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Real-Time Detection of Driver Fatigue using DIP

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***Abstract*: A Drowsy Driver Detection System has been developed, based on eye features detection algorithm and using a computer vision based concepts. The system uses a small monochrome security camera that points directly towards the driver's face and monitors the driver's eye and head movement in order to detect fatigue. The system deals with using information obtained for the binary version of the image to find the edges of the face, which narrows the area of where the eyes may exist. Once the face area is found, the eyes are found by computing the horizontal averages in the area. Once the accurate eyes are located, measuring the distances between the intensity changes in the eye area determine whether the eyes are open or closed. If the eyes are found closed for 5 consecutive frames, the system draws the conclusion that the driver is falling asleep and issues a warning signal. The system is also able to detect when the eyes cannot be found, and works under reasonable lighting conditions.**

***Index Terms*: Drowsiness detection, drowsy driving, sleeps deprivation, opening and Closing.**

I. INTRODUCTION

Driver fatigue is a significant factor in a large no of vehicle accidents. It is an invisible killer for drivers. Recent statistics estimate that annually 1,200 death and 76,000 injuries can be attributed to fatigue related crashes. [1] In the trucking industry, 57% of fatal truck accidents are due to driver fatigue. It is the number one cause of heavy truck crashes. 70% of American drivers report driving fatigued. The National Highway Traffic Safety Administration (NHTSA) [2] estimates that there are 1,00,000 crashes that are caused By drowsy driver stand result in more than 1500 fatalities and 71000 injuries each year in U.S. With the ever-growing traffic conditions, this problem will further increase. For this reason, developing system that actively monitoring a driver's level. This accident rate will be largely decreased if system developed to determine whether driver stay awake or not. Generally for fatigue detection the algorithm based on face features and head movement are widely used. This report uses two method to find fatigue (i) eye detection (ii) head movements of driver. [3] Computer vision, image processing and pattern recognition, detects eye area features after accurate face localization under normal illumination from rough to accurate.

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Also by considering normal face proportion for finding the head movements, this two methods provides the basis for further fatigue detection based on head movement, eye features and implements fatigue driving detection.

II. SKIN DETECTION

A color model is an abstract mathematical model describing the way colors can be represented as tuples of numbers.

RGB:- RGB is a color space (or model) which represent each pixel of three values, red and green and blue and each value vary from 0 to 255 (e.g. blue is equal to RGB(0,0,255) figure 3.1 shows an example of picture with separated RGB values. In image processing usually we do not use RGB because it has a disadvantage of huge light effect on the picture, in other words if we captured any picture and we changed the light brightness and captured the same picture again there will be a huge difference between the two pictures and dealing with three values is very hard and almost all the time there is no need for the RGB color value.

Fig. 1:RGB image & its separate R & G & B values

YCbCr:-

YCbCr or Y'CbCr is a color space that represents any color in three values, Y is the luminance component and Cb and Cr are the blue-difference and red- difference chroma components [5].Figure 3.2 shows an RGB image and the color responding YCbCr. Equations 1 and 2 and 3 shows how to convert from RGB to YCbCr.

$$Y=8432/32768*R+16425/32768*G+3176/32768*B$$
$$Cb=4818/32768*R-9527/32768*G+14345/32768*B$$
$$Cr=14345/32768*R-12045/32768*G-2300/32768*B$$

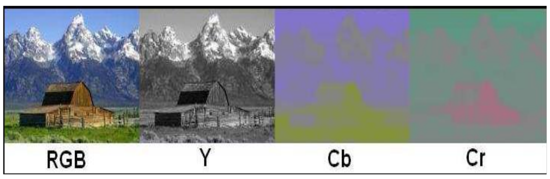

Fig. 2: YCbCr color model

HSV:-

HSV (or YIQ) stands for hue, saturation and value.HSV describe colors as points in a cylinder whose central axis ranges from black at the bottom to white at the top with neutral colors between them, where angle around the axis corresponds to hue, distance from the axis corresponds to saturation, and distance along the axis corresponds to value. Figure 3.3 shows H and V and S color space. Equation 4 shows how to convert from RGB to HSV

$$\begin{pmatrix} H \\ S \\ V \end{pmatrix} = \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.275 & -0.321 \\ 0.212 & -0.523 & 0.311 \end{pmatrix} * \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

