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Driver Drowsiness Detection Using Non-Intrusive Technique

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Abstract:*Development of safety features to prevent drowsy driving is one of the major technical challenges in the automobile industry. Driving while in drowsy state is a major reason behind road accidents especially in the modern age. Driving when drowsy leads to a higher crash risk than being in alert state. Therefore, by using assistive systems to monitor driver's level of alertness can be significant to help prevention of accidents. This paper aims towards detection of drivers drowsiness using visual features approach.Driver drowsiness is detected in real time by detecting drivers face and eyes using HAAR-Cascade Classifier and Yawn detection based on Template matching. The system will provide an alert to the driver if the driver is found to be in drowsy state with help of an alarm.*

Keywords -*Alert system,Driver drowsiness, Driver safety, HAAR-Cascade Classifier, Template Matching, Visual features.*

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I. Introduction

Driving while being drowsy is one of the main reasons for traffic accidents and the related financial losses. Researchers have been working on designing driver drowsy monitoring systems over the last decade. Though, there have been numerous improvements in driver safety, yet a significant number of serious accidents still occur all over the world.The U.S. National Highway Traffic Safety Administration each year reports roughly about 60,000 traffic accidents taking place due to sleepiness related problems. studies indicate that 25%–30% of driving accidents are caused due to drowsiness [1].In 2008, the National Highway Traffic Safety Administration estimated about 100,000 police reports on automobile crashes which were direct results of driver being drowsy resulting in over 71,000 injuries, 1550 deaths, and $12.5 billion in financial losses [2].To detect driver inattention, three main approaches have been developed i.e. via, Physiological, Driving-behaviour-based, and Visual-feature-based approaches. Physiological methods involve analysing of vital signals such as brain activity, heart rate, and pulse rate. However, this technique requires use of electrodes to be attached to the driver's body, which is intrusive in nature therefore, may act as annoyance to the driver [2].

Driving-behaviour-information-based approaches evaluate the driver's conduct over a period based on the variations in the speed, steering wheel angle, acceleration, lateral position and breaking, there by determining whether the driver is alert or not. Liang *et al.* demonstrated a real-time approach to detect driver distraction using the eye movements and driving performance, wherein the data was made to train and test both Support Vector Machine (SVM) and Logistic Regression Models (LRM) to recognise driver distraction. Thus, making it convenient for signal acquisition but highly dependent on the type of vehicle, driver experience, and the road conditions [2]. The feature-based approach analyses visual features from the driver's facial images having unique features such as eye blinks, yawning, and head movements. Hammoud *et al*. proposed a drowsiness detection system that would assess the eye status in the near-infrared spectrum. Moriyama *et al.* predicted the eye state by using templates to match with the eyelids. Percentage of eyelid Closure (PC) which counts the number of eye blinks of the driver is another widely used technique for drowsiness detection. For practical applications, visual-feature-based approaches are preferred since they are instinctive and does not bother the driver [2].

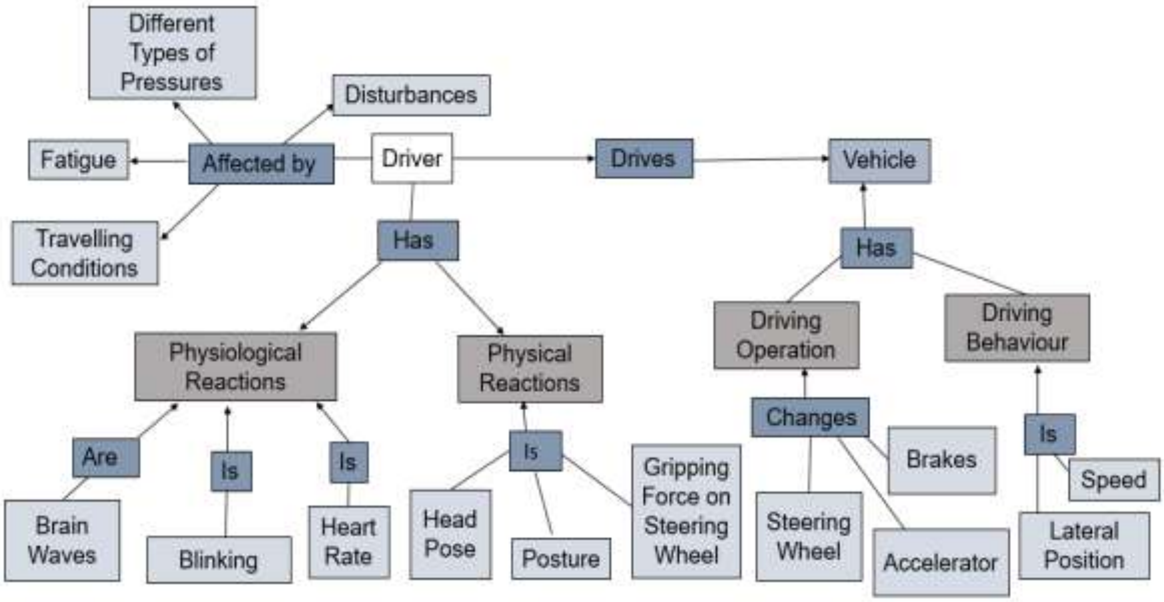

Fig. 1: Aspects that can be used to determine the level of drowsiness of a driver [3]

