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Numerical Simulation and Design of Machine Learning Based Real Time Fatigue Detection System

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Abstract

The proposed research is a step to implement real time image segmentation and drowsiness with help of machine learning methodologies. Image segmentation has been implemented in real time in which the segments of mouth and eyes have been segmented using image processing. Input can be provided by the help of real time image acquisition system such as webcam or internet of things based camera. From the video input, image frames has been extracted and processed to obtain real time features and using clustering algorithms segmentation has been achieved in real time. In the proposed work a Support Vector Machine (SVM) based machine learning method has been implemented emotion detection using facial expressions. The algorithm has been tested under variable luminance conditions and performed well with optimum accuracy as compared to contemporary research.

Keywords*:* Segmentation, Emotion Detection, Machine Learning, SVM, Neural Networks, Image Processing, GUI.

1. INTRODUCTION

Drowsiness is one of the primary drivers of genuine car crashes in our day by day lives. As indicated by the National Highway Traffic Safety Administration, around 150 individuals were murdered in the United States every year as a result of driver tiredness. 71,000 harmed and $12.5 billion in misfortunes [1]. Another report [2] brought up that the US government and organizations spend about $60.4 billion every year on mishaps identified with drowsiness, and due to drowsiness, it adds cost buyers about $16.4 billion Property harm, wellbeing cases, time and efficiency misfortunes drive. In 2010, the National Sleep Foundation (NSF) detailed that 54% of grown-up drivers felt sluggish while driving a vehicle, and 28% were, in reality, snoozing [3]. The German Road Safety Commission (DVR) claims that one-fourth of the thruway car crash passing is brought about by a snapshot of driver tiredness [4].

Immense setbacks, wounds and property harm brought about by drowsiness require critical strides in building up a powerful framework that can identify drowsiness and make a fitting move before a mishap happens. The US Department of Transportation has additionally gained ground in assembling savvy vehicles to avoid such mishaps [2]. As individuals become progressively keen on wise transportation frameworks, building up a powerful and down to earth sluggishness recognition framework is a critical advance. A great deal of research is at present in progress. Search for drowsiness recognition strategies that are reasonable for open use, yet in addition to the continuous location with significant precision. Toyota, Ford, Mercedes-Benz and other auto organizations are additionally utilizing vehicle wellbeing innovation to anticipate mishaps when drivers are lazy. This pattern is relied upon to make vehicles more brilliant and altogether lessen mishaps brought about by driver drowsiness. Clinging to these endeavors, our examination is driven by the measurable essentialness of mishaps brought about by drowsiness and gives an improved and precise technique for identifying drowsiness.

2. LITERATURE SURVEY

A literature review is ought to be incorporated into the writing study and start in the wake of finishing the arranged audit process talked about in the past part. The classification review is the main content of the research process. After a thorough review of the research papers, it should be included in the literature survey and after completing the review process the problem of further research should be identified.

Patel et al. [01] utilized bandpass channels and thresholding to expel commotion from the information ECG information in the low and high frequencies. In the wake of the preprocessing stage, the yield information is broke down in recurrence space by utilizing Fast Fourier Transforms (FFT) and essential highlights are removed for grouping.

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Fu-Chang et al. [28] performed comparative examinations on EEG information to decide the drowsiness of a driver. They utilized Independent Component Analysis (ICA) to isolate and limit blended EEG information to unmistakable mind exercises. From the preprocessed information, highlights are separated in the recurrence area.

Hu and Zheng et al. [02] likewise actualized the drowsiness location framework by utilizing EOG information. They at first distinguished the eye squints from the recorded EOG information and removed the eye top development parameters as highlights to be characterized utilizing Support Vector Machines (SVM). The fundamental characteristic of physiological estimating systems is that they can decide the reduction in dimension of sharpness early before the genuine drowsiness scene begins. People don't normally get sleepy in a moment and there is progressive decline accordingly or action of the different body parts which in the long run lead to drowsiness.

For instance, in EEG investigation, the adjustment in flag control at the alpha range (8 – 12Hz) and shows early indication of drowsiness. Physiological estimating procedures can quantify such changes at the beginning times and the individual can be cautioned or the best possible wellbeing measure can be taken before mishaps could happen. The deliberate signs are likewise dependable to distinguish drowsiness as their connection with the readiness of the driver is very precise and they are normally free of the outer factors, for example, the nature of the street, the sort of vehicle or the traffic. Subsequently, they have more precise drowsiness location ability than vehicle-based and conduct estimating methods.

H. Li et al. [03] performed progressive picture sifting systems, for example, picture subtraction, morphologically shut activities and binarization, lastly checked the number of pixels around the eyes distract to distinguish eye conclusion.

M. Liu et al. [04] removed basic highlights from the fleeting contrast of sequential picture outlines and utilized them to investigate the standards of eyelid development amid drowsiness.

Garcia et al. [05] have additionally displayed a non-meddlesome way to deal with drowsiness discovery. They utilized an IR brightening framework and a high goal camera to acknowledge a surge of pictures and perform face and eye location. They connected channels on the eyes district and performed flat and vertical projections of the pixel estimations of the identified eye territory. The vertical projection compares to the eye tallness which is utilized to assess the PERCLOS.

