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Driver Drowsiness Detection System Based on Eyes, Mouth and Head Tilt

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Abstract*: *The modernization of the automobile manufacturing automatically increases the number of automobiles on transportation way. Day by day with the quick increase in automobiles, the number of road accidents seems to be drastically increasing. In our daily life accidents are common phenomenon. In the Universe, yearly the accidents on road may cause fatal injuries, death and economic losses. Drowsiness of the driver may be one of the prime causes for accidents on the way and the driver is prone to a possible accident. So it is essential requirement to find the driver's drowsiness to reduce the road accident rates. In this paper we proposed a system to find the driver drowsiness based on eye, mouth and head tilt. This system is helpful to monitor a driver's observance level and warns him for a significant part in avoiding road mishaps.

Keywords* : *drowsiness, YCbCr, eye detection, mouth detection, head tilt.

I. INTRODUCTION

Driver fatigueness is the main issue for the accidents on the road. Recent analyses of the problem estimates that greater than 20% of the mishaps on the road are because of drowsy drivers. This may be one of the contributory factors which amount to one fourth of deadly and serious accidents. 50% of accidents / crashes are fatigue related with the result in loss of life or serious injury. The driver with drowsiness has high speed impact and cannot control the vehicle because of sleepiness which reduces his reaction time.

However this number is not properly estimated because all accidents are not reported to the police. Police easily recognize the drunk and driven using the liquor detector machine but for fatigue driver there is no proper machine to find the drowsiness of the driver. In United States every year approximately 1,00,000 crashes occurs due to driver drowsiness or fatigue estimated by National Highway Traffic Safety Administration (NHTSA) [1]. National Highway Traffic Safety Administration reported that in 2013 because of driver drowsiness 72,000 crashes, 44,000 injuries and 800 deaths occurred [2].

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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. The innocent pedestrians and the pets may get victimized for no fault of theirs. Besides other users of the road get affected as casualty for some driver's fault [3] [4]. It's a known fact to all of us that long driving is difficult, tiring and time consuming. One of the root causes behind the road crash is driver's carelessness due to long distance continuous driving and difficult driving without rest and sleep. For highway accidents one of the main reasons is the continuous driving hours together resulting in driver's tiredness amounting to accident [5] [6]. Physically worn out driver losses his alertness and also due to physical tiredness in the driver may get a short sleep while driving. If unfocused for few seconds while driving can be very dangerous and also a life threat for the pedestrian either on the road or footpath.

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.

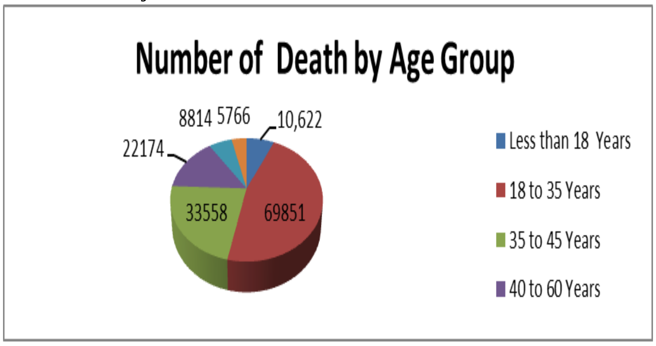

Fig. 1.Number of Road Traffic Deaths by Age Group

Fig. 2.Road Causalities in India

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II. LITERATURE REVIEW

Autonomous Nervous System (ANS) movement detects drowsiness. It is metric using to consume from HRV (Heart Rate Variability) [7]. A method based on spontaneous pupillary fluctuation behavior is used to detect and prevent the traffic accident. Pupil diameter variability is calculated to check the alertness [8].

ECG measurement method with Heart Rate Variability (HRV), a physiological signal used to detect the drowsiness [9].