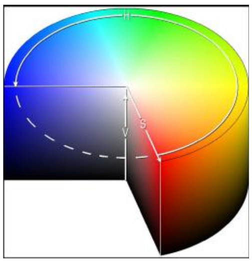

Fig. 3: HSV color model

III. FACE DETECTION

Face detection is considered as a very hard problem because computers are not like humans, they only can do mathematical operations and they do not understand logic. The problem is that there is some things that cannot be described mathematically or do not have specific description. For e.g. a tree cannot be described mathematically and do not have specific description because it does not have specific height neither specific width and it does not has one color. In face detection we usually look for common properties between faces like all faces have eyes but faces differentiate in shape also all faces have skin but skins are different in color and so on.

Fig. 4:- Bounding box for face detection

A) Feature Point Initialization

In order to track a facial feature it must be first identified in an image stream. The initialization process starts with the location of face in the first image. Human face is extracted from the image using skin segmentation techniques. Skin pixels can have very different RGB values for different people depending on their skin color, illumination etc, however their chromatic red and chromatic blue values defined as *ch*R = R/(R+G+B) and *ch*B = B/(R+G+B) are clustered in a limited region of (*ch*R, *ch*B) space and are largely independent of skin color or lighting conditions. Based on their chromatic red and chromatic blue values, the pixels are classified into skin or non skin pixels. After face segmentation the image is subject to blob analysis to locate the exact position of the eyes. The technique makes use of the fact that eyes when open have color different from skin and therefore appear as holes in the face, in the skin segmented image. These holes give the approximate location of the eyes.These locations are then used to track the eyes in the remaining video stream.

B) Eye Detection

Eye detection can be categorized into two categories:
1. Template Matching
2. Using Projection Function
3. Eye ball approach

Eye Detection Using Template Matching:-

The template matching is used to detect the positions of the eyes on the face image can be followed throughout a sequence of video images. Template matching is one of the most typicaltechnique for feature extraction. Correlation is commonly exploited to measure the similarity between stored template and the window image under consideration. Templates should be deliberately design to cover variety of possible image Variations During the search in the whole image scale and rotation should also be considered considered carefully to speed up the process.To increase the robustness of the tracking scheme the method automatically generates a codebook of images representing the encountere d different appearances of the eyes. Yuille first proposed usi ng deformable templates in locating human eye. The weak nesses of the deformable templates are that the processing time is lengthy and success relies on the initial position of the template.Lam introduced the concept of eye corners t oimprove the deformable template approach. In template ma tching, face recognition is parameterized by using a function for a standard face pattern like frontal taken face image.

Eye Detection Using Eye ball approach

Eyeball detection algorithm receives the coordinates of two eye boxes and finds the location of eyeballs within these boxes. Several techniques were considered for the purpose of eyeball detection. Geometrical pattern search or ellipse fitting techniques provide very good results however they are computationally intensive and were rejected in favor of circular Hough transform. Circular Hough transform itself is computationally intensive however it can be improved considerably by pre processing the eye image. This pre processing reduces the number of pixels which can vote in the Hough transform making it much faster.

Eyeball Tracking

Hough transform can be used to locate eye ball in each eye image thus determining the location of the eye ball. This technique however is computationally intensive and slows down the throughput of the algorithm. The advantage of computing Hough transform on the other hand is that we do not have to worry about the loss of tracking. If the Hough transform fails to find a circle in one image, this will not affect the transform computation in the subsequent images.

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Another technique is to use Lucas & Kanade feature tracker explained in section 3 to track the eyeball once its center and radius has been obtained through circular Hough transform. This vastly improves the speed of the algorithm however the tracking will be lost upon the loss of a feature point representing the eyeball. This feature point could be lost due to a blink or a rapid movement of the eyeball or eye itself. We address this problem by constantly monitoring the tracked feature points to determine if the tracking has been lost, in which case Hough transform is used to re initialize the eyeball location. The best feature points for eyeball tracking are the center of the eyeball and its two outer edges. The relative distance among these three points should remain constant as the eyeball moves within the eye. A significant change in the above distance will indicate a loss of a feature point.

