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Driver Drowsiness Detection System Based on Eyes using Canny Edge Detection Algorithm

Kusuma Kumari B.M, Ramakanth Kumar.P, B.L. Mukundappa

Abstract*: Driver drowsiness is the main issue in an ample of vehicle accidents. Annually hundreds of people lose their life or get seriously injured because of sleepiness of the drivers while driving. In this paper, we are mainly concentrated on eyes and Viola Jones algorithm has used to find the Face detection. The eyes are found using the Haar-like features. If the eyes are open then the Iris detected using Canny edge detection with circles drawn on the Iris using Circular Hough Transform algorithm if the driver is alert then two circles appear around the eyes otherwise warning message is displayed to the driver with an alarm signal.

***Keywords*: drowsiness, accidents, canny edge detection, circular hough transform.**

I. INTRODUCTION

The discoveries in the vehicle industry in the last hundred years have made our vehicles more forceful and simpler to drive. The innovated gadgets have ensured control and safety with more energy, efficiency and environment friendly.

The Transportation of goods and people from one location to another through road is called as road transportation. All over the world daily, million and millions of people and vehicles are using the road transportation for their travel.

With the increase in population, there is a sharp increase in demand for public or own vehicle transportation. In today's modern world, almost every person is using the transportation vehicle to reduce time and increase productive work. This practice can also be considered as a luxury for their own comfort. This has become a necessity in a common man's life. Motor vehicles are utilized for many purposes like transportation for general public, things and also for private journeys. With such a huge increase not only in population but also in transportation of vehicles the main concern all over the world is "SAFE DRIVING".

The numbers of road accidents are drastically increasing. As per the survey carried out by various agencies, it is globally estimated that annually around 12 lakh people are killed and around 5 crores people are sustained to minor or major disability / injury in road accidents. Such road accidents are figured as tenth main root cause for the death all over the world. If the present trend continues till 2025, then the road accidents would be figuring as the third leading contributor for the global death. Therefore the road accidents are one of the main reasons for economic losses to the respective families, individuals and nation at large. The Fig. 1 shows the severity of the road accidents.

According to the Global Road Safety Report 2017 in India alone the total around 5 lakh road accidents are notified, in that 1,47,913 are death cases and 4,70,975 are injury cases. Every day around 400 deaths and 1300 injuries are reported. It is also reported every hour that around sixteen Indians die and 53 are injured in road accidents.

Fig. 1. Severity of Road Accidents

II. LITERATURE REVIEW

To monitor the road accidents fatigueness is an important factor [1] [2] [3] [4]. About 20 % of road accidents are because of driver fatigueness while driving on the road. The driver's performance while driving with drowsiness deteriorates and results in road crashes [5].

Various road accidents occur because of driver sleepiness on the wheels [6]. To detect driver's fatigueness and warn the driver in time before the accidents occurs is definitely beneficial to the driver to save lives. For traffic accidents driver fatigueness is the main factor. To detect and prevent fatigueness of the driver is a major challenge to avoid accidents using new technologies. Due to hazardous driving, accidents occurs. The drowsiness and hazardous driving has to be counter attack by the metrics mentioned above and reduce the effects of accidents and its after math.

A system proposed to determine whether eye is open or in closed state, depends on the comparison and differences between Pupil or Iris colour and white part of the eye in open state and the eyes state is determined by using the vertical projection [7].

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* Correspondence Author
Dr. Kusuma Kumari B.M*, Department of Computer Science, University College of Science, Tumkur University, Tumakuru, India. Email: kusuma.kuku@gmail.com
Dr. Ramakanth Kumar .P, Department of Computer Science and Enginerring, R.V. College of Engineering, Bengaluru, India. Email: ramakanthkp@rvce.edu.in
Dr. B.L.Mukundappa Department of Computer Science, University College of Science, Tumkur University, Tumakuru, India. Email: blmukundappa@gmail.com

Jo et.al proposed the method for detecting drowsy driver and distraction by monitoring the system is vision based. In this system new eye detecting algorithm that combines adaptive template matching, adaptive boosting and blob detection with eye validation are used. It significantly reduces the processing time. Support Vector Machine (SVM) is used for enhance eye detection. Principal Component Analysis (PCA) and Logical Analysis of Data (LAD) with statistical features such as the sparseness and kurtosis for detecting eye state [8].