II. Project Objective

Development of safety features to prevent drowsy driving, being one of the major challenges for automobile industry, the objective of this project is to design a system to detect and provide driver safety by alerting the driver in case of drowsiness detection. Drowsiness detection has been implemented using visual features like Eye and Face detection has been implemented using OpenCV Haar- Cascade (.xml files) along with Yawn detection done by Template Matching with Visual Studio 2013. In case the driver is found to be in drowsy state then the alarm would be generated to alert the driver.

III. Literature review

Over the last decade, there have been various studies done related to drowsiness detection. Features using a driver's Visual characteristics, Physiological and Driving- behavior based studies have been conducted each having their own advantages for drowsiness detection. Recent Technologies that have been examined are explained from [1-2, 4-14]. Sinan Kaplan et al., presented a survey that provides a comprehensive insight into the well-established techniques for driver inattention monitoring and introduces the use of most recent and futuristic solutions exploiting mobile technologies such as mobile phones and wearable gadgets. The studies were classified into two groups: driver drowsiness and distraction. A comprehensive compilation, used features, classification methods, accuracy rates, system parameters, and environmental details, was represented. A similar approach was also taken for the methods used for the detection of driver distraction [1]. Ralph Oyini Mbouna et al., presented a visual analysis of Eye State and Head Pose (HP) for continuous monitoring of alertness of a vehicle driver. The proposed scheme used visual features such as Eye Index (EI), Pupil Activity (PA), and HP to extract critical information on non-alertness of the driver [2]. Mona Omidyeganeh et al., designed and implemented an automatic system, using computer vision, which runs on a computationally limited embedded smart camera platform to detect yawning. Implementation of the Viola–Jones algorithm for face and mouth detections and, use of a back-projection theory for measuring both the rate and the amount of the changes in the mouth, to detect yawning along with the histogram of the grayscale image [4].

Jun-Juh Yan et al., developed a real-time system using grayscale image processing and PERCLOS. Wherein using grayscale, the drivers face was found and template matching used to find eyes. PERCLOS was used on the detected eye positions and driver fatigue state was found and an alert would be provided if driver found to be fatigued [5]. Anirban Dasgupta et al., proposed a robust real-time embedded platform to monitor the loss of attention of the driver during day and night driving conditions. The percentage of eye closure was used to indicate the alertness level. Face detected using HAAR -like features, the eye state was classified as open or closed using support vector machines [6]. Boon-Giin Lee et al., proposed a method to monitor driver safety for fatigue using two distinct methods: Eye movement monitoring and Bio-signal processing. The monitoring system was designed on an Android-based smartphone, where it receives sensory data via wireless sensor network and further processed the data to indicate the current driving aptitude of the driver. The sensors used were a video sensor to capture the driver image and a bio-signal sensor to gather the driver

Photoplethysmograph (PPG) signal. A warning alarm was also sounded if driver fatigue was believed to reach a defined threshold [7].

G. M. Bhandari et al., presented an efficient driver's drowsiness detection system, by using yawning detection. The driver's Eye and Mouth detection was done by detecting the driver's face using YCbCr method. After that point eyes and mouth positions by using HAAR features. Lastly the yawn detection was performed by using mouth geometric features [8]. Jürgen Schmidt et al., investigated driver behavior between manual and automated driving conditions, where they developed a framework to check drivers state during automated driving. This framework was based on driver's eye closure and head movements monitoring using a camera. The basis of the evaluation was done with eighteen participantsand long monotonous drives. The data showed a significant differencein the behavioral indicators (eye closure and headmovement) between drivers driving manually or conditionallyautomated, independently of their currentdrowsiness state [9].Tariq Jamil et al., developed an eye blinking detector system to monitor the physical state of the driver at regular intervals during his/herdriving and generate an audible alarm within the vehicle to alert the driver. In case of multiple failures to raise the alertness
level of the driver, the system would automatically inform the law enforcement authorities about the rogue driver on the road [10].