A system monitors the driver's subsidiary behavior increasing and driver's arousal level decreasing indicates that driver has gone to drowsy state. Subsidiary behavior means yawning, hand motion etc. [10]. A method to find driver's fatigueness can be found with the eye state as well as mouth to overcome the challenge of wearing glasses [11]. To develop a system this contains an intelligence wireless sensor network to detect driver fatigue [12]. A method based on infrared light and face detection step with facial components to find the fatigueness of the driver [13].

A method depends on hybrid observers - to find the driver fatigueness. Identify driver drowsiness level through online [14]. A system used to find driver's fatigueness depending on visual information and AI (Artificial Intelligence) which analyzes to find and track drivers face & eye to find the drowsiness [15] [16] [17].

The headband with dry- AgCl electrodes by standard EEG channels technology to find the driver drowsiness, the electrodes receives the signal by wireless and transfers the same to the system [18] [19]. The system is an EEG-based [20] [21] portable wireless recording unit used to find the driver's drowsiness [22]. Heart Rate Variability (HRV) signal measured using Autonomous Nervous System (ANS) and it is an online detector to find the driver fatigueness [23]. A system finds the driver's fatigueness using both lane and driver features, if these visual signs failed, Dempster -Shafer theory is used to detect the drowsiness [24].

III. METHODOLOGY

The proposed system consists of three different models to find the driver fatigueness. The system works for both day light and when dark at night. This system captures driver's face in the camera in the initial stage i.e 30 to 35 fps video sequences. After completion of video capture the images are converted from RGB to YCbCr and again HSV [25]. The system accurately works in digital version of the image to detect the boundaries of the face, eyes and mouth. For face detection, one of the best algorithms called Viola Jones algorithm is used. The face is separated from other back ground details to achieve more and accurate result. It is understood by focusing on the threshold and symmetry of human face.

In the first model after detecting the face, Haar like features are used to detect eyes using the knowledge of important strength varies in the face. When the eyes are positioned, it also detects if the eyes are blinking at a particular time interval by measuring the distance between the intensity differs in the eyes. A big distance corresponds to eye closure when the eyes are shut for consecutive frames counting to 5 frames. Then it concludes that the driver is about fall asleep and issue the signal and message with an alarm to wake up the driver. In the second model the system detect mouth using Haar like features. Once the mouth detected, it checks for yawning of the driver through changing the intensity level at the mouth region. When the mouth is open the numbers of black pixels in binary image are considerably large when compared to idle frames. If the mouth is open for at least 2 seconds it is concluded that driver is drowsy and immediately issues the warning message through display as well as an alarm. In the third model the head tilt of drowsy driver is detected using skin segmentation. If the head is lowered or rotated in other direction automatically number of skin pixels are decreased. If the head tilt continues for more than 2 seconds the warning message is issued through an alarm. The accuracy of the proposed system is approximately 92%. Approximately 2000 image frames are used and around twenty five different video sequences are used. The proposed system has a very high accuracy with less error and quick processing rate.

The Proposed System Consists of the Following Stages

1. Extracting Videos from Camera
2. Extracting Images from Video
3. Face Detection
4. Face Extraction
5. Eyes Detection
6. Mouth Detection
7. Skin Segmentation
8. Head Tilt
9. Alert Warning