III. METHODOLOGY

A non-intrusive mechanism vision based concepts has been developed to find driver's drowsiness. The system uses a good quality camera to capture the facial features of the driver & observers eye to eye to find the driver's fatigueness. The proposed system works for both offline as well as real time environment. This system describes how to find the face with eye & also establishes whether the driver is drowsy or not by looking at the eyes.

The System contains the following procedure

- Video Acquisition
- Divided into Frames
- Face Detection
- Eye Detection
- Iris and Eye Ball Movement Detection
- Eye Status Detection Open or Closed
- Alert stage

The proposed system can be developed using MATLAB software by 2.20 Giga Hertz Intel Core i7 processor and 2 Giga Bytes RAM. It efficiently detects the driver drowsiness with good success rate. The proposed system is based on eye closer and it is accurately works both for day and night time. The system also accurately works for all types of eyes (Small, Medium and Large eyes) even with an obstacle near the eyes. The accuracy rate for the proposed system is 94 %. The tests performed using web Camera for offline and android mobile phones for online videos to evaluate the driver's drowsiness and gives results with 94 percent of accuracy rate. The Fig. 2. shows the flow chart of the proposed system.

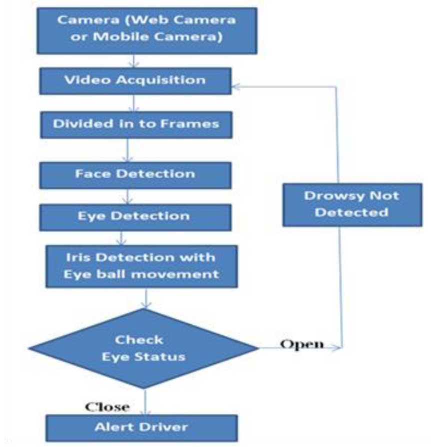

Fig. 2. Flowchart of the Proposed Sysetm

A. Video Acquisition

The driver's video captured, is mainly involved for video acquisition. For this purpose the web camera is used and then it is divided into number of frames i.e, 30 fps. In the proposed system, the live video is also captured using android mobile phone is directly fed to find the driver's fatigueness and it is also divided into number of frames. If the system uses web camera, it gets activated into video and divided in to number of frames. If the system uses android mobile phone it gets activated and take live video of the driver and divided into number of frames.

B. Divided in to Number of Frames

The video captured through web camera or android smart phones are divided in to number of frames i.e, 30 fps.

C. Face Detection

Face detection can be done using Viola Jones algorithm and it takes one frame at a time from the frame grabber. Haar algorithm is a well-known robust feature-based algorithm that can detect the face image efficiently [9] [10] [11].

In real time the Viola Jones algorithm is the frame work to detect an object which provides high detection rate of an object. This object frame work is to find the proposed mechanism by Paul Viola and Michael Jones in 2001 [12]. In this detection frame work, on input of an image, the window of the target size is moved to detect this phase. To define an object with appropriate accuracy a huge number of Haar like features are required. For each sub section of an image the Haar like features are calculated.

D. Eyes Detection

The Haar classifier has thus cropped our ROI (eyes) from the facial images of the driver. They must be processed in the next step in order to make a decision, whether to initiate an alert or not. The fatigue of the driver is detected by analyzing the form of the eyes. The normal assumption is that if the eyes are opened, the driver is alert and if not he must be drowsy. When the eyes of the driver are opened, it is more likely that the pupil of the eye will be present in the image. Exploiting this feature, the cropped eye images are further processed to come to a conclusion.

In this stage, eyes can be detected using the Haar like features using Viola Jones algorithm. The eye region also eliminates the other facial features like mouth or nose with the eyes to eliminate the possible confusions. To highlight the edge, gradient images are used and after that horizontal projection is computed on gradient image to detect the eye boundaries.