Anjali K U et al., purposed this paper 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 implemented is a nonintrusive real-time monitoring system for eye detection. During monitoring, the system can decide whether the eyes were opened or closed. When the eyes were detected closed for too long, a signal issued to warn the driver, the system also has an option for making vibration when drowsiness is detected [11]. T. P. Nguyen et al., demonstrates an eye tracking system for drowsiness detection of a driver. It is based on the application of Viola-Jones algorithm and Percentage of Eyelid Closure (PERCLOS). The system alerts the driver if the drowsiness index exceeds a pre-specified level [12]. Tiesheng Wang and Pendeli Shi developed a real-time driver drowsiness detector using yawn. Kalman filter was adopted to track face region. Further, mouth window was localized within face region and degree of mouth openness extracted based on mouth features to determine driver yawning in the video [13].Rainer Lienhart et al.,introduced an empirically analysis of two extensions to the Viola-Jones Rapid object detection scheme. Firstly, a novel set of rotated Haar-like features wasintroduced where these novel features significantly enrich the simplefeatures of the Viola-Jones method of Rapid Object Detection and how it could be calculated efficiently secondly, a thorough analysis of different boosting algorithms (namely Discrete, Real and Gentle AdaBoost) and weak classifiers on the detection performance and computational complexity [14].

IV. Methodology

The visual feature-based approaches have been used for driver drowsiness detection as its proven to provide better results than physiological and driver behavior methods [2]. Visual features consist of capturing Eye State, Face Position which has been done using HAAR-Classifier while Yawn detection using Template Matching scheme.

4.1 FACE AND EYE DETECTION:

For detection of Face and Eye, HAAR-Cascade classifier is used which is based on Viola-Jones algorithm [15]. The complete algorithm for Face and Eye detection is given by the following steps:

1. On Camera Start we capture the Frames and then display it on the screen using video capture function.
2. On capturing the frames convert them to gray scale. Converting the images to gray scale is advantageous as several computer vision algorithms requires gray level images thus saving read time and minimizing memory usage.
3. Apply histogram equalization on gray scale images. This helps to characterize image content and detect specific objects or texture in an image also helping to normalize the brightness and increase contrast of the image.
4. Then by using Haar-Cascade we find the face and eye region from the given frame, which is done as:

- HAAR feature selection
- Creating Integral image
- AdaBoost Training
- Cascade Classifier

5. Then mark rectangle to the largest face detected and crop face image and set as Region of Interest.
6. From the Region of Interest, we find eyes for faster computation.
7. The eyes detected are then marked with a rectangular box.
8. An alert message is generated if no face or closed eyes found in the frame.