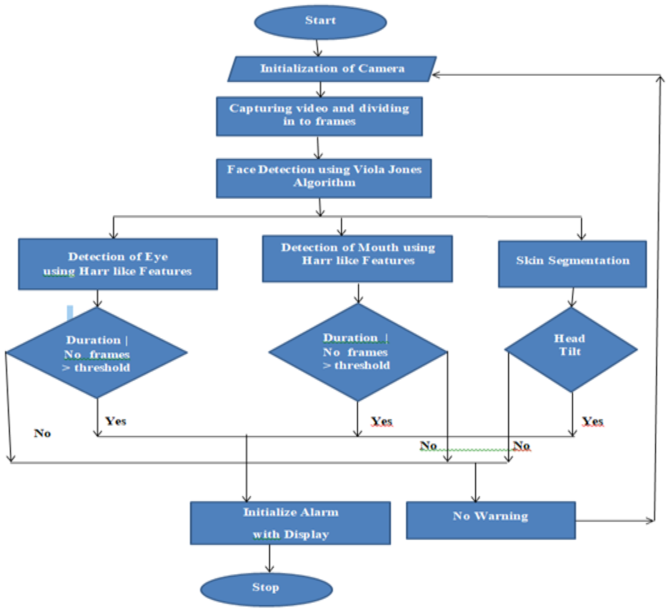

Fig. 3.Flowchart of the Proposed System

A. Extracting Videos from Camera

Image acquisition using the video camera is the primary component for the driver drowsiness. It is based on a digital camera and videos are extracted from the camera.

The proposed system works as follows:

- With the help of video camera the system capturing the video and it extracts frames with the frame rate 30 to 35 fps.

- In front of the vehicle, the video camera is fixed and it is constantly films the driver face.

Most of the researches are using infrared-sensitive camera with the advantage that the light does not affect the field of view to detect and generate eye region. But IR light beam will damage eye cells if the driver exposes it for a long time. For this reason the digital camera in use and uses either CCD (Charged Coupled Device) or CMOS (Complementary Metal Oxide Semiconductor) digital camera for face, eye and mouth monitoring to generate images. This camera is available at affordable cost with high definition. In this system, totally 7 people are used to record the videos and create the database.

B. Extracting Images from Video

After image acquisition stage the next stage is to convert the video into sequence of frames, which can be processed by a computer. The resolution of the camera is 1280 X 720 pixels for video images. The data rate at which the frames are selected is around 30 to 35 fps and it collects an abstract data images from the video frames. The video capturing speed is fast enough to adequately capture the fastest human face, eyes and mouth.

C. Face Detection

In the third step, more accurate and robust Viola Jones algorithm is made to extract the driver's as an image. After extracting the driver's face, the process of binarization can be done to get the binary image by setting a threshold of (minimum pixel value + 10 bits). The Haar-like features are primary source as the Haar classifier for the detection of an object. Those Haar-like atttributes uses alternate different values amongst the adjacent groups of rectangular pixels instead of using the strength of pixel values. To find the light and dark areas, the distinct variance between the pixel groups are used. To form Haar-like features, relative variances of two or three adjacent groups are used. To increase and decrease the group of pixels in size, the Haar-like attributes are used in order to scale and examine. This feature permits to find objects of different sizes.The Haar wavelet's mother wavelet function $\psi(t)$ can be described as

$$\psi(t) = \begin{cases} 1 & 0 \le t < \frac{1}{2} \\ -1 & 1/2 \le t < 1, \\ 0 & otherwise \end{cases} \quad (1)$$

Its scaling function $\phi(t)$ can be described as

$$\emptyset(t) = \begin{cases} 1 & 0 \le t \ll 1 \\ 0 & otherwise \end{cases} \quad (2)$$

The Haar wavelet is graphically represented as shown in the Fig 4

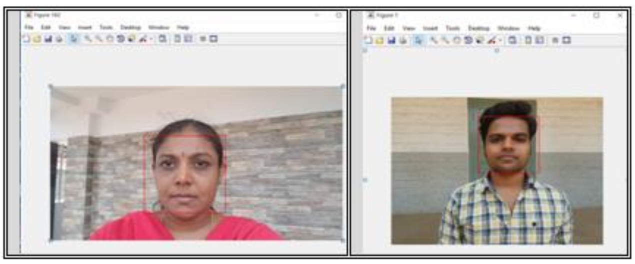

Fig. 4.Graphical Representation of Haar Wavelets

D. Face Extraction

In the Viola and Jones algorithm, the object detection framework is used to detect the face. In this phase the Haar-like features are measured for each subsection of the image after a target size of window moved over the input image [26]. The variance is compared with the learned threshold to find and separate the objects from non-objects. Haar-like features are weak learner or classifier and its recognition feature is somewhat better than the random guessing with sufficient accuracy level.