Zutao and Jiashu [06] at first performed face and eye recognition and followed the eye understudies utilizing non-straight Kalman and mean-move following. They likewise performed vertical and flat projections of the pixels around the eyes district. Since the eyeball shading is a lot darker than the encompassing, they determined the pixel esteems in the vertical projection to decide the level of eyelid conclusion.

3. METHODOLOGY

The general diagram of system has been shown in Fig. 3.1. As it can be seen, the image received from camera is sent to central processor to be processed and then it will operate considering condition of drivers' face.

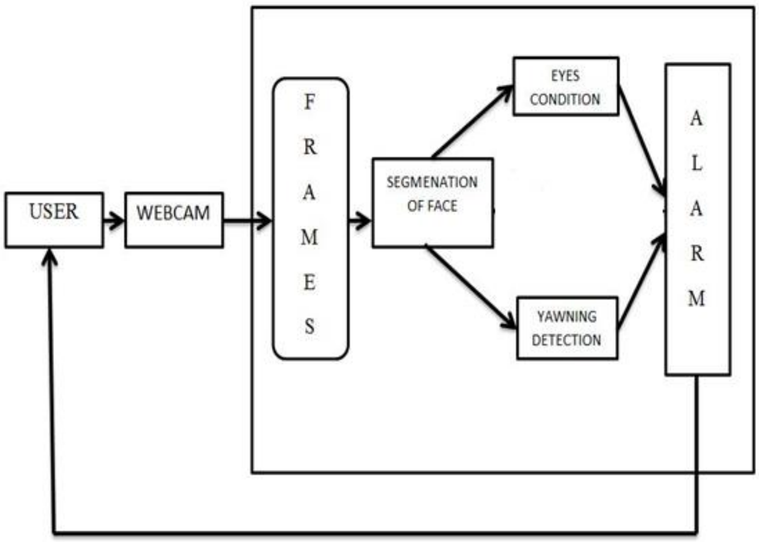

Figure 3.1 System Architecture

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- **Segmentation of face:** The face is segmented from the input image that is initially whatever the video that is recorded by the camera will be fragmented into the frames and this frames will be given as inputs for segmenting the face.
- **Eyes condition:** The position of the driver's eye is determined by using appropriate threshold. In this work, edge detection of the eyes region is considered.
- **Yawning Detection:** Among clustering methods used in segmentation of various parts of the image, the mean-based clustering was utilized for yawning detection. The objective function was to obtain then minimum distance between the classes, or basically between the image pixels.

