A

Project Report On

**A Novel And Efficient Real Time Driver Fatigue And Yawn Detection-Alert System**

*Submitted in partial fulfillment of the requirement For the award of the degree of*

##### BACHELOR OF TECHNOLOGY IN

**ELECTRONICS AND COMMUNICATION ENGINEERING**

*Submitted by*

MAMIDI.SRINIVAS 21A31A04P3

Under the esteemed guidance of **Mrs. L. Gaviramma** M.Tech.., Assistant Professor of ECE



##### DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

PRAGATI ENGINEERING COLLEGE

##### (AUTONOMOUS)

**(Approved by AICTE, Permanently Affiliated to JNTUK, Kakinada, Accredited by NAAC with ‘A+ Grade’)**

**1-378, ADB Road, Surampalem, Near Peddapuram-533437**

**2021 - 2025**

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**CERTIFICATE**

##### DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

****

This is to certify that the project report entitled **“A NOVEL AND EFFICIENT REAL TIME DRIVER FATIGUE AND YAWN DETECTION-ALERT SYSTEM”** is being

submitted by **M. SRINIVAS** (21A31A04P3)**,** in partial fulfilment for the award of the Degree of **Bachelor of Technology**, during the year **2021-2025** in Electronics and Communication Engineering of Pragati Engineering College, for the record of a bonafide work carried out by her.

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# ABSTRACT

Fatigue among drivers is a major cause of road accidents every year in India.

Lack of sound sleep for six to eight hours is one of the primary reasons behind this fatigue. Drivers with sleep deprivation can imbalance the reaction time and decision making when behind the wheels and this can increase the cause of accidents. This type of accidents is more likely to result in death or severe injury as they tend to be in high speed and because of the fact that driver has fallen asleep cannot apply brake or skew to avoid or reduce the impact. Therefore, it is highly essential to create a smart system which can spot and alert the driver of his/her condition. Although there are few solutions proposed in this direction, most of them have not been implemented successfully and many of them only remain in theory. In this research paper, we propose an efficient driver fatigue detection and alert system using mainly open source technologies. We implement and test this system in real time and the results are highly encouraging compared to many existing systems.

**CHAPTER 1**

# RESEARCH MOTIVATION

In the world, people and goods travel from one place to another by buses, trains, cars, scooters, rickshaws, cycles, etc. This movement of goods and individuals is very important in business so that raw materials can reach the place of manufacturer, finished products reach the place of sale or consumption and individuals move around to manage the business, etc. It is associated with every step of our life. Without transport we as well as business units cannot move a single step.

We find that basically transport is possible through land, air or water. On land we use trucks, tractors, etc., to carry goods; trains, buses, cars etc. to carry passengers. In air, we find airplanes, helicopters to carry passengers as well as goods. Similarly in water we find ships, steamers, etc., to carry goods and passengers. All these are known as various means of transport. The modes of transport can be broadly divided into three categories: Land transport, Water transport and Air transport.

Land transport refers to activities of physical movement of goods and passengers on land. This movement takes place on road, rail, rope or pipe. So land transport may further be divided into Road transport, Rail transport, Ropeway transport, Pipeline transport.

Roads are the means that connect one place to another on the surface of the land. Roads in village, towns and cities do not look alike. Some of them contain sand and some may be of chips and cement or coal tar. You find different vehicles plying on roads like bullock carts, cycles, motorcycles, cars, trucks, buses, etc.

All of these constitute different means of road transport. The means of road transport may be divided into three types: -

Man driven ii) Animal driven and iii) Motor driven. Compared with man driven and animal-driven means of road transport, motor driven means of transport have become more important over the years.

This is due to their speedy movement and larger carrying capacity. Extension of roads to every corner of the country has also enhanced the use of motor driven transport.

The types of motor vehicles used to carry goods and passengers include auto- rickshaws, scooters, vans, buses, tempos and trucks etc.

* It is a relatively cheaper mode of transport as compared to other modes.
* Perishable goods can be transported at a faster speed by road carriers over a short distance..

Inspite of so many advantages of this road transport, the greatest disadvantage is the vechicle collisions. The collisions can result in injury, property damage and death. Worldwide motor vehicle collisions lead to significant death and disability as well as significant financial costs to both society and the individual.

A number of factors contribute to the risk of collision including vehicle design, speed of operation, road design, and driver impairment. The driver impairments are inattentive and drowsiness. Drowsy driving is a serious problem that leads to thousands of crashes each year.

Driver fatigue and lack of sleep of drivers especially those who drive heavy vehicles such as trucks, buses etc., have been growing problems in recent year Drowsy, inattentive and enraged drivers are major causes of accidents.

It is estimated that drowsiness contributes to more than 1,00,000 collisions each year resulting over 1,500 deaths and 40,000 injuries costing the government and businesses unbearable loss every year. Automatically detecting alertness of drivers early enough to warn them about their lack of alertness due to fatigue can save many lives, personal sufferings and businesse

# WHAT IS AN IMAGE

An image is a two-dimensional picture, which has a similar appearance to some subject usually a physical object or a person.

Image is a two-dimensional, such as a photograph, screen display, and as well as a three-dimensional, such as a statue. They may be captured by optical devices—such as cameras, mirrors, lenses, telescopes, microscopes, etc. and natural objects and phenomena, such as the human eye or water surfaces.

The word image is also used in the broader sense of any two-dimensional figure such as a map, a graph, a pie chart, or an abstract painting. An image is a rectangular grid



Fig 1.2.1 Color-to-grayscale conversion and edge detection in image processing

of pixels. It has a definite height and a definite width counted in pixels. Each pixel is square and has a fixed size on a given display. However different computer monitors may use different sized pixels. The pixels that constitute an image are ordered as a grid (columns and rows); each pixel consists of numbers representing magnitudes of brightness and color.

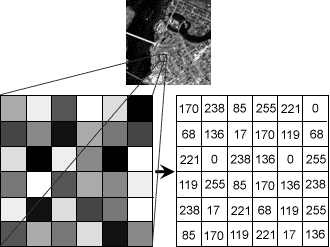


Fig 1.2.2 Image segmentation with Pixel Intensity Values

Image file size is expressed as the number of bytes that increases with the number of pixels composing an image, and the color depth of the pixels. The greater the number of rows and columns, the greater the image resolution, and the larger the file. Also, each pixel of an image increases in size when its color depth increases, an 8-bit pixel (1 byte) stores 256 colors, a 24-bit pixel (3 bytes) stores 16 million colors, the latter known as true color.

# IMAGE PROCESSING

Digital image processing is the use of computers to edit and improve images. It is a relatively new technology compared to humans’ long-standing interest in visual art and images. Even in its short history, it has been used in many different fields with varying levels of success. Pictures naturally grab people’s attention, making digital image processing popular not only among scientists but also among the general public. Like many advanced technologies, it is often surrounded by misunderstandings, myths, and incorrect information. Digital image processing brings together ideas from many areas, including optics, electronics, mathematics, photography, graphics, and computer science. It is a multidisciplinary field that sometimes uses complicated and confusing terms.

There are many reasons why digital image processing has a bright future. One of the biggest reasons is that computers are becoming cheaper and more powerful. New technologies are also helping it grow, such as parallel processing, which allows computers to work faster using multiple processors. Another major improvement is the use of charge-coupled devices (CCDs), which help convert images into digital format, store them, and display them more efficiently. Additionally, low-cost storage options are making it easier to save and process large amounts of image data.

# CHAPTER 2

**EXISTING SYSTEMS**

#### Facial Recognition

Some facial recognition algorithms identify faces by extracting landmarks or features from an image. For example, an algorithm may analyze the relative position, size, and/or shape of the eyes, nose, cheekbones and jaw. These features are then used to search for other images with matching features.

Other algorithms normalize a gallery of face images and then compress the face data, only saving the data in the image that is useful for face detection. A probe image is then compared with the face data.

One of the earliest successful systems is based on template matching techniques applied to a set of salient facial features, providing a sort of compressed face representation.

## Facial Recognition methods

Recognition algorithms can be divided into two main approaches:

* + - 1. Geometric which looks at distinguishing features (feature based) and
      2. photometric which is a statistical approach that distill an image into values and compares the values with templates to eliminate variances (view based).

Popular recognition algorithms Principal Component Analysis and Linear Discriminate Analysis are based on geometric approach.

Elastic Bunch Graph Matching and the Hidden Markov model are based on statistical approach.

###### Principal Component Analysis (PCA)

PCA involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variable called principal components. The first principal component accounts for as much of the

variability in the data as possible and each succeeding component accounts for as much of the remaining variability as possible.

PCA is mostly used as a tool in exploratory data analysis and for making predictive models. PCA involves the calculation of the eigen value decomposition of a data covariance matrix or singular value decomposition of a data matrix.PCA is the simplest of the true eigenvector-based multivariate analysis. Often, its operation can be thought of as revealing the internal structure of the data in a way which best explains the variance in the data.

###### Linear Discriminate Analysis (LDA).

LDA is a method to find a linear combination of features which characterize or separate two or more classes of objects or events. The resulting combination may be used as a linear classifier. In computerized face recognition, each face is represented by a large number of pixel values. Linear discriminant analysis is primarily used here to reduce the number of features to a more manageable number before classification. Each of the new dimensions is a linear combination of pixel values which form a template.

## Three Dimension face Recognition

A newly emerging trend, claimed to achieve previously unseen accuracies, is three-dimensional face recognition. This technique uses 3-D sensors to capture information about the shape of a face. This information is then used to identify distinctive features on the surface of a face such as the contour of the eye sockets, nose and chin.

###### Skin texture analysis

Another emerging trend is the skin texture analyis which uses the visual details of the skin as captured in standard digital or scanned images. This technique turns the unique lines, patterns and spots apparent in a person’s skin into a mathematical space.

