Design of Real Time Drowsiness Detection & Monitoring System

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Abstract— This project is focused on drowsy driver detection and the objective of this project is to recognize driver's state with high performance. Drowsy driving is one of the main reasons of traffic accidents in which many people die or get injured. There is a substantial amount of evidence that suggests that driver drowsiness plays a significant role in road accidents. Driver fatigue is the major cause of accidents in the world. Detecting the drowsiness of the driver is the surest ways of measuring the driver fatigue. The purpose of this paper is to develop a drowsiness detection system. This system works by analyzing the eye movement of the driver and alerting the driver by activating the buzzer when he/she is drowsy. The system so implemented is a nonintrusive real-time monitoring system for eye detection. During monitoring, the system is able to decide whether the eyes were opened or closed. When the eyes were detected closed for too long, a signal was issued to warn the driver. In addition, the system also has an option for making vibration when drowsiness was detected. The aim is on improving the safety of the driver without being obtrusive.

Key words: Drowsiness Detection, Eye Blink Detection, Eye Tracking, Eye Monitoring, Image Processing

I. INTRODUCTION

The word "drowsy" means "sleepy" that is, having a tendency to fall asleep. Drowsiness usually occurs due to insufficient sleep, variety of medications, and also due to boredom caused by driving vehicles for long periods of time. In a drowsiness state, a driver will lose control of his vehicle resulting in an accident. According to WHO reports, every year, more than 1.3 million people die in road accidents and 20 to 50 million people bear severe injuries and disabilities because of road side accidents [1]. To alleviate this problem and to avoid these destructive mishaps, the state of driver needs to be constantly under observation.

The never-ending history of traffic accidents all over the world is due to deterioration of driver's vigilance level. Drivers with lack of vigilance level suffers from a marked decline in their perception, recognition and vehicle controllable ability, therefore pose a serious danger to their own lives and lives of other people. For this reason, developing systems that monitors the driver's level of drowsiness and alerting the driver of any insecure driving condition is essential. Vehicle accidents are most common if the driving is inadequate. This happens when the driver is drowsy or if he/she is alcoholic. Driver drowsiness was recognized as an important reason in the vehicle accidents.

In recent years driver fatigue is one of the major causes of vehicle accidents in the world. A direct way of measuring driver fatigue is measuring the state of the driver i.e. drowsiness. So it is very important to detect the drowsiness of the driver to save life and property. This project is aimed towards developing a prototype of drowsiness detection system. This system is a real time system which captures image continuously and measures the state of the eye according to the specified algorithm and gives warning if required. Though there are several methods for measuring the drowsiness but this approach is completely non-intrusive which does not affect the driver in any way, hence giving the exact condition of the driver. For detection of drowsiness the per closure value of eye is considered. So when the closure of eye exceeds a certain amount then the driver is identified to be sleepy.

The paper is organized as follows: Section 2 presents a literature survey which discusses previous drowsiness detection methodologies presented by different researchers, their strengths and weaknesses in detail. Section 3 discusses the proposed technique in detail. Section 4 describes the results and analysis. Section 5 presents the future work and concludes the paper.

II. RELATED WORK

In this section, we discuss various methodologies that have been proposed by researchers for drowsiness detection and blink detection during the recent years. Strengths and weaknesses have been identified for each technique and suggestions are given for their improvement in future.

Mandeep and Gagandeep [2] in 2012, proposed a method that detects drowsiness using the mean sift algorithm. It perform real time eye blinks detection using a webcam in 640x480 resolution. Eyes are detected from each frame and each eye blink is measured against a mean value. The system compares the eye opening at each blink with a standard mean value and an alarm is triggered if the eye opening exceeds this value for a certain amount of consecutive frames. The authors have recorded an accuracy of 99%. In addition, it runs at a 640×480 resolution that is valid for real-time circumstances. In this algorithm, the system has to retain information about the past frames because the eye blinking measurements from a collective amount of frames are used to monitor drowsiness.

Vitabile et al [3], in 2011 presented a real time drowsiness detector to be used in vehicles. An 850nm infrared light source is fixed on the car dashboard causing a bright pupil effect. This makes eye detection easier as the eye's retina has a property of reflecting 90% of the light incident on it. Drowsiness state is identified when the eyes are more than 80% closed for a certain period of time. Efficient image processing techniques are combined with established hardware technology like Field Programmable Gate Array (FPGA). This permits real time drowsiness detection and enable the system to process an entire 720x576 frame in 16.7 microseconds. FGPA's scalability and code reuse may help to cut down the costs of development. Some false detection has been observed during experiments in the presence of eyesight glasses or the objects reflecting the infrared rays. Further work is required to overcome the limitations in eye detection of glasses wearers to make it available for all type of drivers and enabling the system to support infrared reflecting objects.