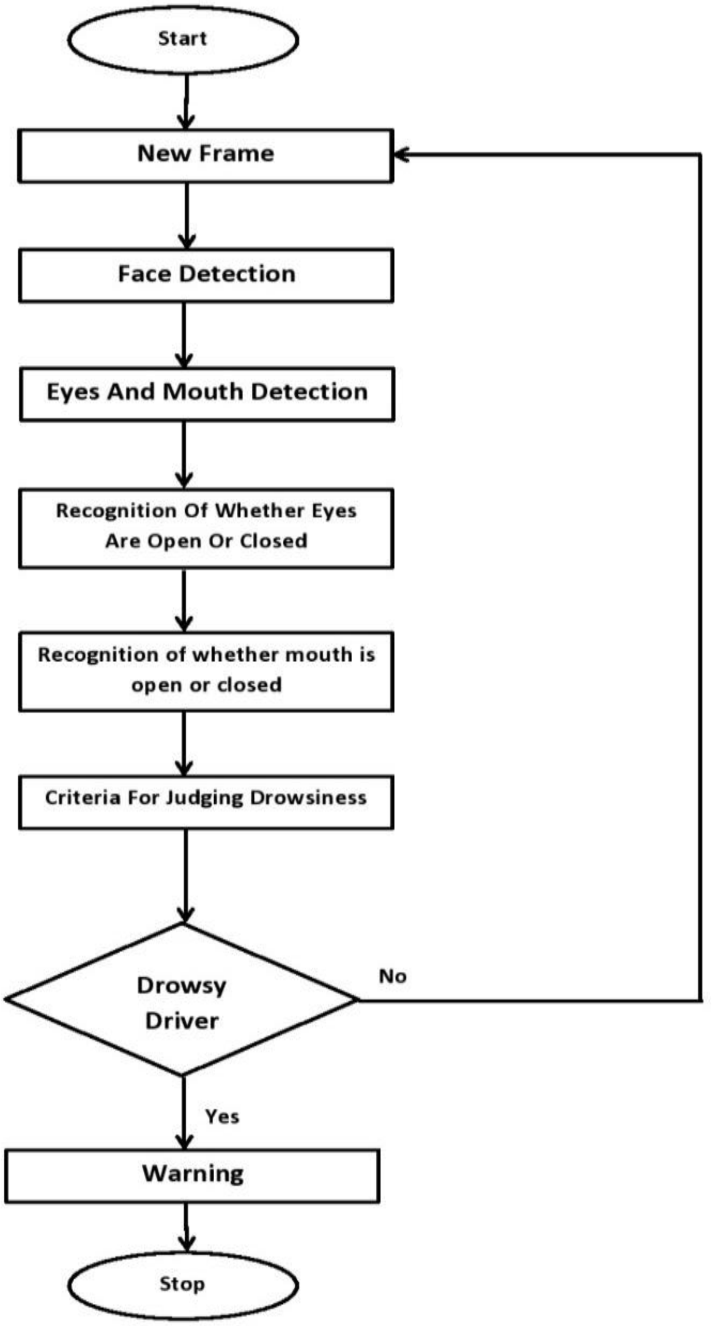

Figure 3.2 Flow Chart of Proposed System

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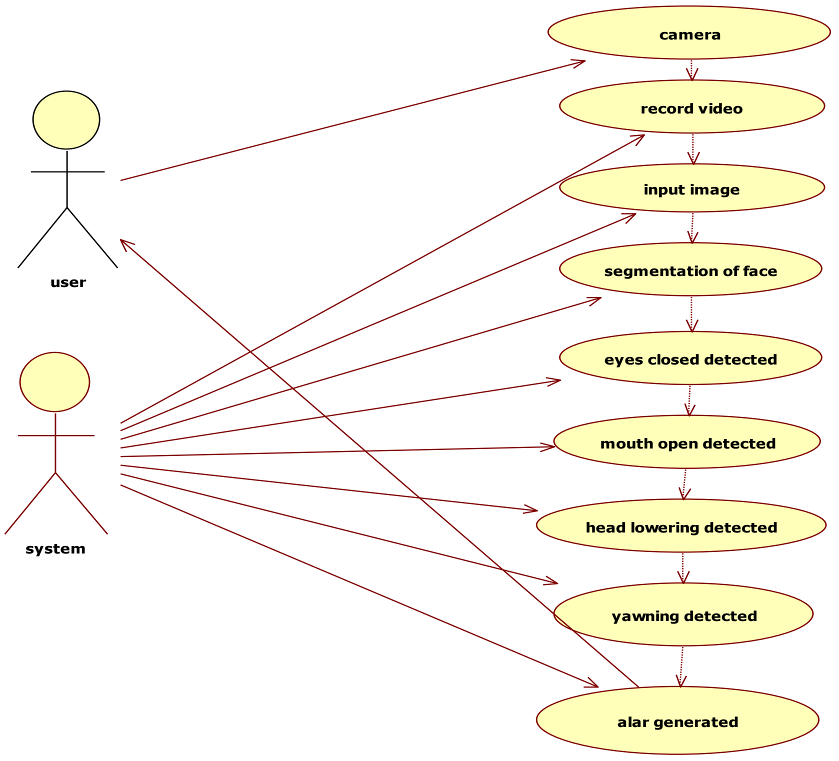

Figure 3.3 Use Case Diagram for Proposed System

In our proposed system sequence diagram there are two actors i.e. the user and system were the camera monitors users face and system records the video and creates images for segmentation of face. Segmentation of face is done in order to extract only the eye and mouth region and discard the surrounding region which we are not interested in. Then the conditions for fatigue and non-fatigue are checked. If fatigue is detected then alarm is generated, if no fatigue is detected then no alarm is generated.

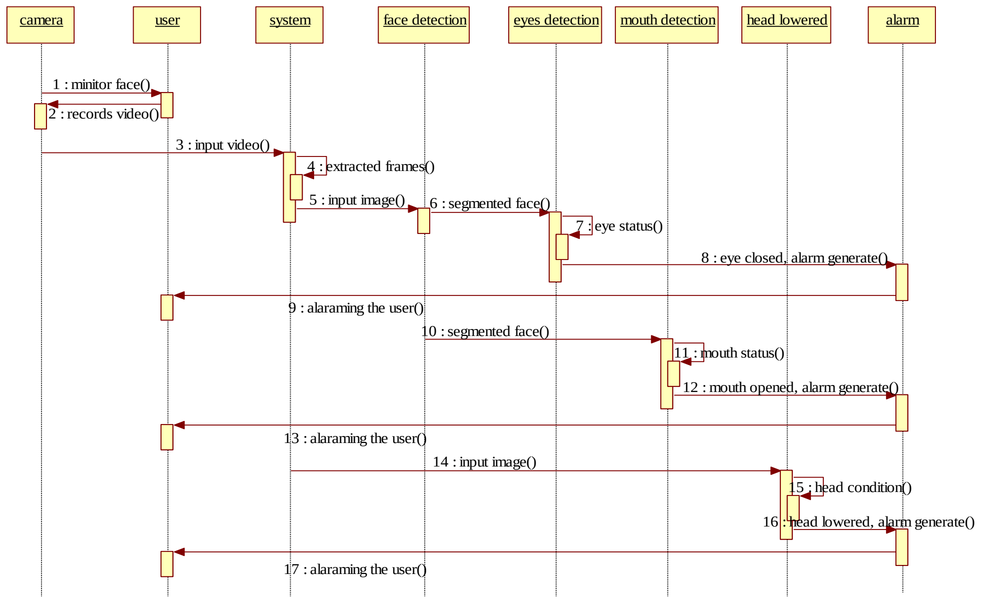

Figure 3.4 Sequence Diagram of Proposed System

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A DFD shows what kinds of information will be input to and output from the system, where the data will come from and go to, and where the data will be stored. It does not show information about the timing of processes, or information about whether processes will operate in sequence or in parallel (which is shown on a flowchart).