## Driver Drowsy Detection System

###### Drowsy detection method

Generally drowsy detection systems can be classified into intrusion and non- intrusion methods. Intrusive techniques detect drowsiness by using sensors, which are used to actuate an alarm system. Such systems involve invasive instrumentation devices or use of thermal sensing electrodes. Certain other intrusive methods are sensing brain waves, heart rate, and eye blinking, sagging posture, leaning of the driver's head and the opened/closed states of the eyes.

These devices are considered to be physiologically and psychologically discomforting to drivers. This is most accurate but not realistic. Since sensing electrodes would have to be attached directly onto the driver's body. It is annoying and distracting the driver. In addition, long time driving would result in perspiration on the sensors, diminishing their ability to monitor accurately.

There is no standardized methodology for recording sleepiness, and for the quantification of automatic sleep, in individuals driving a vehicle. However, there are five recording techniques that have been commonly used. One technique is based on the recording of Electroencephalographic (EEG) brain waves. An EEG records brain wave activity. Sensors, placed on both sides of the head, are wired to a polygraph machine that displays brain activity. In most cases, Electro-oculogram (EOG) is used. The EOG records eye in distinguishing eye movement potentials from other signal artifacts. The visual cues of sleepiness are mainly eye blinking, including blink frequency, blink duration, long closure time, pupil diameter (response) and gaze.

###### Tracking of gaze

The existing method on detection of drowsiness has specifically focused on changes in the eye. Eye detection and tracking method uses infra-red light and

appearance based object recognition. In other method, eye camera follows head movements by keeping pupil central, uses infrared light to produce corneal glints that are picked up by camera to detect pupil-glint vectors. In other variation, eye is tracked using human skin colour properties. Other variation is that video cameras capture images of the driver’s face and a number of cues including eye gaze direction are used to infer driver states such as fatigue.

###### Blink Behaviour

Another method is assessing drivers' eye blinking rate using video monitoring techniques. It is difficult for the system to obtain the value if the driver is wearing spectacles. Image processing by analyzing drivers facial expression exists, but the processing power is high and lighting condition inside the vehicle is an important factor for getting reliable data, and the system may question the privacy of the personals. The economic cost is high besides affecting the privacy of the driver picture processing from which driver states are inferred .

###### Eye Closure

PERCLOS (Percent Eye Closure) methodology stands out as having potential for real-world applications. It is a video-based method that measures eye closure. One of the strengths of PERCLOS is that attempts have been made to establish its validity as a fatigue detection device. The system was evaluated against a number of different performance measures.

###### Facial Tracking

The original PERCLOS methodology involved video recording of the driver’s eyes to be later scored by trained observers. The approach used by Seeing Machines, called face LAB, is different from most other measures of eyes closure and gaze direction Another variation uses Infra-red light to locate pupils and detect head motion. Then, Kalman filtering is used to predict facial feature locations. This method uses predictive analysis to cope with facial occlusion problems.

###### Driver Response method

Some non-intrusive methods sense driver's response by periodically requesting the driver to send a response at every five seconds to the system to indicate alertness. The problem with this technique is that it will eventually become tiresome and annoying to the driver.

###### Yawn Rate Calculation

Yawning detection is performed in two main steps: i) the yawn component in the face independent of the mouth location is detected. This component is basically the hole in the mouth as the results of wide mouth opening. ii) mouth location is used to verify the validity of the detected component.

After skin segmentation, the largest hole located inside the face is selected as the candidate for a yawning mouth. This hole is actually related to a non-skin area inside the face that can be related to eyes, mouth or open

###### Video Camera

The camera based driver drowsiness detection method has been mostly used but it consumes more computational power for processing the data.

###### Head movement

There is a technique that checks head motion by sensors in digital type cameras, and activates alarms when threshold levels are reached and mentions several other unsubstantiated claims. This technique would not work during rotation or other prolonged occlusion of a driver's head.

###### Measuring Doppler component

Other systems such as the applied physical laboratory driver drowsy detection system monitors and quantitatively measures several indices, such as the general activity level, the speed, frequency and duration of eyelid closure, the rate of heartbeat and respiration, by analyzing the Doppler components (angle, velocities) present in the reflected signal

## Multiple measures of driver alertness

Multiple measures are used to alert driver, including head position sensor, Eye-gaze system and Pupil measures. These measures are also used as an in-seat vibration system to attempt to increase driver alertness to current state. A range of physiological measures are used including ECG, EEG, EOG Skin temperature and impedance, Pulse and oxygen saturation in blood, respiration frequency and head movements, eye closure and lane tracking to predict crashes in simulations involving high stress driving (fog) and long driving stints. Positioning system, anti-collision radar, odometer and driver gaze direction sensor. If all these parameters show the driver sleepy, warning signal is given to driver.

The system is currently being piloted. Tested in simulator and found that no single measure was sensitive or reliable for quantifying driver fatigue. A neural-fuzzy hybrid system is suggested to integrate multiple measures of alertness change. There is a need for a more reliable and robust condition monitoring system which is non- intrusive vision based system. Whereby, it is desirable to provide a Driver Drowsy Detection System which will avoid the problems/disadvantages noted above and overcomes other problems encountered in conventional methods

###### Driver Monitoring devices

Technological approaches for detecting and monitoring dangerous levels of driver drowsiness continue to emerge and many are now in the development, validation testing, or early implementation stages. Significant advances in video camera and computer systems have made it possible to characterize and monitor a driver’s state of alertness in real time under all types of driving conditions. In this section, some currently available drowsy driver monitoring devices are identified and described. This information was compiled using a combination of several methods, including literature searches of technical/scientific journals and the Internet.

###### Driver Fatigue Monitor device.

Attention Technology, Inc. has designed and developed the DD850 Driver Fatigue Monitor (DFM), the only real-time, on-board drowsiness monitor that is currently being tested in an extensive field operational test.

The DFM is a video- based drowsiness detection system for measuring slow eyelid closure. It is designed to mount on the vehicle’s dashboard just to the right of the steering wheel, and it provides a continuous real-time measurement of eyes position and eyelid closure. The camera module is mounted on a rotating base to allow the driver to adjust the camera angle.

The field of view is large enough to accommodate normal head movement. The device has a visual gauge that represents the driver’s drowsiness level and emits an audible warning when the driver reaches a preset drowsiness threshold.

###### Driver State Monitor

Delphi Electronics is currently developing an automotive-grade, real-time, vision-based driver state monitoring system that aims to improve safety by preventing drivers from falling asleep or from being more distracted. The system integrates two products, the Fore Warn Drowsy Driver Alert and the Fore Warn Driver Distraction Alert, into a comprehensive Driver State Monitor (DSM). The DSM is a computer vision system that uses a single camera mounted on the dashboard directly in front of the driver and two IR illumination sources.

###### Video-based Sensor

Seeing Machines face LAB provides head and face tracking as well as eye, eyelid, and gaze tracking for human image using a non-contact, video-based sensor. Face LAB has a flexible and mobile tracking system and a wide field of view that enables analysis of naturalistic behavior, including head pose, gaze direction, and eyelid closure, in real time under real-world conditions without the use of wires or magnets. Thus, it is a tool that has great promise for analyzing driver behavior in simulators and test vehicles. Drowsiness can be determined in real time with face

LAB’s comprehensive blink analysis and PERCLOS assessment, including delivery of raw data on the details of eyelid behavior.

###### Eye Tracking System

Applied Science Laboratories (ASL) has been designing and developing eye tracking systems and devices for applications. Their video based eye trackers utilize the pupil/corneal reflection technique for measuring eye movements. In most applications, ASL devices operate with a bright pupil image. They have found that the bright pupil image is less affected by eyelashes, light colored eyes, dark environments, contact lenses, eyeglasses, and distance from the camera. The main disadvantage of the bright pupil technique is that it is not as robust in an outdoor environment since sunlight can interfere with infrared illumination.

###### Eye gaze Analysis System

LC Technologies, Inc. has developed an eye tracking technology that is both an eye operated computer for control and communication and a device for monitoring and recording eye motion and related eye data. The technology, called the Eye gaze Analysis System, is a hands-off, unobtrusive, remote human- computer interface that can be used to track a user’s gaze point or allow an operator to interact with their environment using only their eyes. The Eye gaze Analysis System is a tool for measuring, recording, playing back, and analyzing what a person is doing with his eyes. It includes all the basic video equipment, computer hardware, and Eye gaze software necessary to develop and run custom eye tracking applications. Gaze direction is determined using the Pupil Center Corneal Reflection (PCCR) method.

## Image Enhancement and Segmentation

###### Image Enhancement

The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers or to provide `better' input for other automated image processing techniques. Image enhancement techniques can be divided into two broad categories:

* Spatial domain methods which operate directly on pixels and
* Frequency domain methods which operate on the Fourier transform of an image.

Unfortunately, there is no general theory for determining what good image enhancement is when it comes to human perception. If it looks good, it is good! However, when image enhancement techniques are used as pre-processing tools for other image processing techniques, then quantitative measures can determine which techniques are most appropriate.

There are huge amount of image enhancement methods by considering processing methods that are based only on the intensity of single pixel. Single point processes are among the simplest of all image enhancement techniques. Enhancement is normally done by point processing, spatial filtering and in the frequency domain. Intensity transformation, histogram processing, image subtraction and image averaging comes under point processing.

###### Histogram equalization

Histogram equalization is a method in image processing of contrast adjustment using the image's histogram.This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast without affecting the global contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values.

The method is useful in images with backgrounds and foregrounds that are both bright or both dark. In particular, the method can lead to better views of bone structure in x-ray images and to better detail in photographs that are over or under- exposed. A key advantage of the method is that it is a fairly straightforward technique and an invertible operator. So in theory, if the histogram equalization function is known, then the original histogram can be recovered. The calculation is not computationally intensive. A disadvantage of the method is that it is indiscriminate. It

may increase the contrast of background noise, while decreasing the usable signal.

###### Histogram equalization of color images

The above histogram equalization describes on a grayscale image. However it can also be used on color images by applying the same method separately to the Red, Green and Blue components of the RGB color values of the image. Still, it should be noted that applying the same method on the Red, Green, and Blue components of an RGB image may yield dramatic changes in image's color balance since the relative distributions of the color channels change as a result of applying the algorithm. However if the image is first converted into another color space, Lab color space, or HSL/HSV color space in particular, then the algorithm can be applied to the luminance or value channel without resulting in changes to the hue and saturation of the image.