Flores et al [4], in 2009, presented a component for Advanced Driver Assistance System (ADAS) to automatically detect drowsiness. The module uses artificial intelligence algorithms along with the visual data being captured. The system identifies and monitors the face and eyes and determines drowsiness using support vector machines (SVMs). The system is designed to work under changeable light conditions in real time. This system works by taking into account further other distractions of the driver apart from eye blinking i.e. yawning, head tilt and face orientation are also monitored to detect drowsiness which makes the system highly reliable. Limitation of the proposed system is that the results show some percentage error which means that the system may cause some unexpected false alarms. In future main focus shall be to decreases the false alarms. For achieving this more tests should be conducted, with different drivers and by integrating new modules.

Chuang-Wen et al [5], in 2013 introduced “CarSafe”, the first android smart phone application for drowsiness detection. The application requires a dual camera Smartphone and operates by switching between two camera pipelines. The front camera pipelines monitors the driver’s eye blinks rate and head pose to determine drowsiness. Back camera takes the vehicle based measures into account. It determines the vehicle’s distance with other vehicles on the road to check if driver is close to other vehicles as well as check the lane change situation. Carsafe has an 83% precision and 75% recall.

Sahayadhas et al [6], in 2013 used EOG (Electroculogram- signal that measures cornea-retina potential difference) to monitor eye movements. The readings are then used to detect driver’s drowsiness. The researchers have exploited physiological signal based measures to detect drowsiness which are more accurate and reliable as they use information about the internal state of the driver. There are various other physiological measures e.g. EEG (Electroencephalography), ECG (Electrocardiography), EMG (Electromyography) which could also be used to improve efficiency of the system. In the future ECG (Electrocardiography-detecting heart signals) and EMG (Electromyography-studying muscle activity) signals can be combined with the vision based measures for more accuracy in making decision about the driver’s state.

III. Methodology

Fig.1 shows an abstract level flowchart of the proposed Methodology.

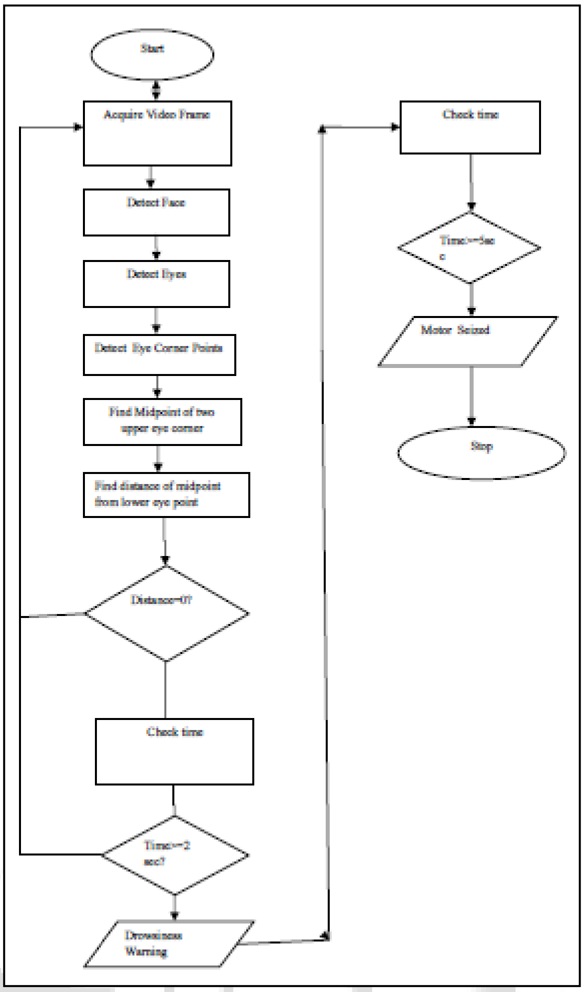

Fig. 1: Flowchart for Proposed Algorithm

An outline of the algorithm is provided below:

1) Step 1: Acquire video frame from the capturing device.
2) Step 2: Detect face.
3) Step 3: Detect and crop the eye region.
4) Step 4: Find the two eye corners and one point on the lower eye lid. (Fig. 2 shows the required eye points).
5) Step 5: Find midpoint of the two upper eye corners and find its distance from the lower eye lid point.
6) Step 6: If the distance is zero or near to zero, the eye state is classified as “closed”.
7) Step 7: If the eye state is “closed” constantly for 2 or more seconds, the driver is assumed to be drowsy and an alarm is triggered.