E. Irish Detection with Eye Ball Movement

After the successful detection of the eyes using Viola Jones algorithm the succeeding step is to find the Iris of the Driver's eyes to confirm whether the driver is sleepy or not. The Fig. 3 shows a front view of the human eye. In the human eye the Iris present is in between the lens and cornea. A skinny circular diaphragm is called Iris. The circular aperture called as Pupil is perforated close at the center of the Iris.

With the help of dilator muscles and sphincter the pupil size is also adjusted. The Iris controls the quantity of light arriving through the Pupil. The normal diameter of the Iris is around 12mm and the pupil dimension may differ between 10 to 20 percent of the Iris diameter [13].

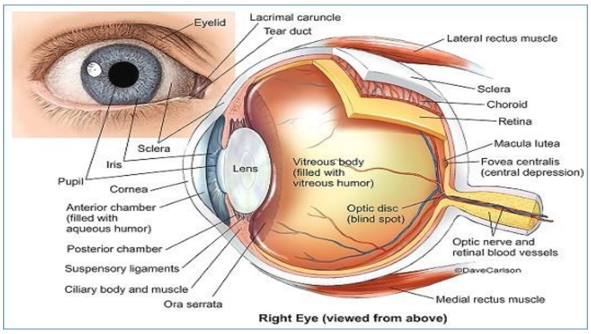

Fig. 3. Front and Side View of the Human Eye

The Iris contains various layers: epithermal layer is the last layer it consists of pigmentation cells. The stromal layer is present above the epithermal layer which consists of blood vessels, two Iris muscles and pigment cells. The external surface is multilayered. The Iris consists of two zones with change in colour [14]. Inner region is the pupillary region and the outer region is the ciliary region. These two regions are separated with collarette zigzag pattern as it appears.

A system uses canny edge detection algorithm to find the Iris. In this algorithm when the driver's open eyes are found then the Circular Hough Transform algorithm is used in conclusion to draw circles around the Iris and it also indicates that the eye ball movement then the driver is awake. If the circles are not found around the Iris then it indicates the closed eyes of the driver that the driver has become drowsy so an alert message will be displayed with an alarm.

F. Canny Edge Detection Algorithm

To find the Pupil and Iris borders, canny edge detection technique can be used in the proposed system. It provides the efficient eye edges [15]. The algorithm is used as an approach in various computer vision frameworks to distinct the valuable basic data for different vision objects. For a small and relatively similar edges this technique works and well suitable. The canny edge detection technique can be represented in the broad range of circumstances.

The Canny algorithm includes several steps as following:

- Gaussian smooth
- Find the image's intensity Gradients
- Non-maximum suppression
- Double threshold

In the first step to eliminate noise, the image becomes blur by the operator which means smoothing the image by applying Gaussian channels. After that, to find the image intensity gradients whenever the operator detects the big gradient size of the image and it represents the edges.

To determine the gradient size the Euclidean distance can be applied that is shown in the equation 1.

$$|G| = \sqrt{G_x^{\ 2} + G_y^{\ 2}} \quad \text{----------------}[1]$$

Edge directions are determined and saved because the images shows the edge neatly as the edges is usually wide and does not show precisely where the edge is. This is shown in the following equation 2.

$$\theta = \arctan g \frac{Gx}{Gy} \quad \text{----------------}[2]$$

In the next phase, Non-maximum suppression method is enforced to get out of wrong responses of the edge and in the double threshold phase, edges are generally settled by suppressing all edges which are not really linked to the powerful edges.

To get best results using coordinating procedure, the basic step is computer vision using edge recognition to request consideration to the real edges.

G. Circular Hough Transform Algorithm

Circular Hough Transfer is a typical computer vision algorithm and in an image, circles of a known radius can be detected using this algorithm. To find the circle of the known radius of an image this algorithm is used.

The circles and the lines presents in an image can be determined by the simple geometric parameters of an object. Different researchers employed [16] [17] [18] [19] Circular Hough Transform is also based on an automatic segmentation algorithm.