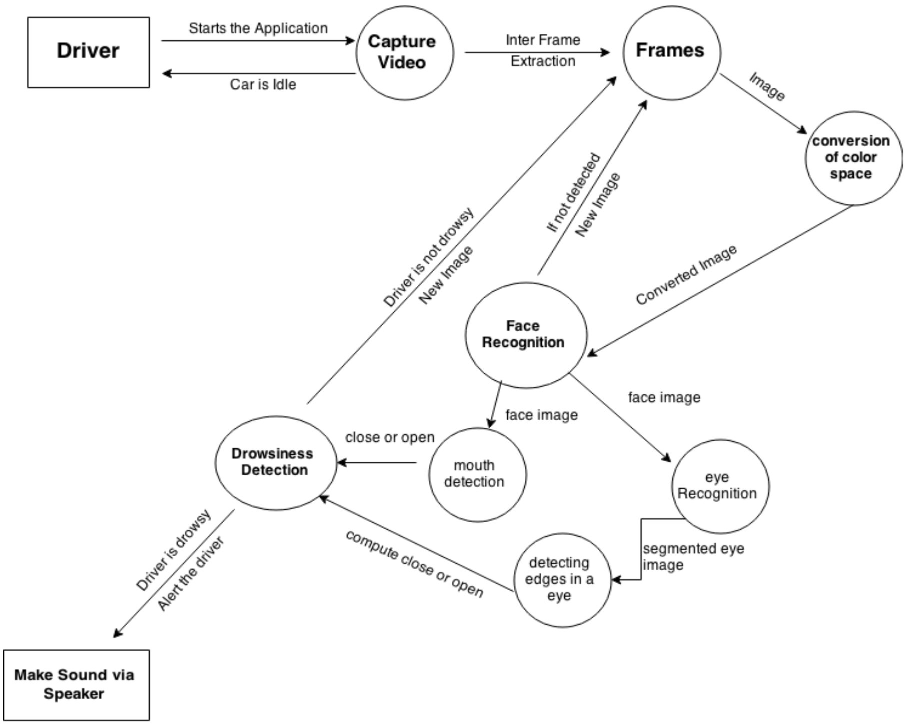

Figure 3.5 Data Flow Diagram of the System

Implementation is the stage of the project when the theoretical design is turned into a working system. Thus it can be considered as the critical stage in achieving a successful new system and in giving the user, confidence that the new system will work and be effective.

The implement stage involves careful planning, investigation of the existing system and its constraints on implementation, designing of methods to achieve change over and evaluation of change over methods.

Here the proposed system includes four modules they are as follows

- Segmentation of face
- Detection of eyes condition
- Yawning detection

This is the very first module in which the face is segmented from the input image that is initially whatever the video that is recorded by the camera will be fragmented into the frames and then into the image, this image will be given as input for segmenting the face.

The partial segmentation of the image by selecting the appropriate threshold is based on dividing the image into the background and foreground classes. Thresholding is primarily concerned with selecting an appropriate threshold according to image histogram. That is, the value of thresholding or border as the brightness intensity is considered as the basis of the division and the brightness intensities greater and less than threshold is equal to 1 and zero respectively.

The purpose of face detection is to minimize the error rate in identifying facial expressions. The importance of this part is to measure the position of the eyes, the mouth and the head.