###### Median filter

In image processing, it is usually necessary to perform a high degree of noise reduction in an image before performing higher-level processing steps, such as edge detection. The median filter is a non-linear digital filtering technique, often used to remove noise from images or other signals. Median filtering is a common step in image processing. It is particularly useful to reduce speckle noise and salt and pepper noise. Its edge-preserving nature makes it useful in cases where edge blurring is undesirable. The idea is to calculate the median of neighbouring pixels values. This can be done by repeating the following steps for each pixel in the image.

###### Segmentation

Segmentation refers to the process of partitioning a digital image into multiple segments. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The

result of image segmentation is a set of segments that collectively cover the entire image or a set of contours extracted from the image. Each pixel in a region is similar with respect to some characteristic or computed property, such as color, intensity or texture. Adjacent regions are significantly different with respect to the same characteristic(s).

###### Clustering methods

The K-means algorithm is an iterative technique that is used to partition an image into *K* clusters. The basic algorithm is:

1. Pick *K* cluster centers, either randomly or based on some heuristic
2. Assign each pixel in the image to the cluster that minimizes the variance between the pixel and the cluster center
3. Re-compute the cluster centers by averaging all the pixels in the cluster
4. Repeat steps 2 and 3 until convergence is attained (e.g. no pixel changes clusters)

In this case, variance is the squared or absolute difference between a pixel and a cluster center. The difference is typically based on pixel color, intensity, texture and location or a weighted combination of these factors. *K* can be selected manually, randomly, or by a heuristic. This algorithm is guaranteed to converge, but it may not return the optimal solution. The quality of the solution depends on the initial set of clusters and the value of *K*.

###### Threshold

Thresholding is the simplest method of image segmentation. From a grayscale image, thresholding can be used to create binary images. During the thresholding process, individual pixels in an image are marked as “object” pixels if their value is greater than some threshold value (assuming an object to be brighter than the background) and as “background” pixels otherwise. This convention is known as threshold above. Variants include threshold below, which is opposite of threshold above; threshold inside, where a pixel is labeled "object" if its value is between two

thresholds; and threshold outside, which is the opposite of threshold inside. Typically an object pixel is given a value of “1” while a background pixel is given a value of “0.” Finally a binary image is created by coloring each pixel white or black, depending on a pixel's label.

###### Categorizing thresholding Methods

Thresholding methods are categorized into the following six groups based on the information:

* Histogram shape based methods where (for example) the peaks, valleys and curvatures of the smoothed histogram are analyzed.
* Clustering based methods where the gray-level samples are clustered in two parts as background and foreground (object) or alternately are modeled as a mixture of two Gaussians.
* Entropy based methods result in algorithms that use the entropy of the foreground and background regions, the cross-entropy between the original and binarized image etc.
* Object attribute based methods search a measure of similarity between the gray-level and the binarized images such as fuzzy shape similarity, edge coincidence, etc.

## Drawbacks

A moving vehicle presents challenges like variable lighting and changing backgrounds that is not easily solvable. The detection of drowsiness effects and the driver’s current state has specifically focused on changes and movements in the eyes. Many devices are included this concept to assess changes in the driver’s direction of gaze, rate of blinking and actual eye closure. Almost all of these methodologies have had limited application on-road or have only been developed in the laboratory, not implemented.

Two important methodologies are the Percent Eye Closure (PERCLOS) methodology and is electroencephalographic (EEG) for detecting drowsiness. The problem associated with the PERCLOS is deciding on the point at which the driver is unsafe and when a warning should be applied. The biggest drawback associated with

EEG is the difficulty in obtaining recordings under natural driving conditions, making it a somewhat unrealistic option for the detection of fatigue. Due to illumination variation, all this traditional method has some issues. So, the proposed system uses new developed preprocessing and eyes detection methods which are explained in Chapter 4 and 5. The key drawbacks of the existing systems are

* Sun light can interfere with IR illumination
* Some devices use the external memory to store the frame
* The existing device gives more percentage false alarm
* The existing methods such as PER CLOSURE ,AVG CLOSURE are not Reliable
* Many existing systems use intrusive method
* The traditional devices are not reliable at day or night time traveling.
* All the above drawbacks are removed in the proposed system. The new device is reliable and work all the time day and night.

# CHAPTER 3 PROPOSED RESEARCH WORK

## Problem statement

Today drowsy driving is a serious problem that leads to thousands of accidents each year. Motor vehicle collisions lead to significant death and disability as well as significant financial cost to both security and individual due to the driver impairments. Drowsiness is one of the factors for collisions. In India, no monitoring device is used to measure the drowsiness of driver.

Some kind of systems like driver fatigue monitor, real time vision based on driver state monitoring system, seeing driver assisting system, user center drowsiness driver detection and working system are implemented in foreign countries.

All the systems focus either changes in eye movement, physiological measures or driver performance measure. Due to illumination variation, the traditional systems have some defects, which have been already explained in the literature survey. Problem: A new system to monitor the driver fatigue.

## Feasibility Study

Vehicle driving has been playing a very important role in avoiding the accidents over millions of people in the country, whose livelihood is more important to their children.

The following table 3.1 shows losses of life and vehicle value in the months of October 2008. Only few examples are shown in the table.

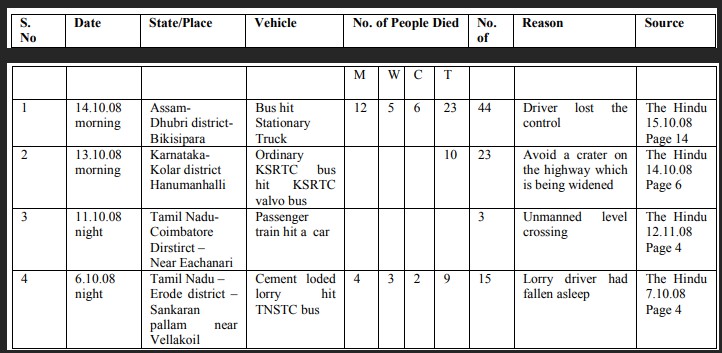


Table 3.1: List of Severe Accidents in the month of October 2008

Accident of October 6, 2008 caused greater devastation in Erode district. In this accident 9 died including two children because of lorry driver had fallen asleep. Nowadays, more than one-thousandth of high ways accidents were affected by massive accidents that destroyed large parts of vehicles and human lives.

I propose to undertake Techno-Economic Feasibility studies to assess the techno-economic feasibility and viability to develop a drowsy driver system.

###### Cost/Benefit analysis

Several cost elements are considered. For example hardware, personnel, facility, operating and supply cost. Also each benefit is identified and then monetary value is assigned. The following table shows developing cost of candidate system.

|  |  |  |
| --- | --- | --- |
| **Category** | **Item** | **Cost** |
| Hardware Cost | Camera | 1000 |
| Alarm Device | 500 |
| Nano Wire | 500 |
| Special Purpose Computer | 33000 |
| Software Cost | Eye Monitoring Software Cost | 8000 |
| Eye S/W Implementation Cost | 2000 |
| Total Developing Cost | | 45000 |

DEVELOPING COST OF DROWSY DRIVER SYSTEM

###### Net Benefit Cost Car

In case of accidents, the following table shows the total loss of the vehicle owner. Let us consider the owner who uses a car, the car may have one driver and minimum three persons.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Approximate loss of the**  **Owner** | **Total Cost(Rs.)** | | **LOSS(Rs.)** |
| Loss |  |  |  |  |
| Vechile cost | 1 | 227000 | 227000 |
| Driver Cost | 1 | 75000 | 75000 |
| Persons in the car | 3 | 75000 | 225000 |
| Total Loss |  |  | 527000 |
| Less |  |  |  |  |
| Developing Cost |  |  | 4500 |
| NET SAVING |  |  |  | 48200 |

## Comparison of existing with proposed system

The total cost of existing system and the candidate system is determined and the net saving is found in the previous section. The visualization is given below.



Fig 3.1: Feasibility study of proposed system

## Lorry

|  |  |  |  |
| --- | --- | --- | --- |
| **Loss** | **No** | **Total Cost**  **(Rs.)** | **Loss (Rs.)** |
| Vehicle cost | 1 | 800000 | 220000 |
| Driver and assistant cost | 2 | 75000 | 150000 |
| Contents | 1 | 100000 | 100000 |
| Total loss |  |  | 470000 |
| Less: Developing cost |  |  | 45000 |
| Net Saving |  |  | 425000 |

**BUS**

In case of accidents, the following table shows the total loss of the vehicle owner.

Let us consider the owner of a bus which has a driver, a conductor and fifty passengers.

|  |  |  |  |
| --- | --- | --- | --- |
| **Loss** | **No** | **Total Cost**  **(Rs.)** | **Loss (Rs.)** |
| Vehicle cost | 1 | 800000 | 220000 |
| Driver and Conductor  cost | 2 | 75000 | 150000 |
| Passenger | 50 | 75000 | 3750000 |
| Total Loss | |  | 4120000 |
| Less: Developing cost | | | 45000 |
| Net Saving | |  | 4075000 |

The total loss for the owner is greater than Rs. **41,20,000/-**. If the proposed system is implemented, the total saving is Rs. **40,75,000/-**.

## ​Technology and tools used

#### Digital Image Processing

The term monogram image or simply image, refers to a two-dimensional light intensity function f(x, y) where x and y denote spatial coordinates and the value of f at any point (x, y) is proportional to the brightness of the image at the point.

A digital image *a(m*,*n)* described in a 2D discrete space is derived from an analog image *a*(*x*,*y*) in a 2D continuous space through a *sampling* process that is frequently referred to as digitization.

Image function f(x, y) may be regarded as being characterized by two components namely illumination and reflection.

f(x,y) = i(x, y)\* r(x, y)

where i(x, y) is determined by the light source, while r(x, y) is determined by the characteristics of the objects in a scene.