To conclude the radius and the midpoint coordinates in the Pupil and the Iris region this algorithm is used. An equation of a circle can be written as

$$R^2 = (x-a)^2 + (y-b)^2 \quad \text{-----------}[3]$$

Where the radius of the circle is represent using r and center coordinates of the circle are represented using the variables a and b. In parametric form, the points on the equation of a circle can be written as follows:

$$x = a + r\cos(\theta)$$
$$y = b + r\sin(\theta) \quad \text{------------}[4]$$

The rectangle image near the eyes is captured. The circles are drawn with the given radius at every point. At the perimeter of the drawn circle another circle is drawn by incrementing the coordinate points. The array of circle thus created indicates the peak in the accumulation array (Hough Space) [20]. The circle is detected using this transformation which requires the knowledge of each radius. To identify the radius of the Pupil or Iris, a range of radii is computed and tested to locate the Pupil or Iris. The radius with the highest peak of a circle would be the center of the Pupil or Iris.

H. Checks the Eye Status

This is the last stage of the algorithm. Once the Iris is detected with eye ball movement using Canny Edge Detection algorithm and with Circular Hough Transform, if the algorithm cannot find circles around the Iris means drowsy detected and immediately display the message drowsy detected with an alarm sound.

If the circles are found around the Iris, it shows that the driver is alert and display the message driver is not fatigue.

IV. OUTCOMES OF THE PROPOSED YSTEM

The eyes condition state whether closed or open determines the driver's situation he is drowsy or not. If the eyes are open it detects the Iris with eye ball movement and finds two circles around both left and right eye of the driver's which confirms that the driver is not in the drowsy state. If the eyes are closed then automatically circles around the eyes disappears indicating the driver drowsiness and then the result alert the alarm signal to give warning to the driver.

A. When the Driver's Eyes are in Open State

The proposed system accurately determines the fatigueness of the driver based on the eye open or closed state. In the following Figures it determines circle around the eyes with open eyes states it indicated that the driver is not sleepy and display the message "Drowsy Not Detected".

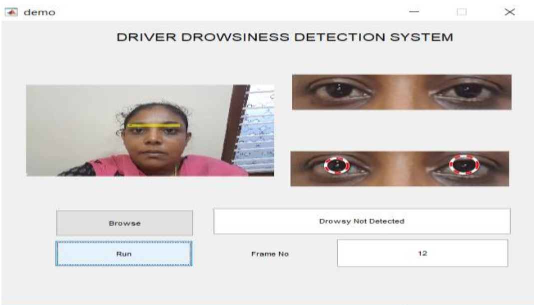

Fig. 4. Eyes are in Open State at Night Time with large Eye Size

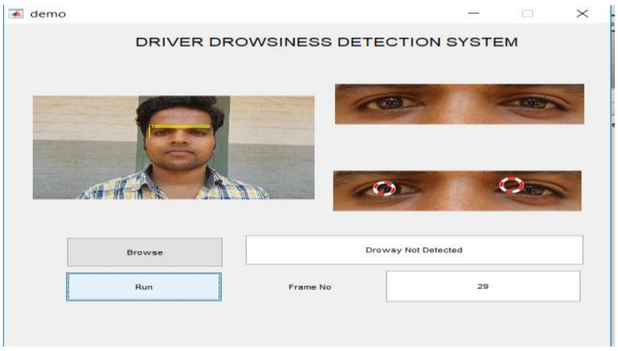

Fig. 5. Eyes are in Open State at Day Time with Small Eye Size

B. When the Driver's Eyes are in Closed State

The result of the proposed system when the eyes are closed is as follows. If the eyes are closed the circle around the eyes disappears which specifies that the driver is in sleepy state and display the notice message "Drowsy Detected" with an alarm.