Blink Detection

The eye tracking reduces the blink detection search space to two eye blobs. The location of these blobs or eyes is passed on to the blink detection algorithm by the eye tracker in each image. When a person blinks the intensity of the pixels that represent the eye also changes. This forms the basis of blink detection. A variance map of the change in intensity values in the corresponding pixels of the two consecutive frames, in an image sequence is created on a pixel by pixel basis.

IV. DESIGN & IMPLEMENTATION

This chapter aims to present my design of the Drowsy Driver Detection System. Each design decision will be presented and rationalized, and sufficient detail will be given toallow the reader to examine each element in its entirety.

Concept Design

As seen in the various references there are several differen t algorithms and methods eye tracking and monitoring. Most of them in some way relate to features of the Eye (typc ally eyeball from the eye) within a frame of the driver.The f ace and then using the absence of eyeball as a way of detecti ng whether eyes are closed. The open and closed eyeball is shown in fig 4.1

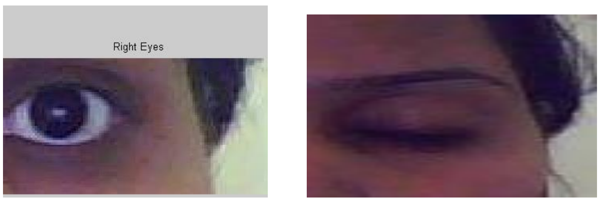
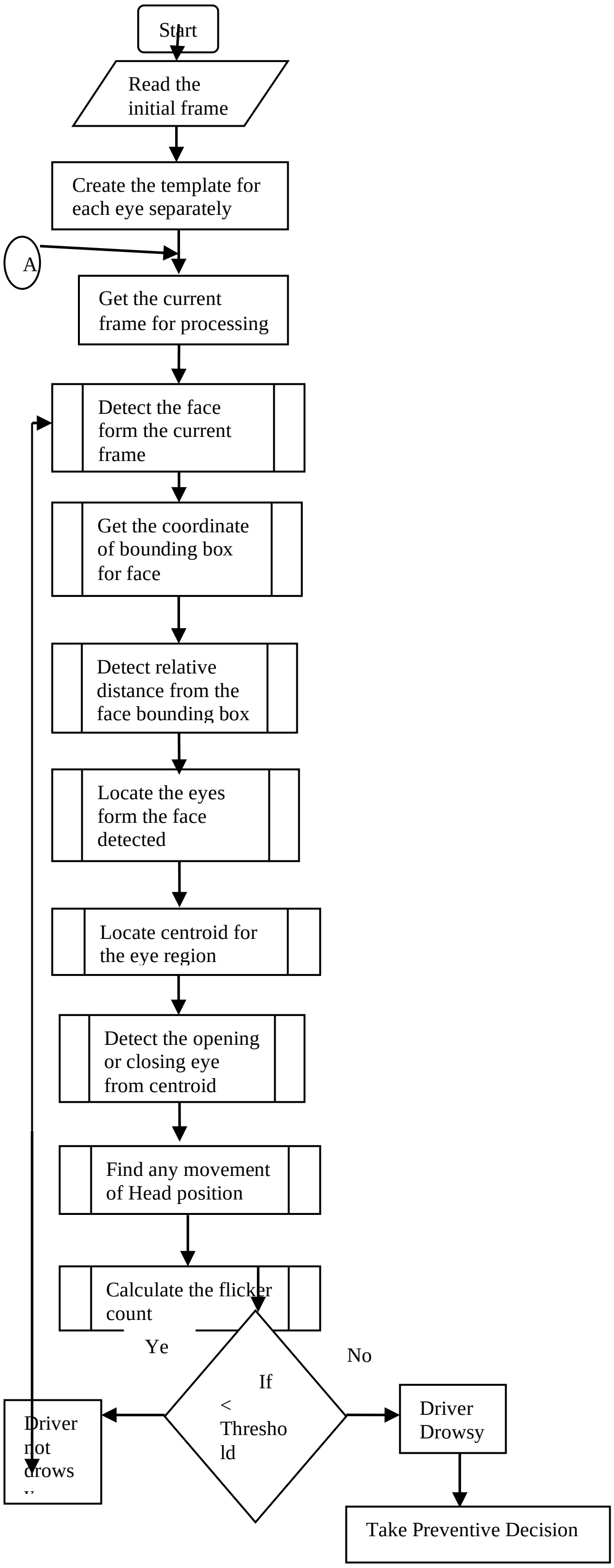