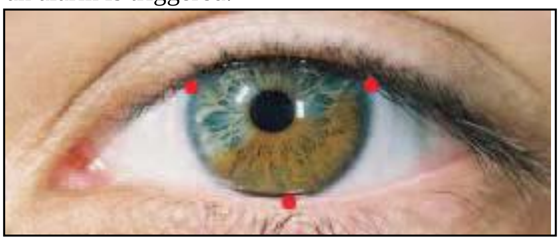

Fig. 2: Required Eye Points. Eye Image [9]

IV. PROPOSED BLOCK DIAGRAM

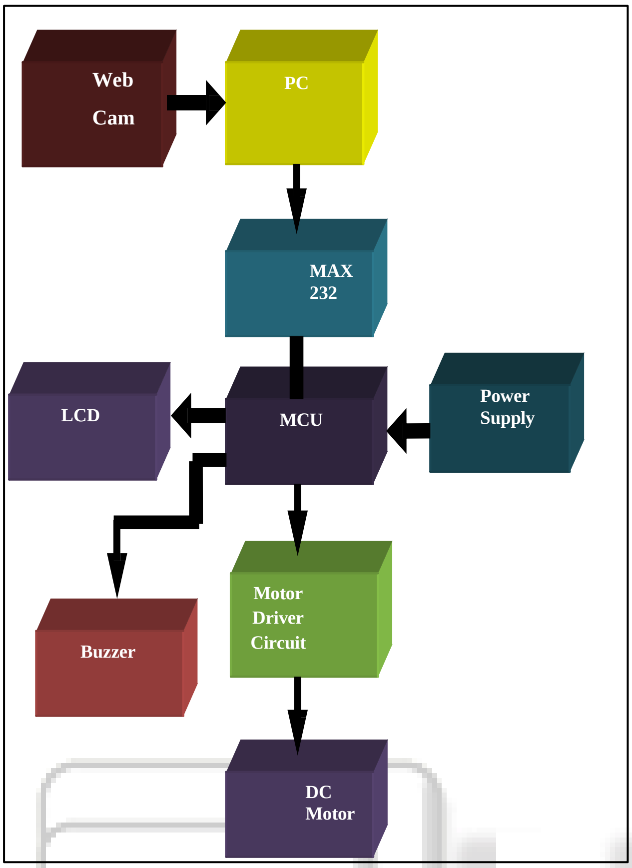

Fig. 3: Block diagram of proposed system

In this section, each step of the proposed technique is discussed in detail.

A. *Face Detection*

First step of the algorithm is to extract the face region from the input video frame. For this purpose the Viola Jones [7] algorithm has been used. Paul Viola and Mike Jones, in 2001, presented the first ever real time face detector. This algorithm classifies images on the basis of values of simple features [7]. Its main benefits are speed and accuracy, as it achieves detection rates comparable to best systems and is much faster than the most of them. A distinctive quality of this algorithm is that it uses rectangular features instead of individual pixels. At first, sum of pixels is calculated within a rectangular box. Combination of box sums form features. Fig. 3 shows rectangle features with respect to the enclosed detection window. Two rectangle features are shown in (A) and (B) while (C) and (D) shows three and four rectangle features respectively [7].

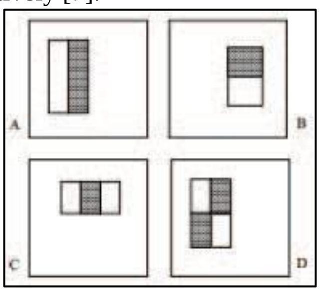

Fig. 4: Rectangle features relative to the enclosing detection window[7]