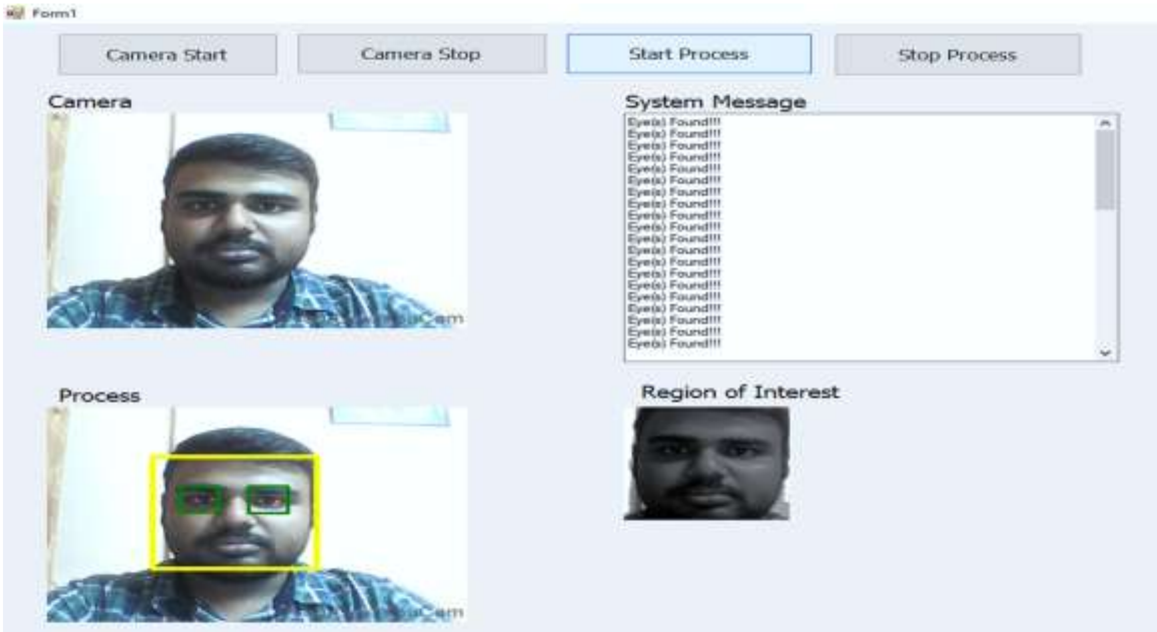

Fig. 2: GUI for Face and Eye detection

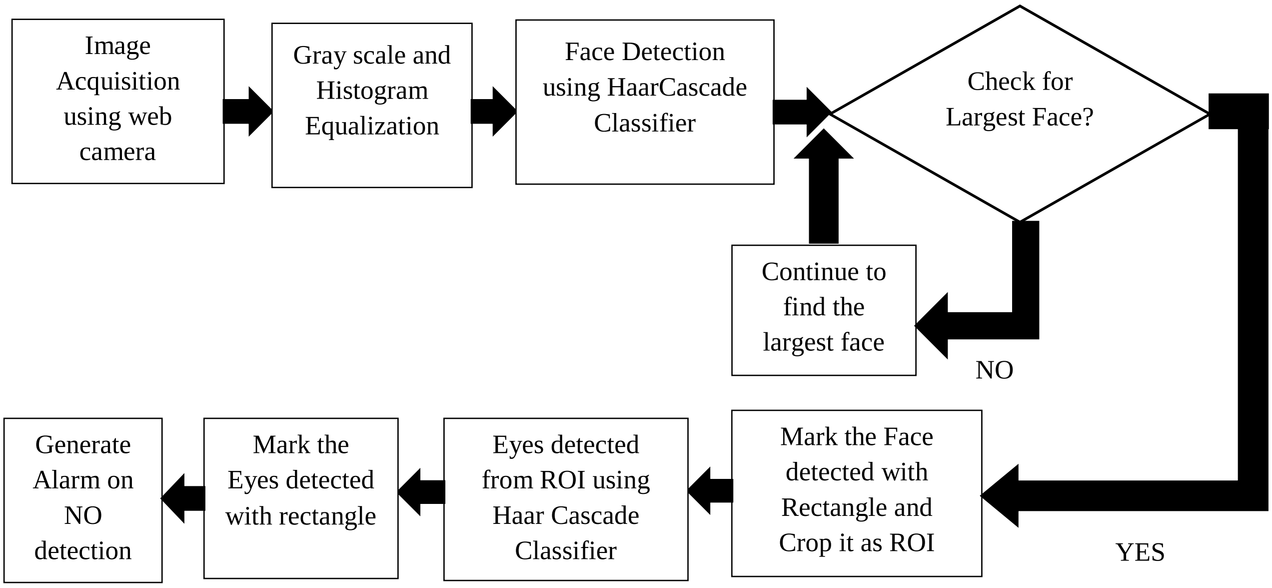

Fig. 3: Flow diagram to determine the level of drowsiness of a driver using visual features.

4.2 Yawn Detection:

For Yawn Detection, we have used Template matching.Template matching is a technique mainly used in digital image processing to find smallest parts of an image which match a template image. Template matching via cv::matchTemplate() is not based on histograms; rather, the function matches an actual image patch against an input image by sliding the patch over the input image using one of the matching methods.There are six different techniques that can be used namely;TM_SQDIFF (Square Difference), TM_SQDIFF_NORMED (Normalized Square Difference),TM_CCORR (Cross Correlation), TM_CCORR_NORMED (Normalized Cross Correlation), TM_CCOEFF (CorrelationCoefficient), TM_CCOEFF_NORMED (Normalized CorrelationCoefficient). The TM_CCOEFF_NORMED template matching scheme has been used as it gave the best results [15].Correlation Coefficient Normalized (CCOEFF_NORMED): Where a relative match for cv::TM_CCOEFF_NORMED will return a positive score and a relative mismatch will return a negative score. It was observed that there were more accurate matches (at the cost of more computations) as we move from simpler measures (Square Difference) to more sophisticated ones (Correlation Coefficient) [15].

$$R(x,y) = \frac{\sum_{x',y'}(T'(x',y') . I'(x+x',y+y'))}{\sqrt{\sum_{x',y'} T'(x',y')^2 . \sum_{x',y'} I'(x+x',y+y')^2}} \ldots..[15]$$

Where, $\boldsymbol{T'(x',y') = T(x',y') - \frac{1}{(w.\ h)\ .\ \sum_{x'',y''} T(x''\ y'')}}$

$$\boldsymbol{I'(x+x',y+y') = I(x+x',y+y') - \frac{1}{(w.\ h)\ .\ \sum_{x'',y''} I(x+x'',y+y'')}}$$

I(x,y)= Value of image pixel in location (x,y)
T(x,y)= Template value of image pixel in location (x,y)
R(x,y)= Result of Matching matrix in location (x,y)