Fig. 5:- Case where eyeball present and not present

One similarity among all faces is that eyebrows are signifi cantly different from the skin in intensity, and that the next s ignificant change in intensity, in theydirection, is the eyesTh is facial characteristic is the centre of finding the eyes on the face, which will allow the system to monitor the eyes and d etect long periods of eye closure. Each of the following sections describes the design of the drowsy driver detection system.

Algorithm Development:-

A flowchart of the major functions of The Drowsy Driver Detection System is shown in Figure 4.1.



Traditional geometry for face:-

There is traditional proportion rule of geometrical features of faces, that is, the distance from hair line to eyebrow, eyebrow to nose, nose to chin occupies 1/3 of the whole face, like shown in fig.4.5

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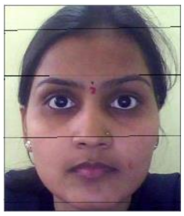

Fig.6:- Normal Face Proportion

Face Top and Width Detection:-

The next step in the eye detection function is determining the top and side of the driver's face. This is important since finding the outline of the face narrows down the region in which the eyes are, which makes it easier (computationally) to localize the position of the eyes. The first step is to find the top of the face. The first step is to find a starting point on the face, followed by decrementing the y-coordinates until the top of the face is detected. Assuming that the person's face is approximately in the centre of the image, the initial starting point used is (299,398). The starting max x-coordinate of 299 was chosen, to insure that the starting point is a black pixel (no on the face). The following algorithm describes how to find the actual starting point on the face, which will be used to find the top of the face.

Fig. 7:- Face Top and Width Detection

Eye Detection Function

An explanation is given here of the eye detection procedure. After inputting a facial image, pre-processing is first performed by binarizing 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 the eye area. The following explains the eye detection procedure in the order of the processing operations. All images were generating in Mat lab using the image processing toolbox.

Eyeball Detection

Eyeball detection algorithm receives the coordinates of two eye boxes and finds the location of eyeballs within these boxes. Several techniques were considered for the purpose of eyeball detection. Geometrical pattern search or ellipse fitting techniques provide very good results however they are computationally intensive and were rejected in favor of circular Hough transform. Circular Hough transform itself is computationally intensive however it can be improved considerably by pre processing the eye image. This pre processing reduces the number of pixels which can vote in the Hough transform making it much faster. after the eye detection eyeball presence or absence decide whether eyes are closed or open to calculate blinking rate. this blinking rates depends on the no of frame per second.

V. EXPERIMENTAL RESULTS

In order to detect driver fatigue detection using face and eye detection based on presence of eyeball approach for detecting driver drowsiness, the system was tested on 10 people and was successful with 4 people, resulting in 80% accuracy. Fig below shows an example of the step-by-step result of finding the eyes.

1) The first step is to read the initial image from the database which is stored in input frames

Fig. 8:-Original image

2) The second step provide the masking or binary image of the original image

Fig. 9:- Face mask

3) Below fig shows the results of face detection using bounding box, face mask and the eyes pair detection using simple geometry of face. this face and eye pair used as template to other image.