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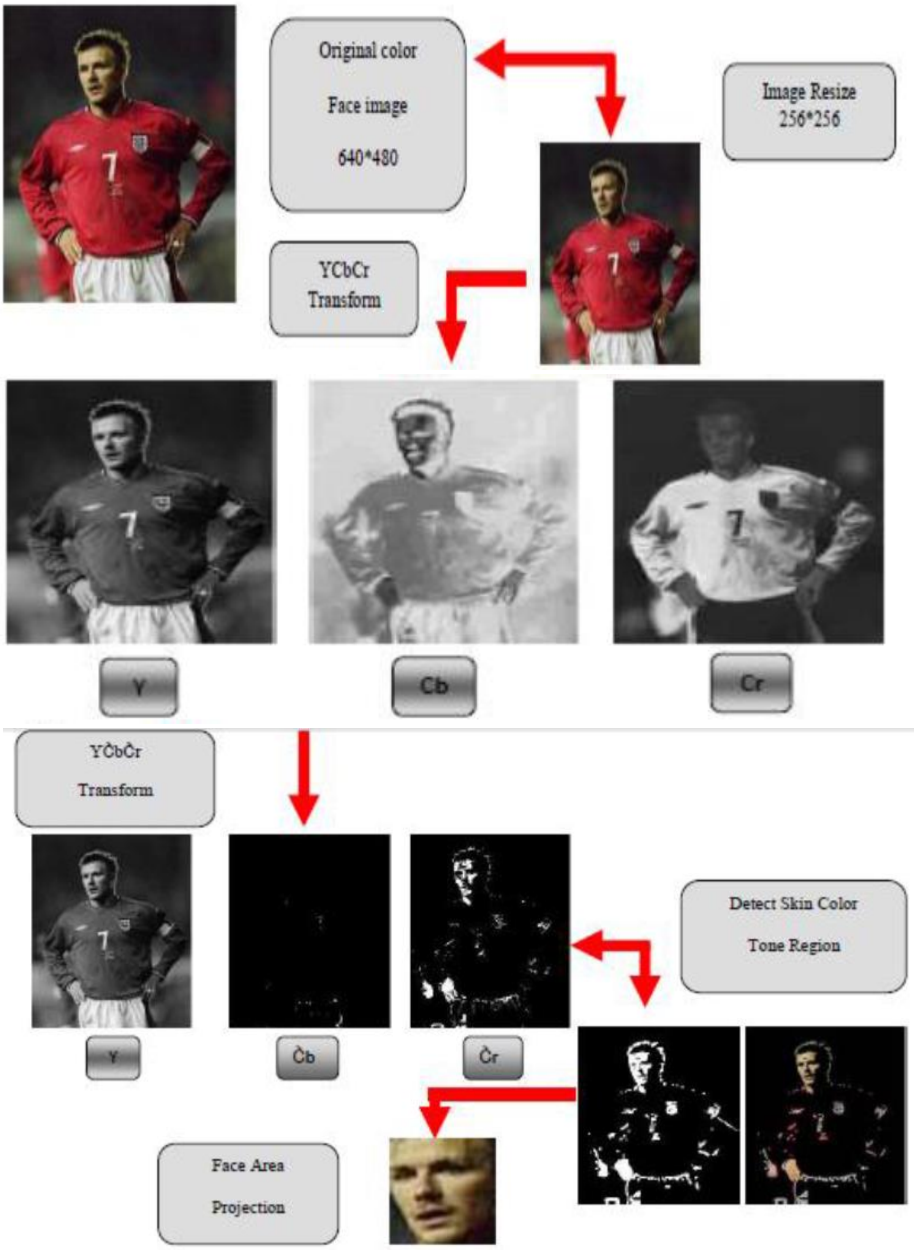

Figure 3.6 Face Detection Process

In this work, Sobel which is an edge detection method is considered. Because of the simplicity and common uses, this method is preferred by the others methods in this work. The Sobel edge detector uses two masks, one vertical and one horizontal. These masks are generally used 3×3 matrices. After successful face and facial feature detection, eye state can be determined in every frame using the correlation coefficient template matching method. By considering the diversity to the nearby pixels and the similarity to the eye pixels sufficiently, the specific region of the eyes can be obtained. After this step, Sobel edge detection method is used again to detect the eyes' precise boundaries. The method has Especially, the matrices which have 3×3 dimensions are used in matlab (edge.m). The masks of the Sobel edge detection are extended to 5×5 dimensions are constructed in this work. A matlab function, called as Sobel5×5 is developed by using these new matrices toolboxes.

been adopted frequently in the eye detection which mentioned above. Our method starts from left and right side, to find eyes, therefore we can detect the eyes separately. We segment the eyes from the image and use them to generate an eye template, by this means we obtain a rather stable eye template for the status analyzing and reduce the influence of light reflections. The eye template is generated as follows.

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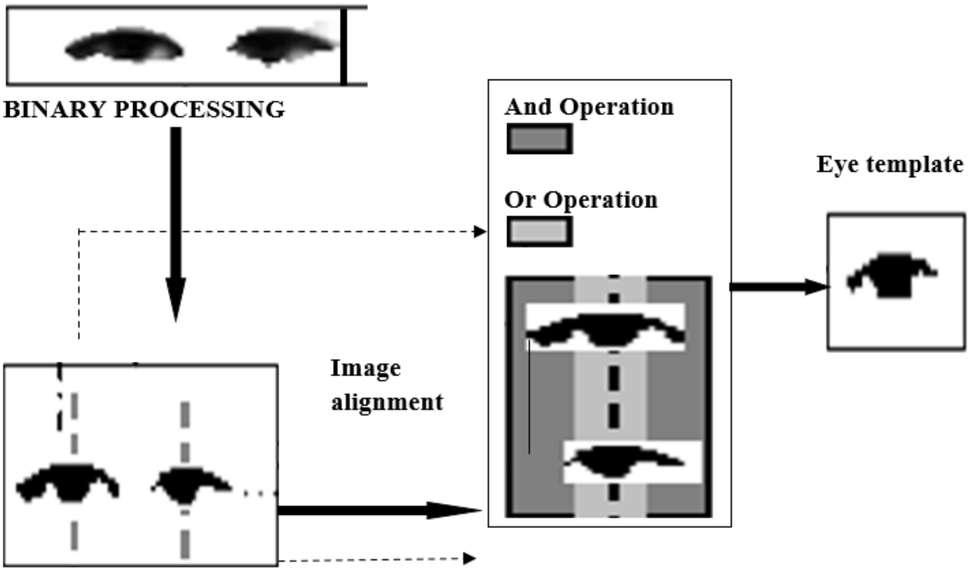

Figure 3.7 Eye Template Generation Procedure

To distinguish the driver's status the eyes' states should be recognized ahead. There are two factors which can affect the size of the eyes in the frames. On the one hand, human eyes are always different in size. On the other hand, the distance between driver and the camera is the other reason. So we normalize the eye template to a fixed size of 12×30 before feature extraction. For each eye template, eye area, average height of pupil, width to height ratio are the most important features to judge eye's status which is shown in below table.