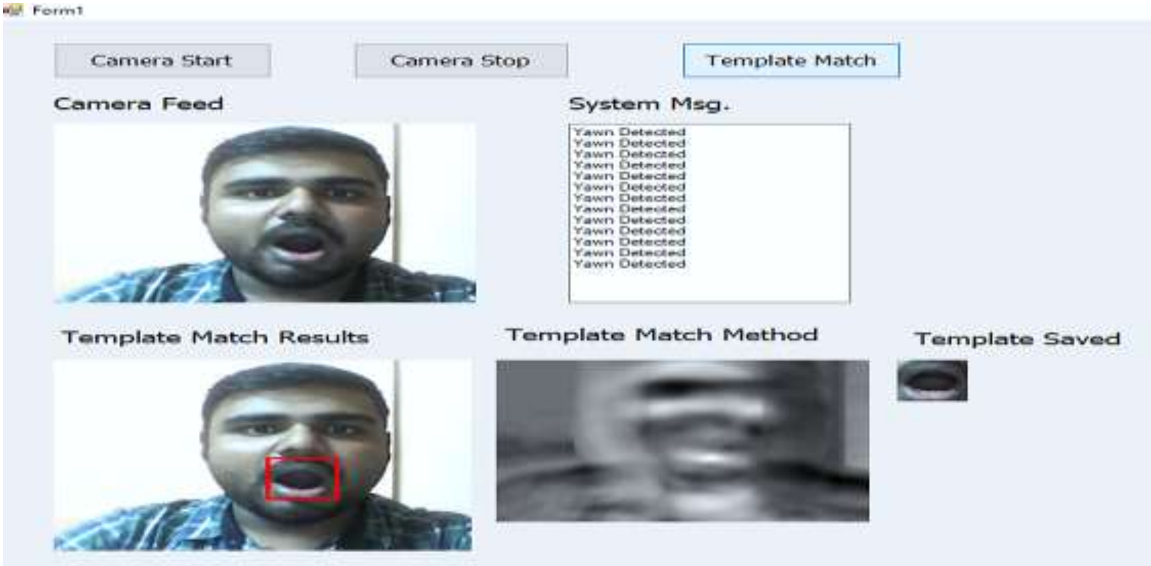

Fig. 4: Yawn Detection using Template Matching

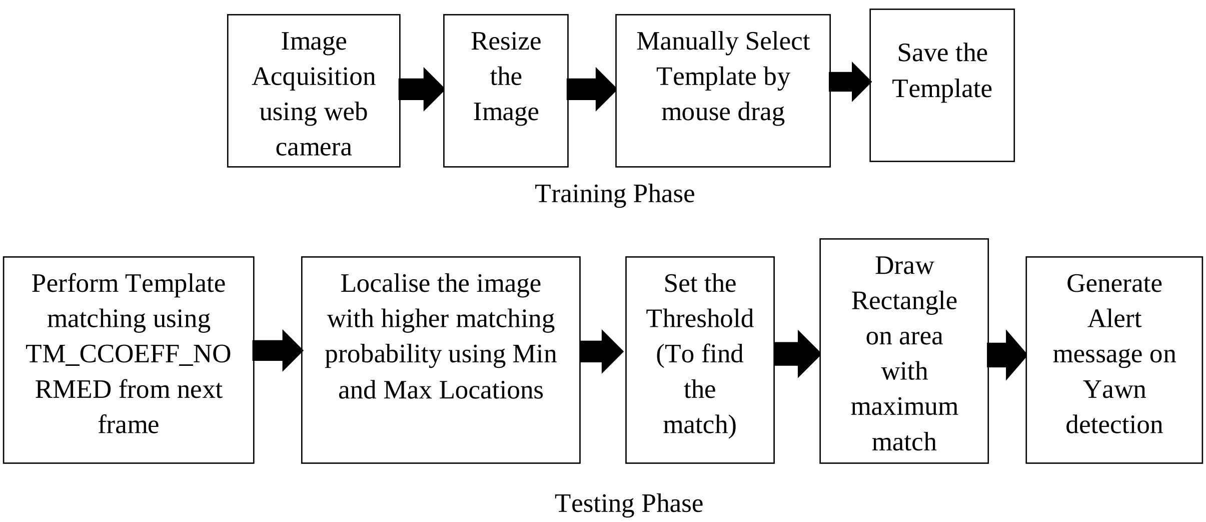

Fig. 5: Flow diagram to determine drowsiness of a driver from Yawn State.

The flow diagram for determining the drowsy state of driver using Yawn state has been shown in Fig. 5. The driversface image is acquired by using a web camera and then resized. The template to be matched is manually selected by mouse drag over the yawn state. The yawn state (mouth opening) is saved as template, this concludes the training part. Next, we perform the template matching, in our case we have used the cross coefficient normalized method, which is applied over the entire frame where the functionmatches the image patch (saved Template) against an input image by sliding the patch over the input image. Proper matching is done using the back projection. Where the region with highest match has a very bright white spot, showing that the object is easily picked out from the scene. Usingcv::minMaxLoc() to find the location of the best match and set threshold. A threshold of 0.85 has been set in order to get exact match to yawn template. A rectangle is then marked over the region of perfect match and an alert message generated if match (Yawn) observed.