The 2D continuous image *a*(*x*, *y*) is divided into *N rows* and *M columns*. The intersection of a row and a column is termed as a *pixel*. The value assigned to the integer coordinates (x, y*)* with {x=0,1,2,...,*M*-1} and {y=0,1,2,...,*N*- 1} is *a(m*, *n)*. In fact, in most cases *a*(*x*, *y*) which we might consider to be the physical signal that impinges on

the face of a 2D sensor is actually a function of many variables including depth (*z*), color ( ), and time (*t*).

## Types of Operations

The types of operations that can be applied to digital images to transform an input image *a(m*, *n)* into an output image *b(m*, *n)* (or another representation) can be

|  |  |  |
| --- | --- | --- |
| **Operation** | **Characterization** | **Generic Complexity/Pixel** |
| Point | The output value at a specific coordinate is dependent only on  the input value at that coordinate. | *constant* |
| Local | The output value at a specific coordinate is dependent on the input values in the  neighborhood of same coordinate. | *P2* |
| Global | The outpuTtabvleal3u.2e: Taytpeas osfpIemciafgiec O  coordinate is dependent on all the values in the input | perations  *N2* |

I

Table 3.2: Types of Image Operations

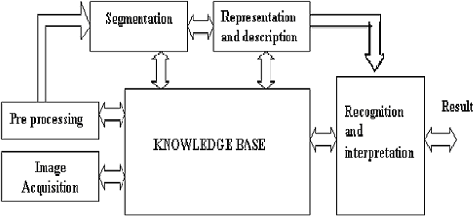
Image size = N x N; neighborhood size = P x P. Note that the complexity is specified inoperations per pixel

Fundamental steps of Image Processing

The following are the fundamental steps in the image processing:

* Image acquisition is the first process. Generally the image acquisition stage involves preprocessing such as scaling.
* Image enhancement is to bring out detail that is obscured or simply to highlight certain features of interest in an image.
* Image restoration is an area that also deals with improving the appearance of an image. Unlike enhancement, which is subjective, image restoration is objective. Image restoration techniques tend to be based on mathematical or probabilistic models of image degradation. Enhancement on the other hand, is based on human subjective preferences regarding what constitutes a good enhancement result.
* Color image processing.
* Wavelets are the foundation for representing images in various degrees of resolution.
* Compression deals with techniques for reducing the storage required to save an image or the bandwidth required to transmit it.
* Morphological processing deals with tools for extracting image components that are useful in the representation and description of shape.
* Segmentation procedures partition an image into its constituent parts or objects.
* Representation and description almost always follow the output of a segmentation stage, which usually is a raw pixel data, constituting

either the boundary of a region. Representation first deals with whether the data should be represented as a boundary or as a complete region. Choosing representation is only part of the solution



## Elements of image analysis

Dividing the spectrum of techniques in image analysis into three basic areas is conceptually useful. These areas are (1) low level processing, (2) intermediate- level processing and (3) high level processing.

Low-level processing deals with functions that may be viewed as automatic reactions, requiring no intelligence on the part of the image analysis system. We treat image acquisition and processing as low level functions. This classification encompasses activities from the image

## About Mat Lab 7.0

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

The MATLAB system consists of five main parts:

## Development Environment.

This is the set of tools and facilities that help you to use MATLAB functions and files. Many of these tools are graphical user interfaces. It includes the MATLAB desktop and Command Window, a command history, an editor and debugger and browsers for

viewing help, the workspace, files and the search path.

## The MATLAB Mathematical Function Library.

This is a vast collection of computational algorithms ranging from elementary functions, like sum, sine, cosine, and complex arithmetic to more sophisticated functions like matrix inverse, matrix eigen values, Bessel functions and fast Fourier transforms.

## The MATLAB Language.

This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw- away programs and "programming in the large" to create large and complex application

# GRAPHICS

MATLAB has extensive facilities for displaying vectors and matrices as graphs as well as annotating and printing these graphs.

It includes high-level functions for two-dimensional and three-dimensional data visualization, image processing, animation and presentation graphics.

## The MATLAB Application Program Interface (API).

This is a library that allows you to write C and Fortran programs that interact with MATLAB. It includes facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine and for reading and writing MAT-files

## 3.4.5 Hardware and Software Selection

#### The minimum Hardware required is:

Processor : Intel Core 2 Duo

Speed : 3.12 GHz

Mother Board : Intel

Main Memory : 1 MB DDR2 RAM Hard Disk : 80 GB

Drive : DVD Writer

Monitor : 15” Digital

Keyboard : Windows Keyboard with 105 keys Mouse : Optical Mouse

## Software specification

Operating System : Windows XP Software : Matlab 7.0

# BENEFITS AND LIMITATIONS

#### BENEFITS

The drowsy driver system detects drowsiness and fatigue prior to the driver falling asleep. The warnings can begin as the driver becomes fatigue and intensify as the system detects increasing drowsiness to avoid endanger himself and/or others.

Other technologies, such as those that detect head motion, do not warn the driver of drowsiness and fatigue until the driver has fallen asleep and possibly lost control of the vehicle. The ideal system should begin to warn the driver’s

drowsiness early before fatigue significantly impairs driving ability. Other benefits include

* an approximate reduction in fuel consumption of 15 percent.
* improved traffic flow.
* increased safety and
* more comfortable working conditions for drivers.

Driver Drowsiness Detection System (DDDS) has the potential to greatly reduce road accidents in the large commercial vehicle sector where driver fatigue is a significant risk and in turn to provide major benefits to road transportation companies in terms of cost savings and improved safety and reliability.

# LIMITATIONS

With 80% accuracy, it is obvious that there are limitations in the system. The most significant limitation is that there cannot be any reflective object behind the driver. The more uniform the background is, the more robust the system becomes.

For testing, rapid head movement was not allowed, since it can be equivalent to simulating a tired driver. For small head movements, the system rarely loses track of the eyes. When the head is turned too much sideways there were some false alarms.

The system has problems little when the person is wearing eyeglasses. Localizing the eyes is not a problem, but the point is to determine whether the eyes are opened or closed.

# CHAPTER 4

**DESIGN AND DEVELOPMENT OF DDDS PROTOTYPE**

## Introduction

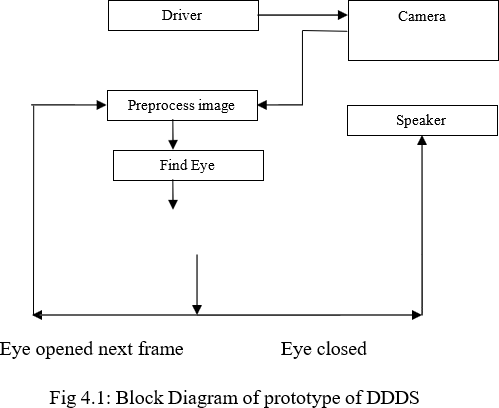
As the eyes closure occurrences dramatically increase during the ten second period preceding an accident, monitoring such closures is a good way to determine drowsiness and prevent the accident. This ten second range means that the system has to determine whether the driver is drowsy in only a few seconds. The algorithm that will be used should not only be fast but effective with as less false alarms (alerting when the driver is awake) and false findings (mistaking other features in the image as eyes) as possible.

The tried approaches are:

* + - Capture the image from web camera and enhance.
    - Edge detection and determining thresholds.
    - Removing isolated pixels and dilation of image.
    - Computing feature measurements for image regions.
    - Determining search parameters and performing search.
    - Marking eyes or alerting driver.

## 4.2. Prototype Algorithm Design Version 1

This part aims to present the design of the Driver Drowsy Detection System. The original aim of this project was to use the retinal reflection (only) as a means to find the eyes on the face, and then using the absence of this reflection as a way of detecting when the eyes are closed. It was then found that this method might not be the best method of monitoring the eyes for two reasons. First, in lower lighting conditions, the amount of retinal reflection decreases; and second, if the person has small eyes the reflection may not show.



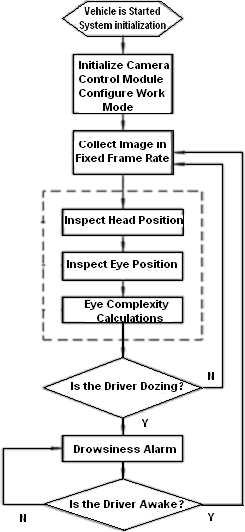
###### The Prototype Algorithm version 1(Gets a video image file as input):

1. Extract the movie to single frames.
2. For each image:
   * Perform preprocess to remove the noise.
   * Apply edge detector on the image (Edge detector threshold is detected automatically).
   * Apply left, right and top find algorithm on the binary image (output image of the edge detector).
   * Find the correct center of the face using self defined algorithm face detect or head detect.
   * Using the output of the center detection and top detection, find the first intensity change (eye brow) i.e. the largest valley with lowest y – coordinate and next intensity change (eye) i.e. the second largest valley with the next lowest y-coordinate.
   * Perform smoothing on the horizontal average intensity change
   * If the difference of first valley and the second valley < 50 then eye is opened (i.e. if opened difference is less); otherwise closed.
   * If closed, make beep sound until driver responses.
     1. **Functional Prototype Description**

The following functions comprise the real-time drowsiness detection system for drivers:

Judge driver alertness based on the inputs received during day and night driving conditions and deliver the information to the processor for further processing. Due to the strict real-time performance requirement of the system, we implemented the image processing algorithms in hardware. The implementation difficulty and robustness of the algorithm will have to be comprehensively studied when choosing the algorithm. The basic image processing algorithm can be realized in the following three steps.

1. Face-Zone Positioning: Pre-process the original image of the driver to determine the zone of face and capture it. In this way, the image zone, which needs further processing, can be shrunk to speed up the processing. In addition, this technique also lightens the influence of a complex background for face feature judgment.
2. Eye-Zone positioning: determine the position of eyes in face zone, and capture driver’s image eyes zone for further processing.
3. Eyes Open/Close Judgment: Analyze the open/close status to determine whether the driver is distracted or drowsy. Figure 4.2 shows the image processing.