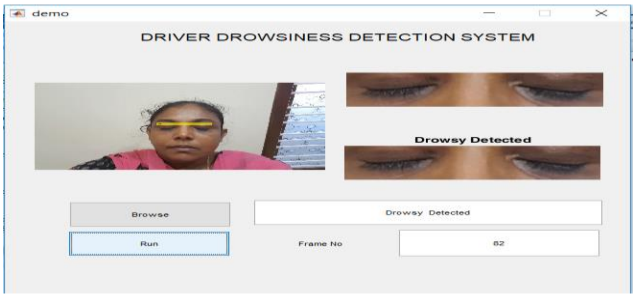

Fig. 6. Eyes are in Closed State at Night Time with Large Eye Size

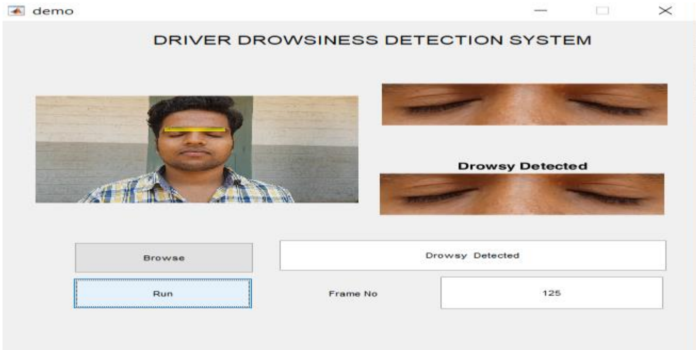

Fig. 7. Eyes are in Closed State at Day Time with Small Eye Size

V. RESULT AND DISCUSSION

The camera captures the video and converts that into a number of frames. The video frames are obtained at 30 fps. The proposed system captures videos from web camera and also live videos from android smart phone. For both the conditions the system accurately detects the drowsiness of the driver.

The following terms describes the used calculates in this system.

- Takes the complete number of frames produced in each experiment
- Find the failure rate - To compute failures of fatigueness detection.

The Table-I of the proposed system describes the results analysis on the study of seven different instances of user.

Table- II: Correct Rate of driver Drowsiness Based on Eyes

Sl.no	Instance User	Gender	Age	Eye Size	Total frames	Detection failure	correct rate	Average
1.	User1	Female	36	Large	480	28	94.11	
2.	User 2	Male	20	Small	1,050	59	94.38	
3.	User 3	Female	17	Large	570	31	94.56	
4.	User 4	Male	21	Small	540	32	94.07	
5.	User 5	Female	18	Medium	720	40	94.44	94.30

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6.	User 6	Female	19	Medium	510	31	93.92	
7.	User 7	Male	38	Medium	1,500	80	94.66	
1.	User 1	Female	36	Large	480	28	94.11	
2.	User 2	Male	20	Small	1,050	59	94.38	

The following Equation is used to find the correct rate of driver drowsiness of the proposed system. It is the ratio of complete number of frames subtracted by the number of drowsiness detection failure frames to the total frames.

$$\text{Correct Rate} = \frac{\text{Number of Total Frames} - \text{Detection of Failure Frames}}{\text{Number of Total Frames}} \quad \text{-------[5]}$$

The average correct rate of the proposed system to find the driver fatigueness is the 94.30 percent for the seven different instance of users with different age group, different eyes size with different eye and skin colours for both male and female.

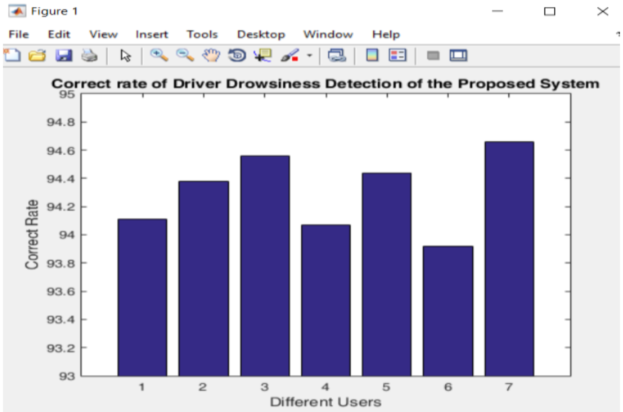

Fig. 8. Correct Rate of Driver Drowsiness Detection Based on Eyes

Table –II defines the other measures regarding the conducted experiments for the same users to find the accuracy rate.