V. Design and Implementation

Developing safety measures to prevent drowsy driving is a major challenge for the car industry. Here a system has been designed to prevent drowsiness while driving. When a driver enters a car, starts the ignition at first, he would be told to provide a yawn sample, by using the web camera. The next step would be face capture. Face capture has been implemented by a web camera that would be placed in front of the driver near dashboard. The camera would capture the face of driver along with eye and mouth tracking. Eye tracking is done to detect whether the driver eyes are open or closed to measure drowsiness level and mouth capture done to check for yawning while driving. After detection and tracking of face, eyes and mouth capture while driving, the system continuously keeps checking for any variations in above parameters. By using Visual Studio 2013 and OpenCV with Emgu tracking and detection of facial features is being done. OpenCV using Emgu being open library contains all .XML files for eye closeness detection and yawn detection is carried out using template matching where picture (yawn template) already stored will be compared to find whether the driver is in a drowsy state or not. If any one of the visual parameters gets checkedwhile driving then an alarm would go off, thus making the driver alert again.The complete flow of driver drowsiness detection is as given below;

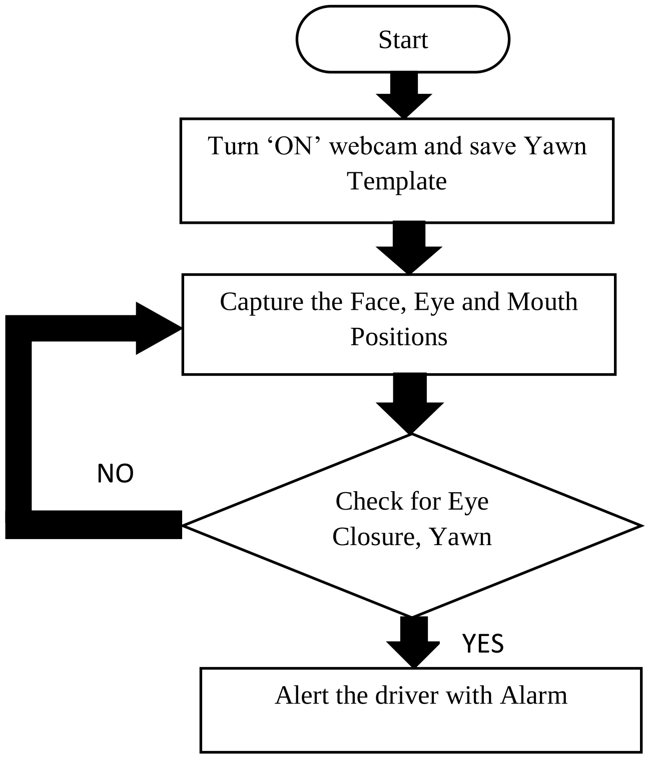

Fig. 6: Working of the entire drowsiness detection system.

The flow diagram for driver drowsiness detection with alert system is as explained in Fig.6. The driver on entering the car turns 'ON' the ignition.The driver then turns on the web camera and saves his Yawn template. The Web camera captures visual features like face, eye and mouth position and will begin process for drowsiness detection. The visual features would be captured in continuous real-time monitoring.On Eye closure, Head Tilts or Yawn detection, will lead to activation of alarm via a buzzer, if not then driver continues to drive.

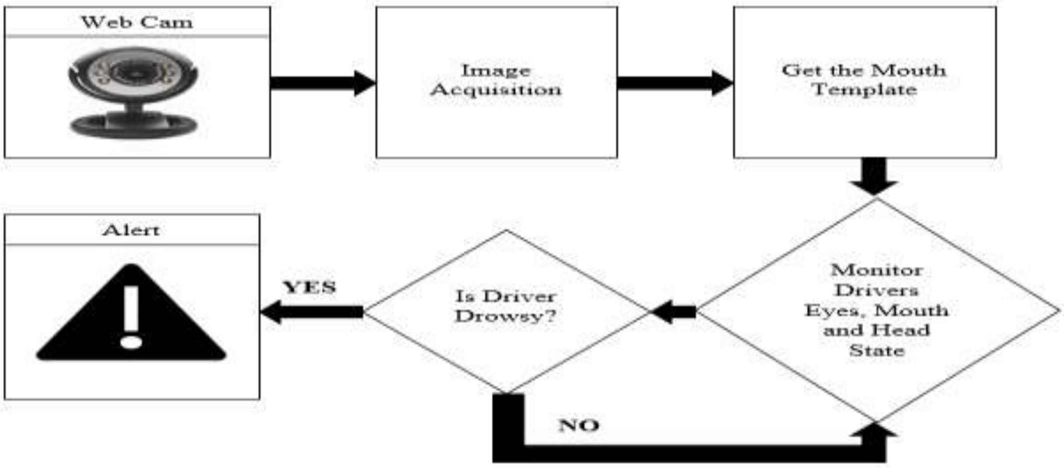

Fig. 7: The complete system set up for driver drowsiness detection.