To compute these rectangle features rapidly and faster, Viola and Jones introduced a representation of the image called integral image. They demonstrated that using this integral image, four array references can be used to compute any rectangular sum. The task of preparing the classifier to select the best feature from the all the features uses the characteristics chosen by Adaboost[7]. Adaboost is a computational approach that finds a single rectangle feature using a weak learning algorithm. The weak learner finds out the best threshold classification function for each feature, such that there is least misclassification of examples. Most of the area, in an image, is non-face region. Hence the better idea would be to discard a region if it is not a face region, and do not process it again. In this way, more time is left to look for a possible face region. Viola and Jones established the idea of "Cascade of Classifiers" to carry out this mechanism. In this method, the features are classified into various steps of classifier. Each feature is applied one at a time, instead of applying all 6000 on a single window. If a window does not pass the first phase of features it is rejected and all other features on it are also discarded. If it passes, the second stage is applied to the window and the method continues. The window that successfully passes through all these stages is selected as face area. This is diagrammatically illustrated in Fig. 4[7].

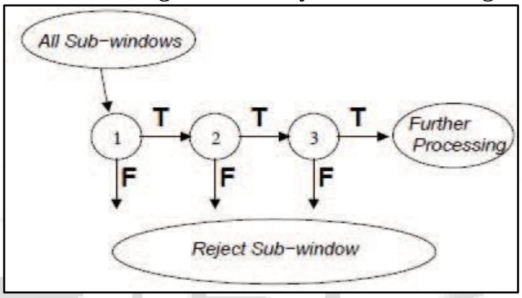

Fig. 4: Cascade of Classifiers [7]

B. *Eye Detection*

Once the face is identified, the Region of Interest (ROI) is set to the face rectangle, detected by the Viola Jones algorithm. On this region again the Viola Jones Cascade classifier is applied to detect eyes. Viola and Jones introduced Haar like features for eye detection [8] which are shown in Fig. 6.

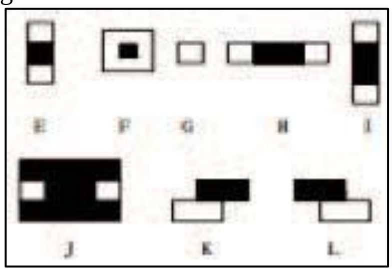

Fig. 6: New Features added to the Viola and Jones paper for eye detection[8]

C. *Eye Blink Detection*

In this section, a step wise description of the proposed blink detection technique is presented along with the experimental results of each step.

1) *Grayscale Conversion*

The colored eye image is first converted to grayscale. Gray scale conversion algorithms use the following three steps to convert color image to grayscale.

1) Take green "G", red "R" and blue "B" values of image pixels.
2) Use any formula method to convert those RGB values into one gray value.
3) New grayscale value replaces original RGB value of image pixel.

For grayscale conversion "Luminosity Algorithm" [9] has been used. The luminosity first averages the R, G, B values of a pixel. This is given as:

$$(R+G+B)/3 \qquad (1)$$

Then it forms a weighted average to deal with human sensitivity [9]. Green is weighted most heavily as human eye is more sensitive to this color.

The formula for luminosity is

$$72G+.21R+.07B \qquad (2)$$

(2lue is replaced with the original value of the pixel. Results of applying the Luminosity Formula to the eye region are shown in Fig. 8.

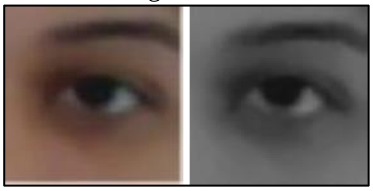

Fig. 8: Eye Image (a) Colored Image (b) Grayscale Image

2) Corner Detection

Corners are defined as intersection of two edges. We propose an eye blink detection algorithm that uses the two eye corner points and one point at the lower eye lid. To detect these points, Harris Corner Detector has been used. The reason for using Harris Corner Detector is one of the most used corner and interest point detector and is invariant to illumination variation, image noise, scale and rotation. Harris Detector calculates difference of the corner on the basis of direction directly [11]. It uses a mathematical approach to determine which case holds for a given point from the following possible cases [11]:

1) flat region implies that there is no change in any direction
2) edge implies that there is no change along the edge direction
3) corner implies a significant change in all directions

This corner detector makes use of the fact that a corner is simply the point where two edges intersect. In other words it is the point at which the two edges change direction. The image gradient has an increased variation in both directions, which can be used to detect it. This "variation" is determined by Harris Corner Detector. On applying the Harris Corner Detector on the input eye image we get the points as indicated in Fig. 9.