Table 3.1
Eye States and Features

	Eye Region	Area(pixel)	Eye Template	Average Height	Ratio
Full open		200		7.6	2.8750
Half open		155		6.8	3.0000
Closed		114		6.0	3.1667

The eye states can be divided into two types: full open, half open and closed. From the table above we can see that eyes of different states present different features. By analyzing the driver's eyes states changes while driving we discovered two principles which can indicate driver drowsiness. Firstly, if a driver's eyes keep closed over 4 consecutive frames it is believed that the driver is drowsy. Secondly, fatigue can be confirmed if a driver's eyes only change between half open and closed over 8 consecutive frames. The different eye states of full open and half open sometimes cannot be well distinguished which has caused more false judgments and the fast movement of drivers head can result in the driver's eyes tracking failure. Before the system is put into use we trained it in advance to get different states parameters for the driver aiming at improving the accuracy of the driver's status analysis.

In this work, the other sign of fatigue during driving, which is manifested in a person's face, is frequent yawning that is due to body reflexes when a person is exhausted and about to fall asleep. Various systems have been proposed for measuring yawning some of which are slow and time consuming while others are not very accurate in separating the mouth area at the time of yawning.

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An efficient technique is needed that is able to display the changes in face configuration and detect the yawning. Among clustering methods used in segmentation of various parts of the image, the mean-based clustering or K-means was utilized. The objective function was to obtain then minimum distance between the classes, or basically between the image pixels.

Figure 3.8 Normal Mouth Detection

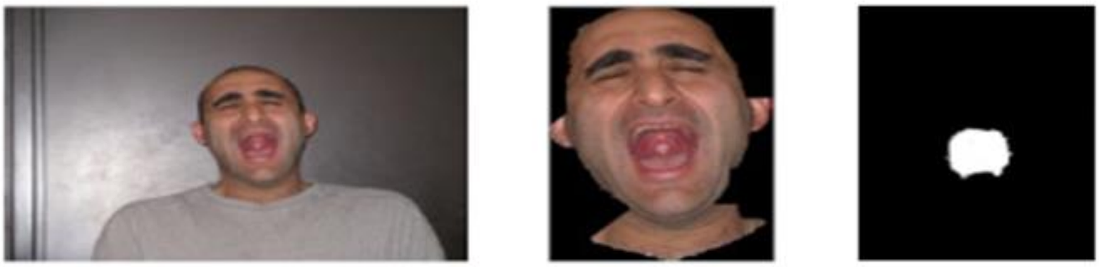

Figure 3.9 Yawning Detection

K-means uses a two-phase iterative algorithm to minimize the sum of point-to-centroid distances, summed over all K-clusters:

- The first phase uses batch updates, where in each iteration consists of reassigning points to their nearest cluster centroid, all at once, followed by recalculation of cluster centroids. This phase occasionally does not converge to solution that is a local minimum, that is, a partition of the data where moving any single point to a different cluster increases the total sum of distances. This is more likely for small data sets. The batch phase is fast, but potentially only approximates a solution as a starting point for the second phase.
- The second phase uses online updates, where points are individually reassigned if doing so will reduce the sum of distances, and cluster centroid are recomputed after each reassignment. For each of the iterations during the second phase consists of one pass though all the points. The second phase will converge to a local minimum, although there may be other local minima with lower total sum of distances. The problem of finding the global minimum can only be solved in general by an exhaustive (or clever, or lucky) choice of starting points, but using several replicates with random starting points typically results in a solution that is a global minimum.

Table 4.2
Feature Matrix of Eye

Feature	**Area (No. of Pixels)**	**Avg. Height**	**Ratio**
Full Open	204	7.62	2.87
Half Open	155	6.79	3.04
Closed	117	6.02	3.17

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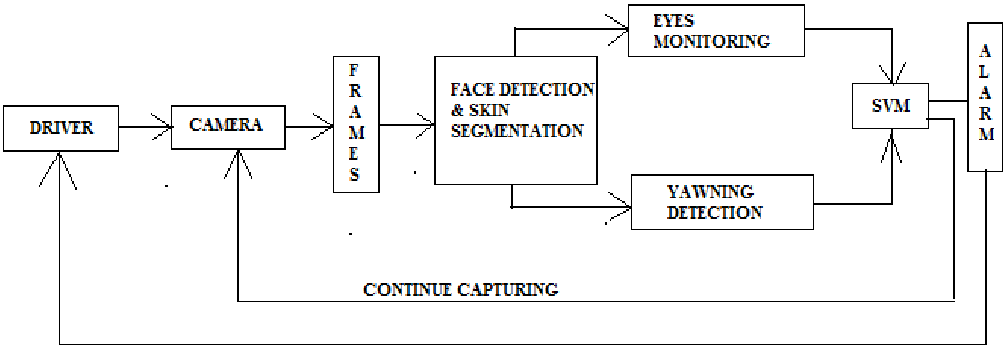