The complete flow of the process to find driver drowsiness is as shown in Fig. 7. Where-in a webcam is used for face and yawn detection. The web camera is interfaced to PC to check the visual features of the driver while driving. The detection would be done in Real Time and the web camera output visible on the PC screen.A yawn template is saved to detect driver yawn state. From the next frame, onwards continuous eye, face and mouth detection takes place. An alert is generated with a buzzer (alarm on PC) and Alert message displayed on the screen if the driver is found to be drowsy. Fig. 8 describes about the driver driving in alert state while Fig. 9 and Fig. 10 describes about the driver driving in drowsy state which results in alarm (alert message) being generated.

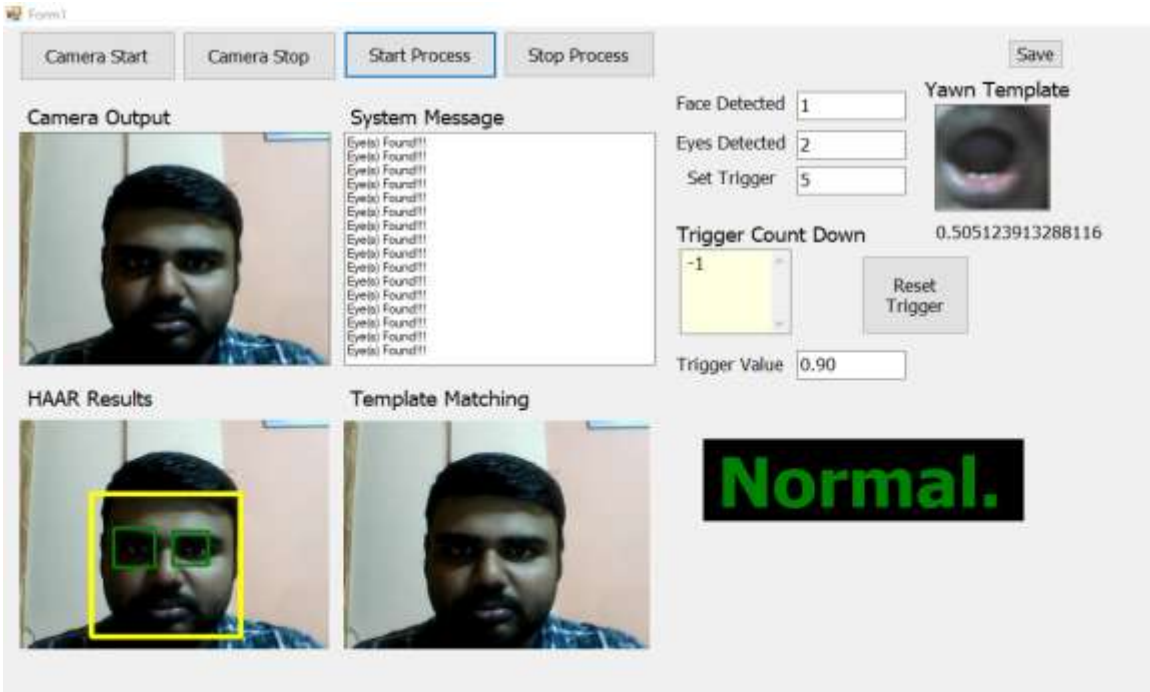

Fig. 8: Showing the normal state when driver is in attentive state.