To form a strong learner or classifier the Haar-like features organized in something called a classifier cascade in the Viola–Jones object detection framework.

The Fig 5 shows the driver face region after applying Viola Jones Algorithm. The Fig 6 shows only the cropped face regions of the driver.

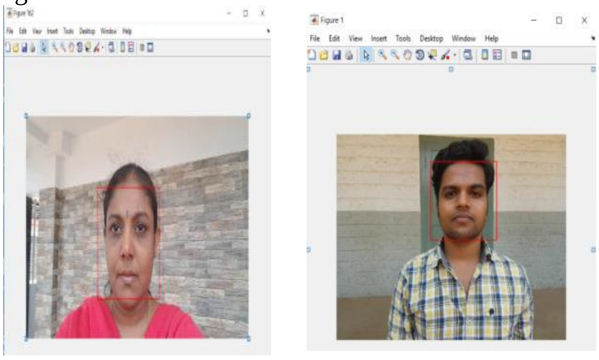

Fig. 5.Face Region after Viola-Jones algorithm is Applied

Fig. 6.Cropped Face Region

E. Face Extraction

After the detection of face, using Viola Jones algorithm, the location of the eyes and mouth has to be separated.

Eye tracking concept is used to track the actual position of the eye. It is a concept where eye search is made as per the central coordinated with the eye in the area of the facial image. In this system, the first image is considered as reference image and using eye tracking system, the data from the captured image are tracked and compare it with the reference image. The actual information can be obtained by detecting next frame by tracking the actual position of the eye. The correct tracking of eyes is decided by the degree of eye openness. The degree of openness of eye varies between the specified ranges. If the eye remains out of this specified range then it means it is not traced correctly. Some coordination system is required to detect the initial points where the region of eye will start. At specified distance once the image is captured the position of eye is located.

To detect the coordinate from where the region of eye is starting certain calculations are done. After the rectangular window is extracted, the system considers that the eyes are located at a distance of (0.25 * height of window) from the top and (0.15 * width of window) from the left. The size of window is (0.25 * height of window) in height and (0.68 * width of window) in width.

A conversion is done before detecting the eye. A complete frame represents the specified configuration of the images, which are captured and over which all the operations are needed to be performed. The Fig 7 shows the eyes region after viola jones algorithm is applied. The Fig 8 shows the cropped eye regions of the driver.

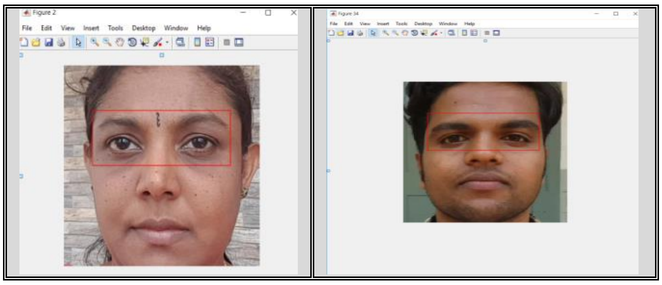

Fig. 7.Eyes Region after the Viola Jones algorithm is applied

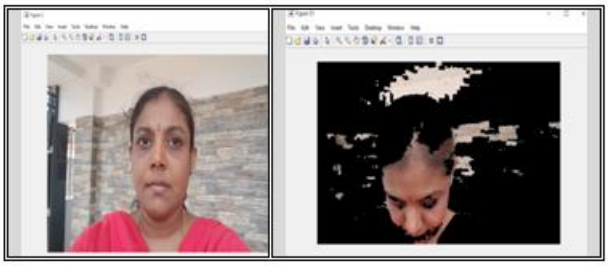

Fig. 8. Cropped Eyes Regions of the Driver

After the eyes are cropped the image is converted from RGB to YCbCr. Then image is converted to gray scale and ultimately to binary image by setting a threshold of (minimum pixel value + 10). The Fig 9 shows the image after converting to binary image.