Figure 3.10 Face Detection Framework

4. RESULTS ANALSIS

This section describes the requirements, constraints, basic architecture, and selected algorithms associated with the prototype of our driver drowsiness detection system. It consists of four stages:

1. System Initialization (Preparation)
2. Regular Stage (Eye Tracking with Eye-State Analysis)
3. Warning Stage (Nod Analysis)
4. Alert Stage

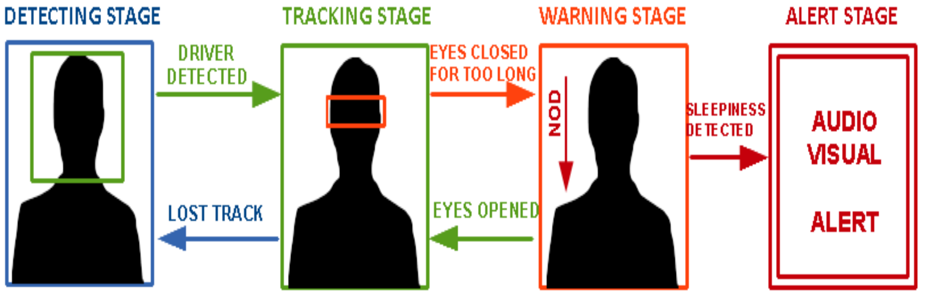

Figure 4.1 Four Stages of Our Drowsiness Detection System

Our methodology pursues a behavioral technique by playing out a non-intrusive checking of outside signs depicting a driver's dimension of sleepiness. We take a gander at this the mind-boggling issue from a frameworks engineering perspective: how to go from a proof of idea model to a steady programming system that can give a strong premise to future research in this endeavour.

The first analysis was done during the day with the best distance. It was seen that the program worked well in normal daylight, with a level of accuracy between 85 and 95%.

The second analysis was done on a cloudy day with the best distance. It was seen that the program ran and worked with average accuracy, with a 10-15% drop in accuracy compared to scenario-1 daylight, where the accuracy was between 75 and 80%. Again, it was seen that the percentage of drowsiness that could be picked up by yawning was better than that of eye movement. The third study was done at night with artificial light and the best distance. It was seen that the program ran and worked with the highest accuracy compared to scenarios 1 and 2, which were both between 90 and 93%.

Table 4.1 Data Analysis

Trial	Scenario	Duration of Detection (Seconds)	Detection Rate
1	Scenario-1	90	91%
2	Scenario-1	90	90%
3	Scenario-1	90	91.5%
4	Scenario-1	90	92%
5	Scenario-1	90	92.1%

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Average Accuracy			**91.00%**
1	Scenario-2	90	77%
2	Scenario-2	90	80%
3	Scenario-2	90	83%
4	Scenario-2	90	81%
5	Scenario-2	90	82%
Average Analysis			**81.00%**
1	Scenario-3	90	91%
2	Scenario-3	90	92.5%
3	Scenario-3	90	93%
4	Scenario-3	90	94.2%
5	Scenario-3	90	94%
Average Accuracy			**93.00%**
1	Scenario-4	90	65%
2	Scenario-4	90	68.5%
3	Scenario-4	90	66%
4	Scenario-4	90	70.2%
5	Scenario-4	90	72%
Average Accuracy			**68.00%**
Overall Average Accuracy			**83.25 %**