###### Fig: 4.2 Flow of Driver Drowsiness Detection System System Initialization

The proposed system starts on when the driver turns the switch to the "on" position. Then the system starts to monitor the eyes to find the state.The system is shut down when the driver makes sure that no need to use the system and then turns the switch to the "off" position. The connection to the vehicle will be shut down. Then the driver is free to operate the vehicle.

## Prototype Algorithm development

It consists of two key functions called eyes detection function and drowsy detection function

###### Eyes Detection Function Face top and width detection

After facial image is pre-processed, eye detection procedure is applied to the image. The top and sides of the face are detected to narrow down the area of where the eyes exist. Using the sides of the face, the centre of the face is found, which will be used as a reference when comparing the left and right eyes. Moving down from the top of the face, horizontal averages (average intensity value for each y coordinate) of the face area are calculated. Large changes in the averages are used to define. All images are generated in Mat lab using the image processing toolbox.

###### 4.2.2.2. Noise Removal

The removal of noise in the digital image is very straightforward. Starting at the top, (x2, y2), move left on pixel by decrementing x2, and set each y value to white (for 200 y values). Repeat the same for the right side of the face. The key to this is to stop at left and right edge of the face; otherwise the information where the edges of the face are will be lost. After removing the black blobs on the face, the edges of the face are found again

###### 4.2.2.3 Capturing facial image

The web camera in the system is capturing the facial image. The camera takes every 2 seconds a snap shot and stores this as temporary image file for processing.

## Module description

The prototype has several modules which are discussed one by one.

###### Module: Acquire ()

Purpose: To capture the image and store the image values into an array, BW.

Initially, the image is stored into the predefined buffer, and so this buffer is copied into the BW array. The BW array will be used in most of the other functions, and is defined as a global variable.

###### Module: Binarization ()

Purpose: To convert the image into a binary picture.Based on a predefined threshold, the image is binarized into two values, black and white. If a pixel in the BW array is less than or equal to the threshold it is set to black, if greater, set to white. The binary image is

stored in the BW1 array.

###### Module: Face detect ()

Purpose: To find an accurate centre of the face in the x- directio**n.**Starting at the point (100,240) of the binary image, the edges of the face are found along the x-direction.

When the left and right edges are found, the centre of the two is assigned to x1. This value (x1) is returned, and is later used as the new centre of the face

Purpose: To find the top of the face.This function passes two integers. i) x is the x- coordinate corresponding to the centre, obtained from either the output of Face detect module or Detect centre module depending on at which point in the algorithm it is being called. ii) y is the y- coordinate corresponding to the centre of the face. The top is detected by decrementing the y-coordinate, keeping track of the number of black pixels found. The function returns the top value (y-coordinate).

* 1. **Introduction**

# CHAPTER 5 PRE PROCESSING

The preprocessing of real image is a crucial aspect in many useful applications like video coding of faces for video phony, animation of synthetic faces, driver behavior analysis, word visual recognition, expression and emotion analysis, tracing and recognition of faces. The detection of facial features has been approached by many researchers and a variety of methods exist. Nevertheless, due to the complexity of the problem and illumination changes, robustness and preprocessing steps of these approaches are still a problem. Most commonly, natural face feature templates taken from real person are used for a template matching algorithm [18]. These templates have to satisfy a set of requirements like orientation, size and illumination. Therefore preprocessing step is necessary for at least aligning and size changes. Face images and face features have to be aligned in orientation and size in preprocessing step.

In this thesis we propose three novel low cost methods designed for preprocessing. They are modified equalization, modified Homomorphic and sub image Homomorphic filter.

## Modified Histogram equalization

In order to obtain appropriately-segmented binary images, an image preprocessing is applied. The preprocessing has three steps. In the first step, modified histogram equalization is used to enhance the brightness and the contrast of the images to compensate for illumination variations and to obtain more image details. In the second step, median filter is used to remove the noise. In the third step binaried images are obtained through thresholding. The preprocessing steps are shown in Fig 5.1.



Input Video

image

Enhancing video image

Thresholding

Median

filtering

Binary image

Fig. 5.1: Preprocessing steps using HE

## Proposed Modification

While the results of a standard histogram equalization filtering over the whole image give promising results, we wanted to see whether the results could be further improved. Many well-known enhancement algorithms such as histogram equalization and homomorphic filtering are global in nature and are intended to enhance an image and deal with it as a whole. We tried to split the original image in sub-images and filter each sub-image individually. First we decided to try and split the image into two halves vertically (thus obtaining two *sub-images* of the original image) and then apply the filter to each half individually. Second idea was to split the image horizontally and again apply the filter to each half individually. Encouraged by the good results obtained with both these methods (see Section 5.2.3 for details), further tried to combine the filtering results into a joint representation. Let *IHEV*(*x*, *y*) be the image split vertically and each half filtered with histogram equalization filter individually and let I*HEH*(*x*, *y*) be the same for horizontally split images and let *IHEMOD*(*x*, *y*) be our proposed modification:

*IHEMOD*(*x*, *y*) = 0.5[ *IHEV*(*x*, *y*) + .70 I*HEH*(*x*,*y*)]

Since *IHEV* scored higher results than *IHEH* in our tests, we decided to keep the whole *IHEV* and multiply *IHEH* with a constant of 0.70 (chosen based on experimental results), to lower its influence on the final representation. This combination produced highest results in our experiments and was kept as a final representation. We will show in the following section that our method yields superior results, and therefore justifies further research of the histogram equalization filtering variations as a means of simple yet efficient image preprocessing

## ​Thresholding

After median filtering, threshold is set to 128, so that only dark pixels remain, including eye pair structure. Then a binary image is obtained which obviously contains the facial structure. Taking into account that the non face area can influence the speed and the results of template matching, the oversize black area, which is useless in the binary image, is eliminated by the conventional connected components labeling process.

## ​Binary image

Binary images are obtained through the thresholding. Then the final feature image is obtained, as shown in Fig. 5.5 (c).

As shown in Fig. 5.5 (a), the input image has low contrast due to illumination; segmentation results, therefore, are unlikely to be good. Fig. 5.5 (b)

demonstrates the image enhanced by modified histogram equalization filtering; the contrast is improved, and the details in the face region are enhanced.

* 1. **Modified Homomorphic filter**

To compensate for illumination variations and to obtain more image details, a Homomorphic filter is used to enhance the brightness and the contrast of the images. Then a clustering algorithm is used to separate the facial feature from the skin. Binaries



Enhancing video image

Input Video image

Thresholding

Clustering

Structure image

Binary image

Fig. 5.2: Preprocessing steps using HM

Capturing image

The required images are taken from the video image using web camera.

## 5.3. 1 Enhancing the Image

Homomorphic filtering is a generalized technique for nonlinear image enhancement and correction. It simultaneously normalizes the brightness across an image and increases contrast.

## 5.3.2 Clustering

The intensity in the eye region and other facial features is dark in a grey- level facial image. The image has been enhanced through Homomorphic filtering. Next, the features of interest are separated from the skin and other pixels by clustering the grey- level image into three clusters through the K-mean clustering algorithm. The lightest grey level that represents the light pixels in the image is set to 255, the intermediate that represents the skin is set to 128, and the darkest that represents both the features and other dark pixels of the image (for example the hair, beard and some dark background) is set to 0.

Binary images are obtained through the thresholding. The thresholding is done as in the image equalization.

## Experimental Results

The proposed method was tested on the real video images. The video image of [480 x 640 pixels] of 75 different test persons and has been recorded during several sessions at different places. This image has a larger variety of illumination, background and face size. It stresses real world constraints. So it is believed to be more difficult than other datasets containing images with uniform illumination and background. The facial image can be preprocessed successfully in most cases, no matter whether face patterns are in different scale, expression, and illumination conditions. Typical results of modified histogram equalization preprocessing with the proposed approach are shown in Fig.5.3. The input images vary greatly in background, scale, expression and illumination, the images with partial face occlusions and wearing spectacles.

## Methods Tested

###### No enhancement (NE):

For this test we only geometrically normalized the images (actually, images were geometrically normalized in all subsequent tests as well). No filtering or histogram equalization is used.

###### Standard histogram equalization (HE*)*:

Images were geometrically normalized and a standard histogram equalization (HE) technique was employed. HE enhances the contrast of images by transforming the values in an intensity image, so that the histogram of the output image is approximately uniformly distributed on pixel intensities of 0 to 255.

## Modified Histogram equalization result

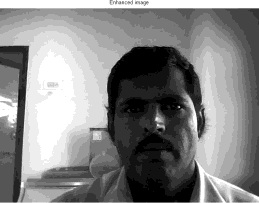
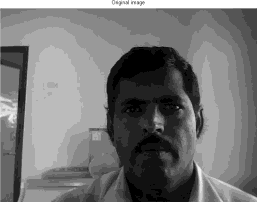
###### HE modified (HEMOD*)*.

Method proposed in Section 5.2.1, consists of results combined from HEV and HEH.

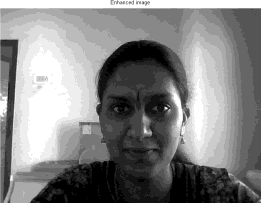
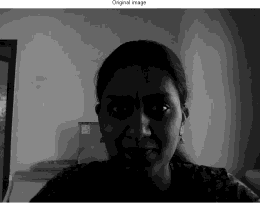
Table 5.1, gives the results of applying all the techniques on video images. The numbers in the table represent recognition rate (RR) in percentages of correctly recognized images.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Method | N  E | HE | HEV | HEH | HEMOD |
| RR % | 4.1  5 | 48.20 | 60.0  0 | 58.3  0 | 60.20 |

Table 5.1: Eye recognition rate using HEMOD



(a) (b) (c)



(a) (b) (c)

Fig. 5.5: An example of preprocessing (a) Original Image (b)Enhanced image (c) Binary image

The fig 5.5 shows the implementation results of image modified histogram equalization preprocessing. The fig 5.5(b) and fig 5.5(c) are the results of enhanced image and binary image. By looking at the extremely low recognition rate on NE images just 4.15%, the proposed method is better. In our experiment the standard preprocessing HE which yielded only 48.20%. HEV and HEMOD give significant

improvement with 60% and 60.20% respectively. Therefore, we can see clearly that our proposed method is superior to all other methods and recognition rate is 12% is higher than the standard HE. The superiority of the proposed method is further confirmed in Fig. 5.4 where the cumulative match score curve for the standard method and proposed method could be seen. The cumulative match score curve is the rank ‘n’ versus percentage of correct identification, where rank ‘n’ is the number of top similarity values.