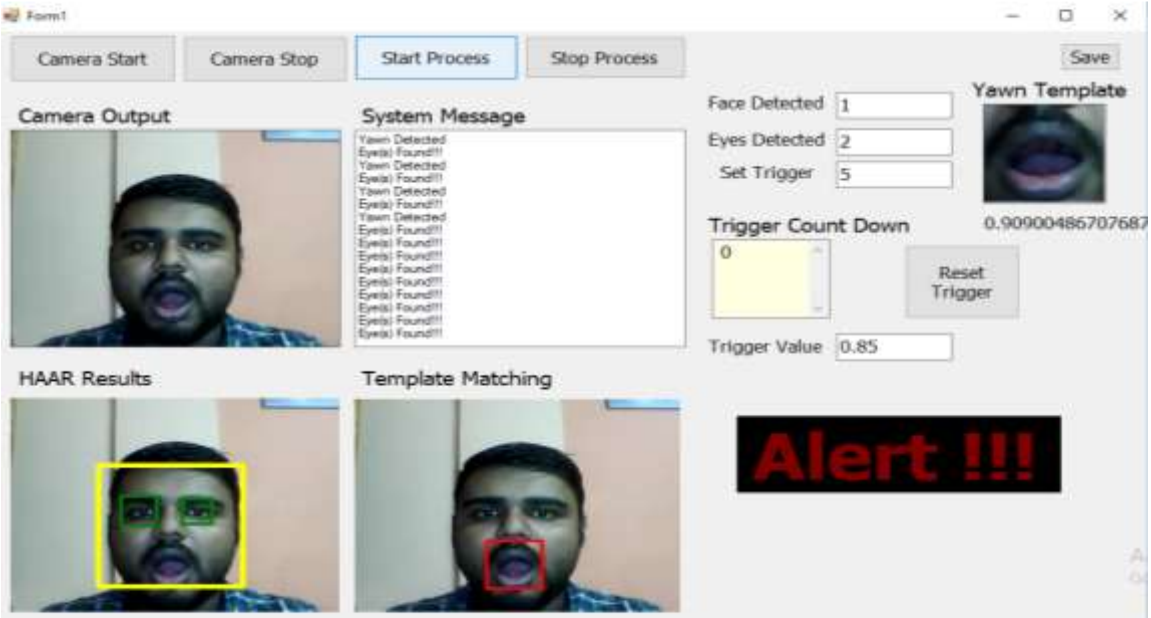

Fig. 9: The alert message generated when driver found to be in drowsy state (Yawn State).

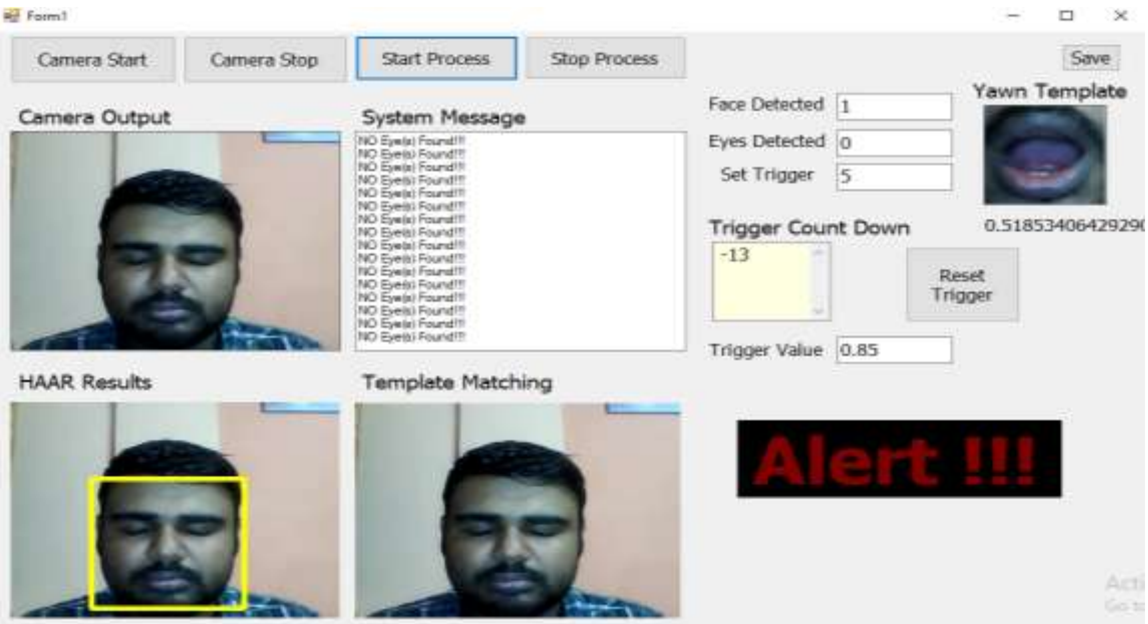

Fig. 10: Alert message generated when driver found to be in drowsy state (Eye Closure).

VI. Conclusion and Future Scope

Over the decade several drowsiness detection techniques have been developed. Even so there have been large number of accident cases due to driver drowsiness. This system has been implemented using non-intrusive techniques that do not bother the driver while driving thereby increasing chances to find the driver drowsy state detection. This framework uses the face, eye detection for drowsiness detection that has been merged with yawn detection so that in case a driver wears glasses or shades while driving, still the drowsy state can be detected using yawn results. The only disadvantage is the results may vary as per lighting condition, for which a better camera can be used to improve the accuracy at low lighting conditions. The proposed system had very high accuracy when tested in well-lit conditions. Development of hardware to alert the driver is currently being worked upon along with addition of Drunk state detection which is another major cause of road accidents.

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