky, RF headset WinCE embedded system, dsPIC microchip	Illuminator, IR-camera, Driving simulator, LCD screen, laptop and DAQ devices, Electrodes
Advantages	Lightweight code, simple method	Can work in dark, uses eyebrow monitoring	Non-intrusive, Software based, Alerts	Higher accuracy, easy implementation due to readily available hardware and software	accuracies of 98.12% and 90.97% for the ECG and EMG
Disadvantages	Face needs to be in exact centre	Face needs to be in exact centre	Costly, Short battery life, slow reaction time	No particular research data is available for	Intrusive, non-realistic

				drowsiness detection	
Algorithms	Sobel edge detection, Erosion	Background sub.(face), Horizontal Projection (Eyebrow), template match (mouth)	Viola & jones, image comparison	Alpha and beta brain wave monitoring	electrocardiogram (ECG) and surface electromyogram (sEMG) signals

Table 1: Comparison of different implementation methodologies for driver drowsiness detection systems

Implementation of driver drowsiness detection systems is done in past with different methods. The comparison between different implementation methodologies for detecting driver drowsiness is as shown in table 1. Different parameters are taken for comparison such as Area of implementations, implementation methodologies, Resources used and Algorithm of implementation.

The intrusive methods are heartbeat monitoring [5] & brain wave monitoring [4]. The heartbeat monitoring method includes measurement through ECG & EMG signals. The advantage of this method is, it is highly accurate, but it has disadvantages like it is an intrusive method. Using the sensors for longer period, results the false data due to perspiration, so it is non-realistic method. The other intrusive method is brain wave monitoring method. In this method the alpha and beta wave are monitored using sensors on head. It was developed on a dedicated embedded system. The waves between 12 to 30 Hz are beta waves. They are associated with concentration. The waves between 8 to 12 Hz are alpha waves. They are associated with relaxation and state of mental calm. The resources used in this method was readily available, so that makes the implementation easier and faster. The accuracy of brain wave monitoring method is also high, but it is also affected by the surrounding signal noise and it is not comfortable for driver to wear the device on head while driving. So it makes it non-realistic to use.

The non-intrusive method used in other systems is image processing. Most systems [1, 2 ,3] use driver's facial features to determine if the driver is drowsy or not. Some system [3] also use the image processing technique to check the distance of other vehicle from driver's vehicle.

All image processing methods [1, 2 ,3] use eye state detection as primary property to detect drowsiness. Some method [1, 2] uses yawning detection to detect the drowsiness in early stages. Eye blinking rate [1] & eyebrow monitoring [2] can also be used for this purpose. Eye blinking rate remains moderate in normal state of driver, but increases or decreases when driver is feeling drowsy. The infrared Light source [2] and camera can also be used to make image processing more effective. By this the result can also be achieved in darker environment, especially at night time. The vibration alert [3] can also be used to provide a warning to the driver, when the system detects drowsiness. This provides additional warning, rather than only providing sound warning.

All image processing systems [1, 2, 3] are developed on MATLAB. The Software MATLAB was installed on PC/LAPTOP, and image processing was done using webcam. This setup provides easiness of implementation, as the MATLAB contains most of the codes readily available in it, only algorithm is needed to be developed. There are also several disadvantages of MATLAB. It is Costly and bulky software. In terms of performance and response time, result of MATLAB is also poor. If the hardware alarm & vibration alert [3] is also used, it will add additional delay in the system.

The setup with Laptop becomes larger in size. The working of system totally depends on battery of laptop. So it becomes unreliable to use this setup in real working condition.

Different algorithms are used for image processing techniques. Sobel edge Detection [1] Algorithm is used to detect edges in image, in order to detect the facial features. RGB to grey conversion is done [1, 2, 3] to process the image. Erosion/dilation method is to blur the image. The background subtraction [2] & viola and Jones [3] algorithm is used detect face from image. The horizontal projection [2] method is used to detect eyebrow & template matching [2] is used to detect mouth state, for yawning detection. The image comparison [3] method is used detect eye state by taking reference images with open and close eyes at start up of system.

V. CONCLUSION

In this paper, review of driver drowsiness detection is given. Different methods for detecting drowsiness are explained. The comparison of different implementation methods is also given. This paper gives a brief review of methods, implemented in past, as well the algorithms, advantages & disadvantages are also discussed. After study of all this methods, it seems like driver's facial feature extraction method is more realistic for this application. The main advantage of this method is, it is non-intrusive method, so it does not distract driver while operation, as well it does not introduce any discomfort to driver during operation. The problem associated with this method is, it is implemented on MATLAB, so it is slow & less responsive. It works on Laptop, which also make it unreliable for use in real environment. Some solutions for this problem are,

- Using a small size computer board (i.e. Raspberry Pi which is size of a credit card) to reduce size & power consumption
- Using openCV instead of MATLAB to increase performance and response of application

It is possible that, using the above solutions, the application may become more reliable and more responsive.

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