# CHAPTER 6 EYE DETECTION

## Introduction

Detection of eye is a crucial aspect in many useful applications ranging from face recognition and face detection to human computer interface design, model based video coding, driver behavior analysis, compression techniques development and automatic annotation for image data bases etc. A large number of materials proposing various techniques have been published on this subject in the last couple of decades but the effectiveness of these techniques have not been satisfactory enough due to the complexity of the problem

. Given the benefits of this aspect in a multitude of areas, a solution to this problem has to be found. Generally, the detection of eyes is done in two phases: locating the face to extract eye regions and then extract the eyes from these regions [1], [2], [20]. Previous work on this subject came up with different approaches such as neural network, skin color based methods and independent components[19]. Little research has been done on the direct search for eyes.

## Template and knowledge based method

This section presents an eye pair detection algorithm that can be illustrated using a standard web camera in the real world while skipping the initial segmentation step to extract the face region as commonly done in literature.

The developed eye detection algorithm works on the grey-level image. The structure of the eye region is used as a robust cue to locate eye pair candidates. Eye pairs are extracted by using binary template matching and eye ball detection method.

## Proposed method.

We achieve eye detection in three stages. In the first stage, the captured image is preprocessed. In the second stage, the binary template method is used to extract the eye pair candidate without using support vector machine. In the third stage, the right set of rows that contain the eye are extracted based on the condition of eye symmetry.

## Preprocessing

In an ordinary face image, the contrast of the eye region is usually relatively weak. Homomorphic filter is used in this stage to enhance the contrast at edges. Thus, eye images with poor contrast are also enhanced [17].

## Binary template matching and eyeball detection (BTMED)

In order to determine the set of rows that contain the eyes, a binary template matching is applied to the feature image, searching for the two eyes [3]. The difficulty is that the object we are looking for is not of a fixed shape. For this reason a binary template is adopted that models two eyes in a very rough way. A single template has been used for all the images which are of significantly different sizes, thus showing a desirable scale independent property.

Among the positions with the high cross correlation, all the candidates are extracted and they are normalized into the size of 25×8 pixels**.** Then the eye ball is identified in the eye pair. The eye ball identification is validated by satisfying the following conditions. (i) The candidates (eyes) are situated in a parallel line and

(ii) the candidates (eyes) are symmetric [4]. In the literature of previous work on this subject, eye candidates are verified by using the support vector machines (SVM – is a concept in statistics and computer science for supervised learning

## Experimental Results

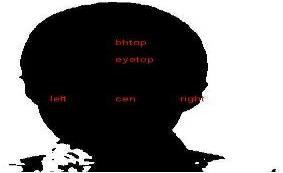
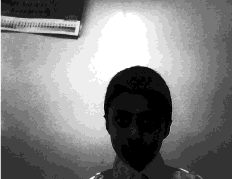
The proposed method was tested on the real driver images. The video image [480 x 640 pixels] of 75 different test persons has been recorded during several sessions at different places. The eye pair can be selected successfully in most cases, no matter whether face patterns are on different scales, expressions, and illumination conditions. The proposed system is compared with color cues and projection function method. This projection method achieves eye in three stages. sequentially. It is followed by a connected component analysis to quantify spatially connected region and further reduce the search space to determine the contending eye pair windows. Finally the mean and variance projection functions are employed in each eye pair window to validate the presence of the eye. The eye location rate is 82.67% whereas the proposed system rate is 90.67%. Typical results of eye detection with the proposed approach are shown in table andFig.6.1.

Table 6.1: Correct Judgment Rate testing using BTMED

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Algorithm** | **Test Scenario** | **Sample Number** | **Correct Judgment** | **%** | **Mean false alarm**  **Rate** |
| **Color cues and projection function** | Day | 73 | 62 | 82.67 | 21.7% |
| Night | 50 | 37 | 74.00 |
| **BTMED** | Day | 75 | 68 | 90.67 | 14.7% |
| Night | 50 | 40 | 80.00 |

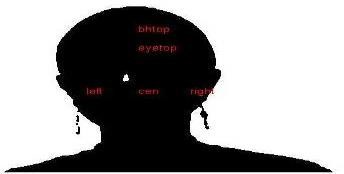
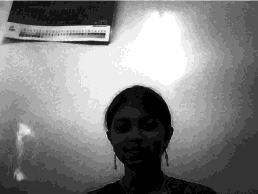
(a) (b). (c)



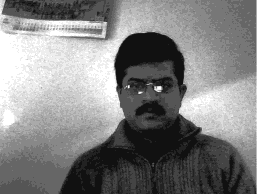
(a) (b). (c)



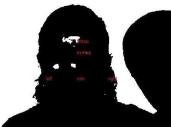
(a) (b). (c)



(a) (b). (c)



(a) (b). (c)



(a) (b). (c)



(a) (b). (c)

Fig 6.1: Real Image capture from video using BTMED (a) Original Image. (b) Binary image after preprocess (c) both eyes

In this chapter, an efficient and effective method for detecting eyes in video images in unconstrained backgrounds is presented. The images are subjected to the

first stage of preprocessing. The second stage of Homomorphic filtering is then applied to enhance the contrast of dark regions; therefore facial images with poor contrast are enhanced. Finally eye pairs are extracted by using binary template matching method with eyeball detection.

## 6.3 Eye detection knowledge based method (EDKBM)

This method is same as the previous method except Eye detection is done using knowledge based method instead of template method.

## Proposed method

Detection of the human eye is a very difficult task because the contrast of the eye is very poor. Under this situation, a good edge image is not to be obtained. However it is found that some eye marks have relatively much higher contrast, such as the boundary points between eye white and eyeball. Besides this, eyes also have good symmetric characters. These marks can be used as knowledge to find the eye.

The proposed method has two main phases to find eye pair such as locating face and eye region and finding eye. In the first phase, the novel approach to fast locating the face and eye region is developed.

In the second phase, eye finding directed by knowledge is introduced in detail. The proposed method is robust against moderated rotations, clustered background, partial face occlusion and glass wearing. This is discussed one by one in the following section.

## Face locating

Detecting the locations of human face in a scene is the first step in the recognition system. In this step the region of the face candidate is roughly estimated using histogram thresholding technique. To simplify the segmentation, we assume that there is only one face in the image and is to be located. The binary image *B* (x, *y)* consists of all active pixels which include eye features. Histogram smoothing and automatic thresholding techniques are employed in this stage to eliminate the noises in the image and select the threshold.

## Eye region extracting

The purpose of this stage is to roughly extract the eye region, which encloses two eyes from the face. The next eye detecting algorithm then will be applied only on this region. It therefore improves the efficiency of the system. The eye region extraction has the following steps:

* + - * 1. Find the hair region from the binary image.
        2. Identify the lower boundary of the hair region. The left and right ending points are denoted by ledge and redge*,* respectively. The eye region is enclosed by ledge and redge called as *E.*
        3. Find a pair of dark areas in E that may represent the locations of the eyes. This pair of dark areas should satisfy the following conditions:

Eyes are situated on the line that is parallel to the line joining ledge and redge*.*

Eyes are symmetric with respect to the perpendicular bisector of the line

Eyes are situated below the eyebrows.

## Eye detection

Since in the image processed through the first step part of the eye information may have been lost, original eye region image is used at this second stage. It can be obtained by applying the eye region coordinates extracted from previous section

6.3.1.2 to the original face image. Eye detection has the following two steps i. preprocessing and ii. Knowledge oriented edge detection.

## Preprocessing

Modified Homomorphic filter is used to enhance the contrast at edges. Since this preprocessing is applied directly in the eye region based on the image situation in it, the edge information becomes more prominent.

## 6.3.1.4. Knowledge-oriented edge detection

Edge detection of the eye region image has the following steps.

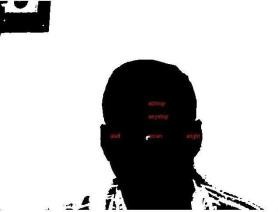
1. Locate big dark areas as the iris candidates using the following properties on a right eye pattern:
   1. The two dark areas have the similar area
   2. The line passing through the centre of the two dark areas is approximately Parallel to the image ***x*** axis, and
   3. The two dark areas are ellipse shaped.
2. Find the top and bottom points of each iris. Let the point be called *(topx, topy)*

and *(bottomx, bottomy),* respectively.

1. Find the upper eyelid starting from *(topx, topy)* towards left part and right part of eyelid respectively using slope calculation. Apply the following knowledge to determine whether the last point is corner point.
   1. The distance between two corners is larger than that between the points *(topx, topy)* and *(bottomx, bottomy)* and
   2. Two corners are not lower than *(bottomx ,bottomy).*
2. Find lower eyelid i.e., Illumination variation usually has greater effect to the lower eyelids than to the upper eyelids.
3. This makes the above algorithm not so effective to detect the low eyelids. However as the eye corners and points *(bottomx, bottomy)* have been known, easily we can approximate each lower eyelid.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Algorithm** | **Test Scenario** | **Sample Number** | **Correct Judgment** | **%** | **Mean false alarm**  **Rate** |
| **Binary Template Matching** | Day | 75 | 68 | 90.67 | 14.7% |
| Night | 50 | 40 | 80.00 |
| **EDKBM** | Day | 75 | 70 | 93.33 | 10.3% |
| Night | 50 | 43 | 86.00 |

Table 6.2: Correct Judgment Rate testing using EDKBM

(a) (b). (c)



(d) (e) (f)

Fig 6.2: Real Image captured from video using EDKBM (a) Original Image. (b) Binary Image (c) Detection of binary eye(d) both eyes (e) Left eye (f) Right eye.