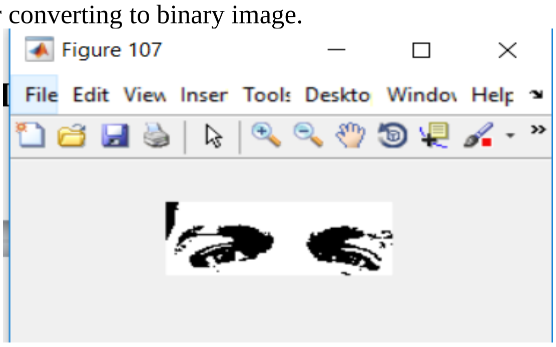

Fig. 9.after converting to binary image

The eyes regions are extracted from the image and check whether eyes are open or closed. If eyes are closed issue the alarm with message display.

F. Mouth Detection

The mouth is detected using Haar like features to detect the coordinate from where the region of mouth is starting after certain calculations are done. After the rectangular window is extracted, we have considered that the mouth are located at a distance of (0.67 * height of window) from the top and (0.27 * width of window) from the left.

The size of window is (0.20* height of window) in height and (0.45 * width of window) in width.

The mouth region is extracted from images and check mouth is open or closed. If the mouth is open more than 2 seconds then it is nothing but the yawning of the driver and indicates that the drivers becomes drowsy and issue an alarm with message display. The Fig 10 shows the region of the mouth to be extracted and the Fig 11 shows the cropped mouth region of the driver.

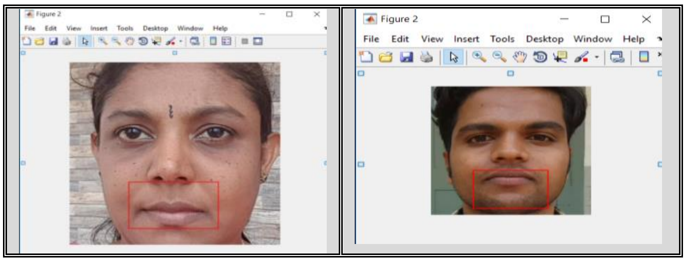

Fig. 10.Region of Mouth to be extracted

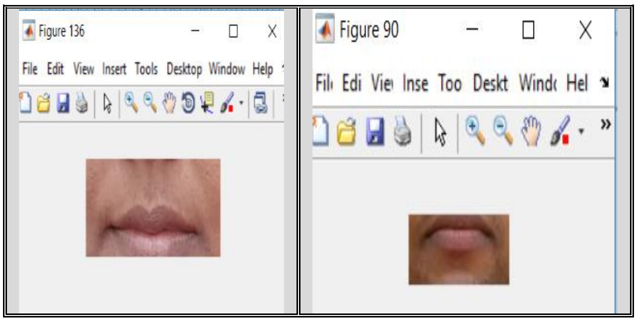

Fig. 11.Cropped Mouth Region

Again the mouth is converted to Y Cb Cr colour space, and then it is converted to gray scale image and eventually converted in to binary image with a threshold of (minimum pixel value + 10 bits).

G. Skin Segmentation

To distinguish between skin and non-skin pixels of an image a color segmentation technique is used to acquisite the driver's video. The video is taken and converted that into number of frames. Typically a camera captures the images with RGB (Red, Green, and Blue) Model. RGB color space is the most normally used color space in digital images. However the RGB model contains illumination in addition to the colours. For image brightness RGB model is very sensitive but it is very easy and simple colour model.

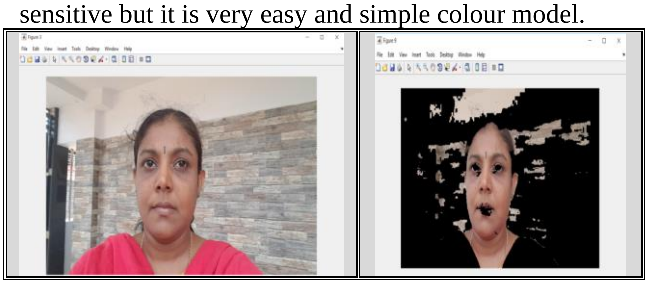

Fig. 12. An Image of driver after Skin Segmentation along with Original Image

H. Head Tilt

The skin pixel decreases drastically when compared to the idle frame. if the driver's head is drooped or rotated for two or more seconds then it is an indication that the driver has fallen asleep.