Fig. 9: Corner points after applying Harris Corner Detector

3) Midpoint Calculation

Let(x1,y1) be the coordinates of upper left corner and(x2,y2) be the coordinates of the upper right corner. A line segment is drawn between these two points. The midpoint of this line segment can be calculated using the following formula [12]:

$$X1+X2/2, Y1+Y2/2 \qquad (3)$$

Fig. 10 (a) shows the line segment drawn between the two points. (b) Illustrates the midpoint of the line segment.

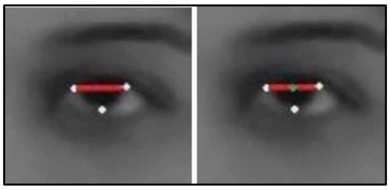

Fig. 10: (a) Line Segment drawn between two upper corner points. (b) Midpoint between the corner points shown in green.

4) Distance Calculation

Distance is a mathematical description of how far objects are from each other. As next step, we find distance of the midpoint from the point at lower eyelid. In analytic geometry, distance between two or more points is calculated by using the distance formula given by the Pythagorean Theorem[13]. The distance between two points (x1, y1) and (x2, y2) is given as:

Fig. 11 illustrates the line segment that joins the midpoint to the point at the lower eyelid.

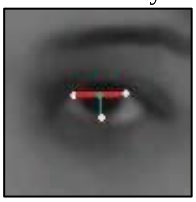

Fig. 11: Line segment that joins mid point to the point at the lower eyelid

5) Eye State Determination

Finally the decision for the eye state is made on the basis of distance 'd' calculated in the previous step. If the distance is zero or is close to zero, the eye state is classified as "closed" otherwise the eye state is identified as "open".

Authors	Technique	Accuracy	Testing Data	Testability	Intrusive	Bad Illumination	Camera Type	Working with sun glasses /spectacles	Working with Face Tilted	Real time	Error Rate
Mandeep et al 2012.	Eye Blink Monitoring using Mean Sift Algorithm	99.4%	Not Specified	Yes	No	No	Webcam	Not Specified	No	Yes	1%
Salvatore, et al 2011.	FPGA based prototyping	Not Specified	Not Specified	Yes	No	Yes	IR CCD Camera	Not Specified	Yes	Yes	Not Specified

Flares, et al 2009.	Face and Eye monitoring based on neural networks & visual information	95.6%	5	Yes	No	Yes	Monocula r Camera	Yes	Yes	Yes	4.4%
Chuang-Wen, et al 2013.	Computer Vision & Machine Learning Algorithm	83%	12	Yes	No	Not Specified	Dual camera smartphon e	Not Specified	Not Specified	Yes	17%
A.Sahayadha s, et al 2013.	Electroculogr am and vehicle based measures	Not Specifi ed	15	Yes	Yes	Yes	Not Specified	Yes	Yes	No	Not Specifie d
Proposed Technique	Real Time Drowsiness Detection using Eye Blinks Monitoring	94%	16	Yes	No	No	16MP webcam	No	Yes	Yes	6%

Table 1:

V. RESULTS

An analysis table for the proposed algorithm is shown in Table I. The table shows that results depend significantly on the camera resolution and illumination conditions. The algorithm was tested using a high and a low resolution camera, under varying lighting conditions. With a 16 Megapixel camera high percentage of accuracy is achieved provided the lighting is normal or bright. Under bad illumination, the results are poor, even with a high resolution camera. When a low resolution camera was used, a high percentage of missed detections were observed. However under bright illumination, results are improved significantly. Table II shows the analysis table for the drowsiness detection techniques discussed in the literature survey. From the table it is clear that the technique proposed by Flares et al is the most efficient, providing an accuracy of 95.6%. This system is able to work under variable lighting and percentage accuracy. Sahadhayas et al's technique supports varying lighting conditions and different face positions but this technique does not run quite accurately in real time and is intrusive. conditions and also works if the driver's face is slightly tilted to the side. Their system also provides positive results even if the driver is wearing sun glasses. The second most efficient is Mandeep et al's algorithm which provides 99.4% accurate results with a negligible error rate. The system is non intrusive, that is, it does not distract the driver but the system cannot work under bad illumination conditions. It also does not support driver's wearing sun glasses. Chuang-Wen, et al's technique has shown 83% accuracy over a dataset of 12 videos. The paper does not describe the working of the system under varying face orientations. Flares et al's facial expression recognition is able to cater both varying lighting conditions and different face orientations. It also supports drivers wearing spectacles. However, this paper does not elaborate the test results.

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