(a) (b). (c) (d)



(a) (b). (c) (d)

Fig 6.3: Eye captured using digital camera (a) Original Image (b) Both eyes (c) Left eye (d) Right eye

In this section, we present a new technique for detecting eyes in video images. To obtain eyes, the preprocessing is applied to input images. Homomorphic filtering

is applied to enhance the contrast of dark regions; therefore facial images with poor contrast are enhanced. Eye pairs are extracted by using knowledge oriented eye detection technique. Typical results are shown in Fig. 6.2 and 6.3. The proposed method can deal with wearing spectacles and partial face occlusions. However the eye detection will fail if the reflection of spectacles is too strong. If the reflection of glasses is too strong, the eyes can not be extracted. Closed eyes will not influence the results of eye location. The advantage of this method is that its computational cost is very low.

**CHAPTER 7**

**CONCLUSION AND FUTURE SCOPE**

* 1. **CONCLUSION**

This paper presented the design and analysis of an efficient and smart driver fatigue detection system. The proposed system is used to avoid road accidents created by human factors such as drowsy driving. It also helps the driver to stay awake during driving by generating an alert as soon as the driver is feeling sleepy.

The Raspberry Pi module along with Camera is used to monitor the drowsiness of the driver in real time. Fatigue is detected with face, eye and mouth using Haar Cascade Classifier, and also with the use of facial landmarks and Eye Aspect Ratio by estimating the Euclidean Distance between the eyes and mouth.

During the monitoring, the system is able to detect if the eyes are closed or open. When the eyes have been closed for a specified period of time, the system issues an alarm. Our system also implements the detection of yawn.

If the yawn count has crossed a predefined number, the system sends an alert message to the owner of the car indicating the chances of the driver falling asleep. The system implemented in real time gave highly accurate results and promises a reliable fatigue detection.

# ​FUTURESCOPE

###### Automotive Industry:

* **Driver Fatigue Monitoring Systems**: In cars and trucks, a fatigue detection system could be integrated into autonomous or semi-autonomous vehicles to monitor drivers' alertness and provide timely alerts to prevent accidents caused by drowsiness.
* **Self-Driving Cars**: Autonomous vehicles could benefit from these systems to assess when human intervention is needed, improving the interaction between human drivers and self-driving cars.

###### Aviation Industry:

* **Pilot Fatigue Detection**: Pilots often experience fatigue due to long flight hours. A system that detects fatigue and yawning could significantly improve aviation safety by alerting pilots and ground control about the need for rest or a change in personnel.
* **Air Traffic Control**: Controllers, like pilots, work in shifts and could benefit from similar fatigue detection to prevent errors that result from tiredness.

###### Healthcare Sector:

* **Monitoring Healthcare Workers**: Fatigue detection in doctors and nurses is essential in high-pressure environments like hospitals and emergency rooms. An alert system could prevent mistakes due to tiredness, ensuring better care for patients.
* **Remote Patient Monitoring**: Fatigue and yawning detection can also be extended to monitor elderly patients, ensuring they get proper rest and alerting caregivers when necessary.

###### Workplace Safety:

* **Construction, Manufacturing, and Transport**: In high-risk professions, fatigue detection systems can be incorporated into workers' equipment to monitor alertness, reducing workplace accidents and enhancing overall safety.
* **Shift Work Optimization**: For industries that rely on shift work, the system can help schedule workers' shifts more efficiently, ensuring that they are not overworked and reducing burnout.
* **Smart Glasses & Headbands**: The system could be integrated into wearable devices such as smart glasses or headbands to detect yawning and eye movements, alerting wearers when they’re becoming fatigued.
* **Mobile Apps**: Mobile applications can use a smartphone’s camera or sensors to detect signs of fatigue and alert users in real-time.

###### AI & Machine Learning Applications:

* **Deep Learning Algorithms**: Advances in deep learning can improve the accuracy of fatigue and yawn detection, enabling systems to identify subtle indicators of tiredness across diverse populations and environments.
* **Personalized Alerts**: These systems could learn individual user patterns and provide more personalized and timely alerts based on users' unique fatigue signatures.

###### Autonomous Robotics & Human-Machine Interaction:

* **Assistive Technology**: Robots that interact with humans, such as in healthcare or service industries, can use these systems to adapt their responses based on the fatigue levels of the human operator. This improves overall collaboration and safety in human-robot interactions.
* **Factory Automation**: Robots in industrial settings could monitor human workers' fatigue and adjust work processes accordingly to optimize productivity while ensuring safety.

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# APPENDIX

clc; clear all; close all;

%%

load DB load svm

clop = {'open','close'};

dim\_drv = [30 60;

30 60

40 65];

delete(imaqfind) vid\_inp=videoinput('winvideo',1); triggerconfig(vid\_inp,'manual'); set(vid\_inp,'FramesPerTrigger',1 ); set(vid\_inp,'TriggerRepeat', Inf);

% View the default color space used for the data — The value of the ReturnedColorSpace indicates the color space of the image data. color\_spec=vid\_inp.ReturnedColorSpace;

% Modify the color space used for the data — To change the color space of the returned image data, set the value of the ReturnedColorSpace property.

if ~strcmp(color\_spec,'rgb') set(vid\_inp,'ReturnedColorSpace','rgb');

end start(vid\_inp)

% Create a detector object

vidfaceDetector = vision.CascadeObjectDetector; vidfaceDetectorLeye =

vision.CascadeObjectDetector('EyePairBig'); vidfaceDetectorM = vision.CascadeObjectDetector('Mouth'); tic

% Initialise vector

LEC = 0; % Left eye closer REC = 0; % Right eye closer MC = 0; % Mouth closer TVF = 0; % Total frames VC = 0; % Total closure Feature = [];

c1p = 1;

driver = 'Non-Fatigue'; for ii = 1:600

trigger(vid\_inp);

img=getdata(vid\_inp,1); % Get the frame in im

imshow(img)

subplot(3,4,[1 2 5 6 9 10]); imshow(img)

% Detect faces

b\_box = step(vidfaceDetector, img);

if ~isempty(b\_box);

b\_box = b\_box(1,:);

% Plot box rectangle('Position',b\_box,'edgecolor','r');

S = skin\_seg(img);

% Segment skin region bw\_3 = cat(3,S,S,S);

% Multiply with original image and show the output Iss = double(img).\*bw\_3;

Ic = imcrop(img,b\_box); Ic1 = imcrop(Iss,b\_box); subplot(3,4,[3 4]); imshow(uint8(Ic1))

bbox\_eye = step(vidfaceDetectorLeye, Ic);

if ~isempty(bbox\_eye); bbox\_eye = bbox\_eye(1,:);

E\_eye = imcrop(Ic,bbox\_eye);

% Plot box rectangle('Position',bbox\_eye,'edgecolor','y');

else

disp('Eyes not detected') end

if isempty(bbox\_eye)

continue; end

Ic(1:bbox\_eye(2)+2\*bbox\_eye(4),:,:) = 0;

% Detect Mouth

bbox\_M = step(vidfaceDetectorM, Ic);

if ~isempty(bbox\_M); bboxMtemp = bbox\_M;

if ~isempty(bboxMtemp)

bbox\_M = bboxMtemp(1,:); Emouth = imcrop(Ic,bbox\_M);

% Plot box rectangle('Position',bbox\_M,'edgecolor','y');

else

disp('Mouth not detected') continue;

end else

disp('Mouth not detected') continue;

end

[nre nce k ] = size(E\_eye);

% Divide into two parts

L\_eye = E\_eye(:,1:round(nce/2),:); R\_eye = E\_eye(:,round(nce/2+1):end,:);

subplot(3,4,7) imshow(edge(rgb2gray(L\_eye),'sobel')); subplot(3,4,8) imshow(edge(rgb2gray(R\_eye),'sobel'));

Emouth\_3 = Emouth; L\_eye = rgb2gray(L\_eye); R\_eye = rgb2gray(R\_eye);

Emouth = rgb2gray(Emouth);

% K means clustering X = Emouth(:);

[nr1 nc1 ] = size(Emouth);

cid = kmeans(double(X),2,'emptyaction','drop');

k\_out = reshape(cid,nr1,nc1); subplot(3,4,[11,12]);

% Segment

Ism = zeros(nr1,nc1,3);

% Ism(:,:,3) = 255;

% Ism(:,:,3) = 125;

Ism(:,:,3) = 255;

bw\_m = k\_out-1;

bw\_m3 = cat(3,bw\_m,bw\_m,bw\_m); Ism(logical(bw\_m3)) = Emouth\_3(logical(bw\_m3)); imshow(uint8(Ism));

% Left eye

L\_eye = imresize(L\_eye,[dim\_drv(1,1) dim\_drv(1,2)]); c1 =match\_DB(L\_eye,DBL);

subplot(3,4,7) title(clop{c1})

% Right eye

R\_eye = imresize(R\_eye,[dim\_drv(2,1) dim\_drv(2,2)]); c2 = match\_DB(R\_eye,DBR);

subplot(3,4,8) title(clop{c2})

% Mouth

Emouth = imresize(Emouth,[dim\_drv(3,1) dim\_drv(3,2)]); c3 = match\_DB(Emouth,DBM);

subplot(3,4,[11,12]); title(clop{c3})

if c1 == 2

LEC = LEC+1;

if c1p == 1

VC = VC+1;

end end

if c2==2

REC = REC+1;

end

if c3 == 1

MC = MC + 1;

end

TVF = TVF + 1; % Total frames toc

if toc>8

Feature = [LEC/TVF REC/TVF MC/TVF VC]

driver = svmclassify(svmStruct,Feature);

tic

% Initialise vector

LEC = 0; % Left eye closer REC = 0; % Right eye closer MC = 0; % Mouth closer

TVF = 0; % Total frames

VC = 0; % Total closure end

subplot(3,4,[1 2 5 6 9 10]); if strcmpi(driver,'Fatigue')

text(20,20,driver,'fontsize',14,'color','r','Fontweight','bold') beep;

else

text(20,20,driver,'fontsize',14,'color','g','Fontweight','bold') end

c1p = c1; pause(0.00005)

end end



# A NOVEL AND EFFICIENT REAL TIME DRIVER FATIGUE AND YAWN DETECTION-ALERT SYSTEM

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M. SRINIVAS6

##### ABSTRACT

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Fatigue among drivers is a major cause of road accidents in India each year. One of the primary reasons behind this fatigue is the lack of adequate sleep, typically six to eight hours. Sleep deprivation significantly impacts a driver’s reaction time and decision-making abilities, increasing the likelihood of accidents. Such accidents are particularly dangerous as they often occur at high speeds, and since the driver has fallen asleep, they are unable to apply the brakes or steer to minimize the impact, resulting in severe injuries or fatalities.