It is an indication for an accident to occur and hence the system displays a message and also generates a warning bell to avoid an accident.

The skin segmentation can be done to find the driver head bent or turn around for different position. If head tilt occurs issue an alarm with message display.

I. Alert Warning

If the system detects eyes closed, mouth opened and continuously yawning or head tilt, immediately alert the driver by an alarm sound with display message to wake up the drivers.

IV. RESULT AND DISCUSSION

The system should be operative for the driver wearing glasses. The first frame is used for learning. All the results are calculated taking first frame as ideal frame. The system should work during both daytime and nighttime.

A. Drowsiness Detection without wearing the glasses and eyes are closed

The Fig 13 shows the drowsiness detection of the driver without wearing the glasses with the driver original image while eyes are closed. The system alerts the driver with proper alarm signal with display message.

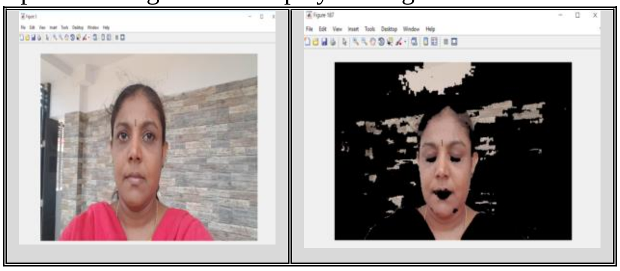

Fig. 13. An Image of driver after detecting closed eyes along with original Image and without wearing glasses

B. Drowsiness Detection with wearing the glasses and eyes are closed

The Fig 14 shows the drowsiness of the driver with wearing the glasses while eyes are closed. If the system finds the closed eyes immediately warn the driver by an alarm signal with message.

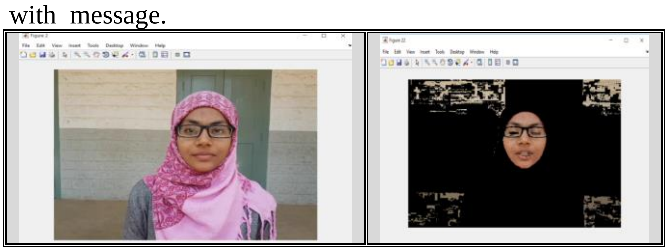

Fig. 14. An Image of driver after detecting closed eyes along with original Image and with wearing glasses

C. Drowsiness detection for yawning of the driver

The Fig 15 shows the driver drowsiness detection while the d river mouth is open with yawing along with original image. If the drowsiness detected alert the driver with alarm signal.

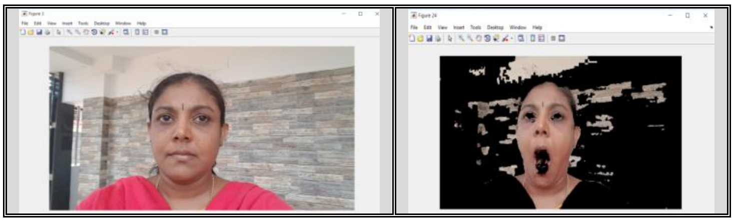

Fig. 15.An Image of driver after Detecting Mouth Open with Yawning along with Original Image

D. Drowsiness detection for head tilt of the driver

The Fig 16 shows the driver drowsiness detection while the d river head is drooped or rotated around along with original image. If the drowsiness detected alert the driver with alarm signal.