Table- II: Accuracy Rate of driver Drowsiness Based on Eyes

Sl.no	Different User	Closed Eyes	Real dozing	Generated warning	False positive	False negative	correct rate	Accuracy Rate	Average
1	User1	42	9	9	0	0	9	100	
2	User 2	50	10	11	1	0	10	90.9	
3	User 3	41	8	9	1	0	8	88.88	
4	User 4	40	8	8	0	0	8	100	
5	User 5	43	9	10	1	0	9	90	94.3
6	User 6	48	10	11	1	0	10	90.9	
7	User 7	60	12	12	0	0	12	100	

The accuracy rate of the driver drowsiness can be calculated by using the formaula for the proposed system. It is the ratio of correct warning divided by the generated warning

$$\text{Accuracy Rate} = \frac{\text{Correct Warning}}{\text{Generated Warning}} \quad \text{----------[6]}$$

For the proposed system the average accuracy rate is around 94 percent for the seven different people considering the number of eye closed, actual real dozing of the driver, generated warning, correct warning, false positive and false negative.

The result obtained for the proposed system differs with regards to the following reasons.

- Total frames captured in numbers
- Dimension of the eyes

Moreover to specify the result of the system the training data play a main role. The performance of the proposed system directly proportional to the quantity means the quality of eye images captured in numbers means the different images of eye obtained for data.

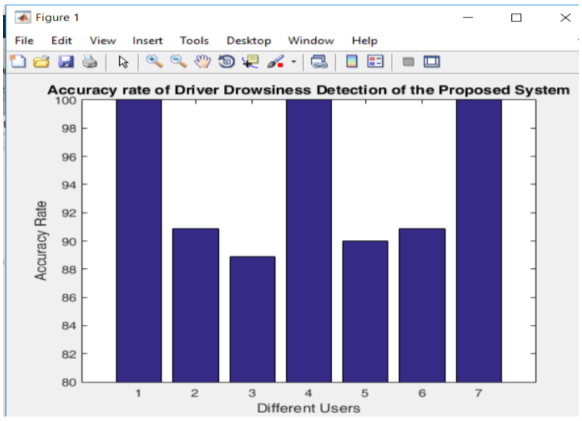

Fig. 9. Accuracy Rate of Driver Drowsiness Detection Based on Eyes

VI. CONCLUSION

This system is used to find the driver drowsiness based on eye. The videos are captured and divided in to number of frames. In the first step the face is detected using Viola Jones algorithm with Haar like features. The Viola Jones algorithm successfully detects the face with high accuracy rate. After face detection, the second step is to detect the Eyes region which has been done by again Viola Jones algorithm with Haar like features.

During the detection of the eyes the proposed system is able to decide whether the eyes are open or closed. If the eyes are open, then in the next step Iris detects using the Canny Edge Detection algorithm and circles are drawn around the Iris using Circular Hough Transform algorithm. If two circles appear around the Iris indicates that the driver is awake, and displays "No drowsy detected". Otherwise if the eyes are closed, immediately circles around the Iris disappear. If the eyes are closed for 5 consecutive frames then the system declares that the driver is drowsy. A warning signal is passed to the driver through display message with an alarm. The accuracy rate is around 94 percent. It supports for real time drowsy driver detection.

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AUTHORS PROFILE

Dr. Kusuma Kumari B.M is awarded Doctorate from Tumkur University, Karnataka, India, has teaching experience of around 13 years in academics. Her area of research is on Digital Image Processing, Software Engineering. She presented 22 papers in national and international conferences and published 25 Research papers in reputed referred journals.

Dr. Ramakanta Kumar, P was awarded Doctorate from Mangalore University, Karnataka, India has teaching experience of around 25 years in academics and Industry. His area of research is on Digital Image Processing, Pattern Recognition, Natural Language processing. He has to his credits 33 papers presented in national and international conferences and 62 Research Publications. He is guiding 13 PhD students.

Dr. B.L. Mukundappa was awarded Doctorate from Tumkur University, Karnataka ,India, has teaching experience of around 33 years in academics. His area of research is on Digital Image Processing, pattern recognition. He presented many papers in national and international conferences and published 6 Research papers in reputed referred journals.