Given these risks, it is crucial to develop a smart system capable of detecting and alerting drivers about their fatigue levels. Although several solutions have been proposed in this area, many remain theoretical or have not been successfully implemented in real-world conditions. In this research paper, we propose an efficient driver fatigue detection and alert system using open-source technologies. We implement and test this system in real- time, and the results demonstrate significant improvements over many existing solutions, making it a promising approach to reducing fatigue-related accidents.

##### INTRODUCTION

Driver fatigue is a leading cause of road accidents worldwide, posing significant risks to both drivers and pedestrians. The primary cause of fatigue-related accidents is insufficient sleep, which impairs reaction time, cognitive abilities, and decision-making while driving. Unlike other types of accidents, fatigue-related incidents often occur at high speeds, making them more severe and potentially fatal. Due to the lack of immediate response from drowsy drivers, these accidents tend to result in more severe injuries and fatalities.

To mitigate these risks, there is a growing need for smart systems that can detect driver fatigue and provide timely alerts. While several solutions have been proposed, many remain theoretical or lack practical implementation. The need for a real-time, efficient, and cost-effective driver fatigue detection and alert system is crucial for reducing road accidents and enhancing transportation safety. This research focuses on developing a real-time fatigue detection system using advanced image processing and machine learning techniques.

##### LITERATURE SURVEY

Several studies have explored various approaches to driver fatigue detection, ranging from physiological-based methods to behavioral and hybrid systems.

* **Physiological Methods:** Some systems use biosensors to measure heart rate, brain activity (EEG), and skin conductance to detect fatigue. While these methods provide high accuracy, they require wearable sensors, which can be uncomfortable for drivers.
* **Behavioral Methods:** Many researchers have focused on using computer vision techniques to analyze facial features and detect signs of drowsiness. Methods such as the Percentage of Eyelid Closure (PERCLOS) and yawning detection have been widely used.
* **Hybrid Systems:** Combining physiological and behavioral approaches, hybrid systems leverage multiple sensors and AI-based models to improve accuracy. These systems offer better performance but often come with increased complexity and cost.

Despite advancements in driver fatigue detection, existing methods have limitations, such as sensitivity to lighting conditions and the need for high computational power. The proposed system addresses these challenges by optimizing image processing algorithms and leveraging machine learning techniques for real-time detection.

##### PROPOSED SYSTEM

The proposed driver fatigue detection system is designed to identify signs of drowsiness and alert the driver in real time. This system integrates advanced image processing techniques with machine learning models to accurately analyze facial expressions and eye movements. The key components of the proposed system include:

1. **Real-Time Monitoring:** The system continuously captures and analyzes the driver's facial expressions using a camera mounted on the vehicle's dashboard.
2. **Eye State Detection**: Using image processing algorithms, the system detects whether the driver's eyes are open or closed. Prolonged eye closure is a strong indicator of drowsiness.
3. **Facial Landmark Tracking:** The system tracks facial landmarks such as blinking rate, yawning frequency, and head movements to assess fatigue levels.
4. **Alert Mechanism:** If the system detects signs of drowsiness, it triggers an alert through a buzzer or vibration to wake up the driver.
5. **Adaptive Learning:** The system improves its accuracy over time by learning from the driver's unique facial patterns and behaviors.

The implementation of this system aims to enhance road safety by preventing accidents caused by driver fatigue. The use of non-intrusive image processing techniques ensures comfort for the driver while maintaining high detection accuracy.

While the results of a standard histogram equalization filtering over the whole image give promising results, we wanted to see whether the results could be further improved. Many well-known enhancement algorithms such as histogram equalization and homomorphic filtering are global in nature and are intended to enhance an image and deal with it as a whole. We tried to split the original image in sub-images and filter each sub-image individually. First we decided to try and split the image into two halves vertically (thus obtaining two sub-

images of the original image) and then apply the filter to each half individually. Second idea wasto split the image horizontally and again apply the filter to each half individually. Encouraged by the good results obtained with both these methods (see Section 5.2.3 for details), further tried to combine the filtering results into a joint representation. Let IHEV(x, y) be the image split vertically and each half filtered with histogram equalization filter individually and let IHEH(x, y) be the same for horizontally split images and let IHEMOD(x, y) be our proposed modification:

IHEMOD(x, y) = 0.5[ IHEV(x, y) + .70 IHEH(x,y)]

Since IHEV scored higher results than IHEH in our tests, we decided to keep the whole IHEV and multiply IHEH with a constant of 0.70 (chosen based on experimental results), to lower its influence on the final representation. This combination produced highest results in our experiments and was kept as a final representation. We will show in the following section that our method yields superior results, and therefore justifies further research of the histogram equalization filtering variations as a means of simple yet efficient image preprocessing



DetectEyestate

Find Eye

Speaker

Preprocess image

Camera

Driver

Figure.1 Flow diagram

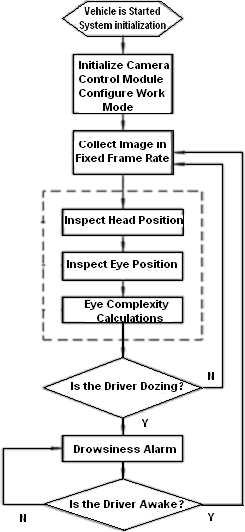


Figure.2 Execution Process



Enhancingvideoimage

InputVideoimage

Thresholding

Medianfiltering

Binaryimage

Figure.3 Flow Chart

##### STIMULATION RESULTS

The proposed method was tested on the real driver images. The video image [480 x 640 pixels] of 75 different test persons has been recorded during several sessions at different places. The eye pair can be selected successfully in most cases, no matter whether face patterns are on different scales, expressions, and illumination conditions. The proposed system is compared with color cues and projection function method. This projection method achieves eye in three stages. sequentially. It is followed by a connected component analysis to quantify spatially connected region and further reduce the search space to determine the contending eye pair windows. Finally the mean and variance projection functions are employed in each eye pair window to validate the presence of the eye. The eye location rate is 82.67% whereas the proposed system rate is 90.67%. Typical results of eye detection with the proposed approach .

An efficient and effective method for detecting eyes in video images in unconstrained backgrounds is presented. The images are subjected to thefirst stage of preprocessing. The second stage of Homomorphic filtering is then applied to enhance the contrast of dark regions; therefore facial images with poor contrast are enhanced. Finally eye pairs are extracted by using binary template matching method with eyeball detection.

Face locating

Detecting the locations of human face in a scene is the first step in the recognition system. In this step the region of the face candidate is roughly estimated using histogram thresholding technique. To simplify the segmentation, we assume that there is only one face in the image and is to be located. The binary image B (x, y) consists of all active pixels which include eye features. Histogram smoothing and automatic thresholding techniques are employed in this stage to eliminate the noises in the image and select the threshold.











Figure.4 Real Image capture from video using BTMED &Original Image. Binary image after preprocess &both eyes





Figure.5 Eye captured using digital camera & Original Image &Both eyes &Left eye &Right eye

##### CONCLUSION

This paper presented the design and analysis of an efficient and smart driver fatigue detection system. The proposed system is used to avoid road accidents created by human factors such as drowsy driving. It also helps the driver to stay awake during driving by generating an alert as soon as the driver is feeling sleepy. The Raspberry Pi module along with Camera is used to monitor the drowsiness of the driver in real time. Fatigue is detected with face, eye and mouth using Haar Cascade Classifier, and also with the use of facial landmarks and Eye Aspect Ratio by estimating the Euclidean Distance between the eyes and mouth. During the monitoring, the system is able to detect if the eyes are closed or open. When the eyes have been closed for a specified period of time, the system issues an alarm. Our system also implements the detection of yawn. If the yawn count has crossed a predefined number, the system sends an alert message to the owner of the car indicating the chances of the driver falling asleep. The system implemented in real time gave highly accurate results and promises a reliable fatigue detection.

##### FUTURESCOPE

**Automotive Industry:**

* Driver Fatigue Monitoring Systems: In cars and trucks, a fatigue detection system could be integrated into autonomous or semi-autonomous vehicles to monitor drivers' alertness and provide timely alerts to prevent accidents caused by drowsiness.
* Self-Driving Cars: Autonomous vehicles could benefit from these systems to assess when human intervention is needed, improving the interaction between human drivers and self-driving cars.

**Aviation Industry:**

* Pilot Fatigue Detection: Pilots often experience fatigue due to long flight hours. A system that detects fatigue and yawning could significantly improve aviation safety by alerting pilots and ground control about the need for rest or a change in personnel.
* Air Traffic Control: Controllers, like pilots, work in shifts and could benefit from similar fatigue detection to prevent errors that result from tiredness.

**Healthcare Sector:**

* Monitoring Healthcare Workers: Fatigue detection in doctors and nurses is essential in high-pressure environments like hospitals and emergency rooms. An alert system could prevent mistakes due to tiredness, ensuring better care for patients.
* Remote Patient Monitoring: Fatigue and yawning detection can also be extended to monitor elderly patients, ensuring they get proper rest and alerting caregivers when necessary.

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