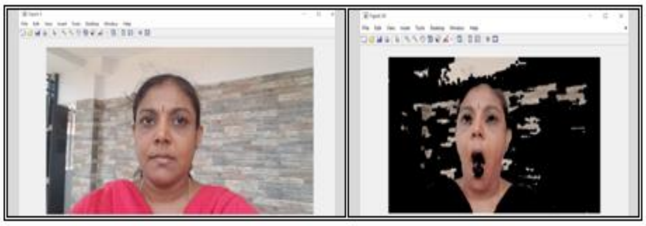

Fig. 16.An Image of driver after detecting head tilt along with Original Image

E. Accuracy rate of the Proposed System

The Accuracy rate for the proposed system is 92% to detect driver's drowsiness for driver's wearing with or without glasses. It also detects the drowsiness of the driver through Mouth detection to find the yawning and also head tilt of the driver.

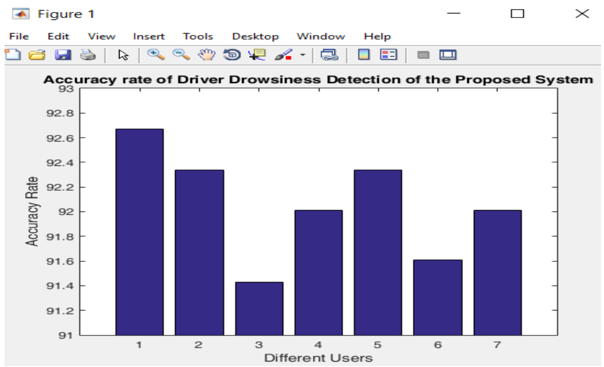

Fig. 17.Accuracy rate of the driver drowsiness detection based on Eyes, Mouth and head tilt

The Table I shows the Accuracy rate of the proposed system. In this system we are using 7 different users and the table contains the data according to the driver drowsiness detection of the captured images.

V. CONCLUSION

In this paper we proposed a system for monitoring driver drowsiness based on eyes mouth and head tilt. This system is a non-intrusive approach and reduces the number of road accidents because of driver fatiguness. The system gives the accuracy rate of around 92 percent to detect the driver drowsiness based on eye, mouth and head tilt. It is suitable and accurately detects the drowsiness for driver's wearing glasses. If the eyes are closed for more than 5 consecutive frames then the system display the warning message to the driver's with an alarm sound. If the mouth opens for more than 2 seconds or head is found bend or turn around to other direction for atleast 2 seconds then the system gives warning message to driver with an alarm.

Table I: Accuracy Rate of the Driver Drowsiness Detection Based on Eyes, Mouth and Head Tilt

Sl. No	Diffferent Users	Gender	Age Group	Eye Glasses	Detection Type	Total Frames	Correct Judgment	Accuracy Rate	Average Accuracy Rate
1.	User 1	Female	36	No	Eye Detection	167	158	94.61	92.67
					Mouth Detection	167	153	91.61	
					Head Tilt	167	154	92.21	
2.	User 2	Male	20	No	Eye Detection	183	172	93.98	92.34
					Mouth Detection	183	165	90.16	
					Head Tilt	183	170	92.89	
3.	User 3	Female	18	No	Eye Detection	167	156	93.41	91.43
					Mouth Detection	167	150	89.82	
					Head Tilt	167	152	91.08	
4.	User 4	Male	21	No	Eye Detection	167	158	94.61	92.01
					Mouth Detection	167	153	91.61	
					Head Tilt	167	150	89.82	
5.	User 5	Female	17	Yes	Eye Detection	183	168	91.80	92.34
					Mouth Detection	183	170	92.89	
					Head Tilt	183	169	92.34	
6.	User 6	Female	19	No	Eye Detection	167	157	94.01	91.61
					Mouth Detection	167	150	89.82	
					Head Tilt	167	152	91.01	
7.	User 7	Male	38	No	Eye Detection	167	155	92.81	92.01
					Mouth Detection	167	152	91.01	
					Head Tilt	167	154	92.22	

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