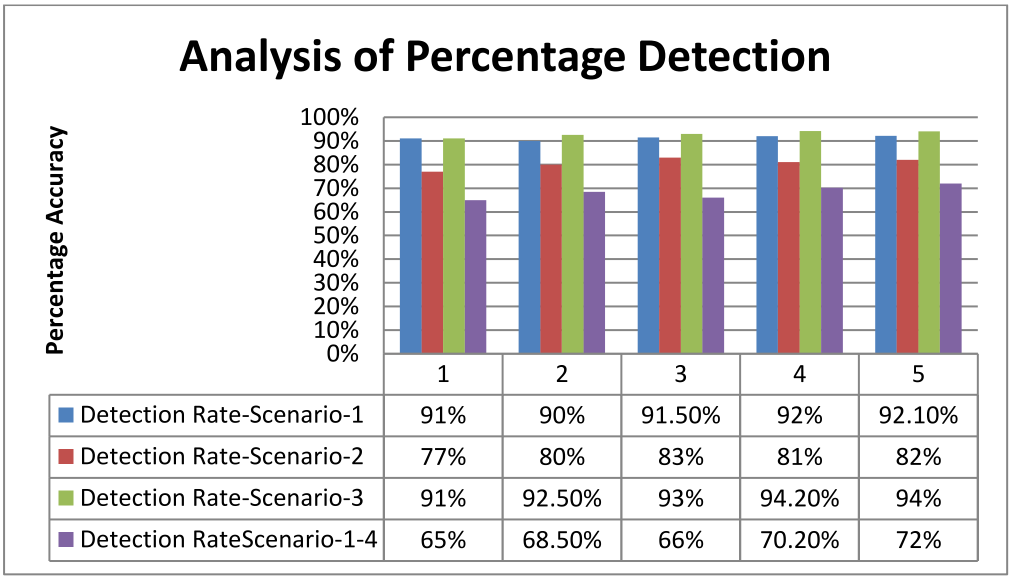

Figure 4.2 Analysis of Percentage Face Detection

Table 4.1 shows the analysis of how well and how many times each scenario was found in 5 trials. Each scenario's average accuracy has been calculated and compared in this table. The comparison analysis is shown in figures 5.8 and 5.9, respectively.

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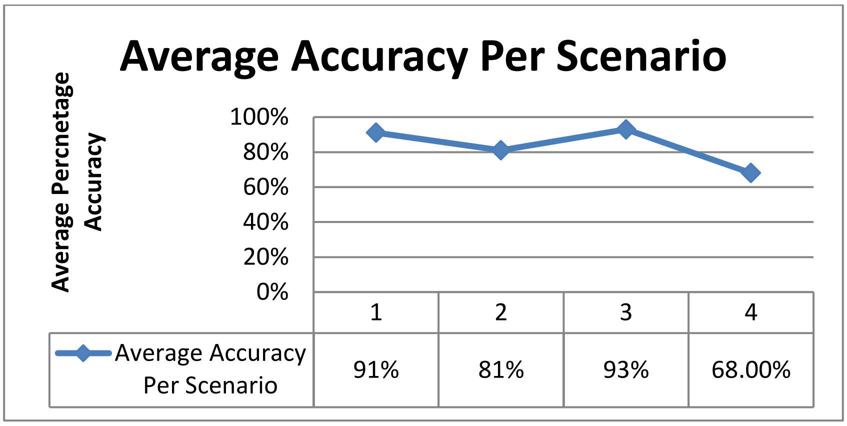

Figure 4.3 Average Accuracy per Scenario

The final analysis was done at night, when there was less light and they were the closest. It was seen that the program ran and underperformed with the least amount of accuracy compared to scenarios 1 and 2, which were between 65 and 68 percent.

Again, it was seen that the percentage of drowsiness that could be picked up by yawning was better than that of eye movement.

5. CONCLUSION AND FUTURE WORK

Conclusion: The system proposed in this work is acceptable level of performance and an average accuracy of 93.18%. The high fatalities of road accidents, which is primarily due to human errors committed out of fatigue, justifies the use of this system to alarm drivers at the time of driving. High-speed data processing and great accuracy distinguish this system from the similar ones. The development and improvement of this system can save the lives of millions of people annually. The processing rate or framing of this camera is 15 fps and the first video sequence is related to the state where the head is in a lowered position which includes 85 sample frames. The second video sequence deals with the recording of the open or closed state of the eyes in which 48 image frames indicate that eyes are closed in a 6 seconds period while 65 frames show that the eyes are normally open. The third video sequence shows the yawning or the frequent opening of the driver's mouth. And finally the fourth video sequence is a combination of all three modes and its recon ling takes a longer time. The average accuracy (AAC), the detection rate (DR) and false alarm rate (FAR) has been calculated. These three factors, which have been proposed for assessing the detection accuracy of the video sequence, indicate the acceptable performance of the proposed system in detecting the signs of fatigue in driver's face at the time of driving.

Future Work: In future works, a driver's distraction identification system will be developed. With its complex and ever-changing nature, including the effect of the light and the condition of shooting environment, it makes the skin segmentation of human faces in color images severely affect face detection, and also makes it an important research topic. A method of face-region segmentation based on skin detection has been proposed in this paper, which partly comes from other studies. Compared with the conventional method of segmentation, we put these methods into this article, such as adjudging the images with the light interference, enhancing the images and improved threshold segmentation. Determination of the light interference not only improves the accuracy of image segmentation in the follow-up processing, but also expands the scope of application with skin segmentation in color images. Image enhancement mainly deals with the skin-likelihood image which is transformed through Gaussian model, aiming at getting the gray images with better and higher contrast. In this article, we use the method that combines the histogram with Otsu, which is the initial use of histogram threshold method to determine the threshold, and then we set it as the threshold of Otsu, and respectively, find the best.

On detecting the drowsiness the system generates the alarm to wake up the driver. Ultrasonic sensors are connected on the left and behind the car to detect the distance between the car and the road side and to detect any other car behind. Based on the situation the system tries to reduce the speed and to stop the car. When the driver is feeling drowsy the future technology would be enhanced so that the sensors are applied in cars and the car gives the indication to the neighboring vehicle and just moves towards the lane and park the vehicle.

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