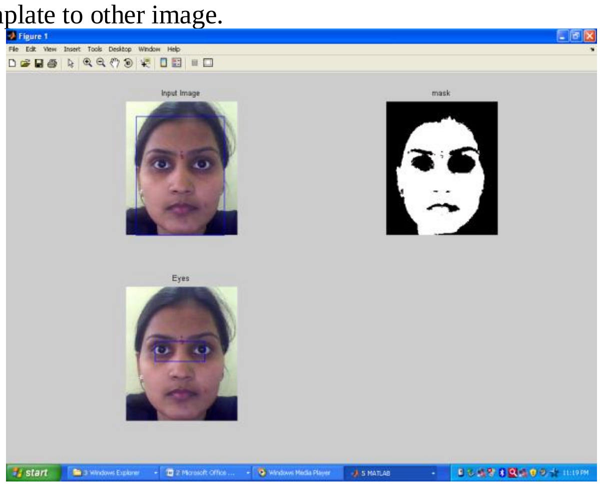

Fig. 10:- bounding box for face, face mask, bounding box for eyes pair

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4) Following fig shows the eye pair and separate eyes.(Left and Right eye) from this result it considered as open eye template for left and right eye.

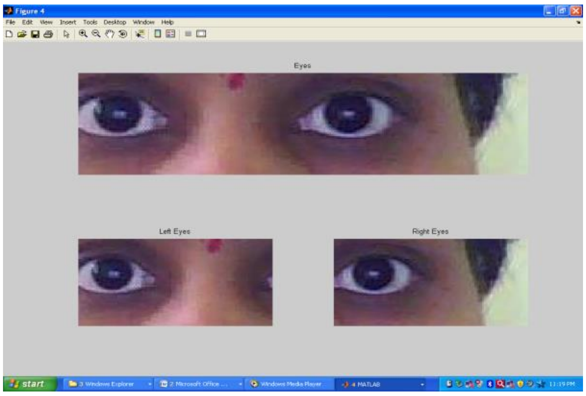

Fig. 11:- Eye pair, Left and Right eye

5) This code is divided into different module. these module are separately run to get the output of each program.

(5a) Fig shows the output of Current frame processing code. in which only face is detected and remaining face covered with mask.

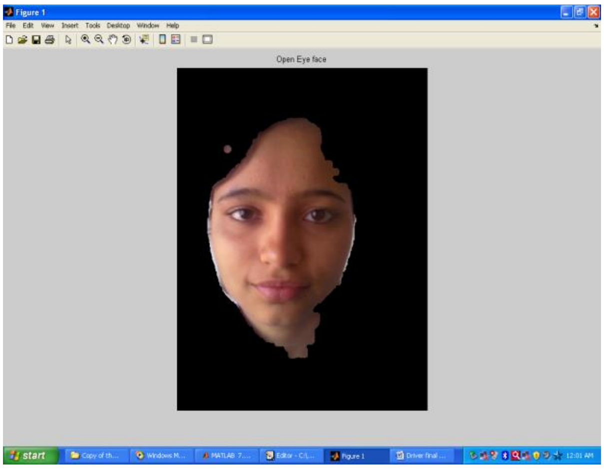

Fig. 12:- Current frame processing

(5b) Fig shows the output of get axis code. in which only face is detected and remaining face covered with mask

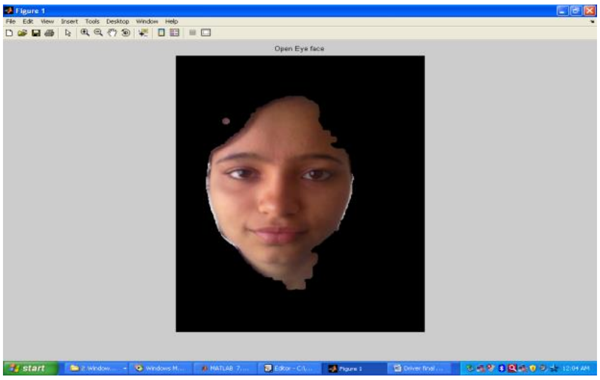

Fig. 13:- Open eye face to get axies

(5c) Fig shows the output of get face code. in which only face is detected and remaining face covered with mask and shows face area.

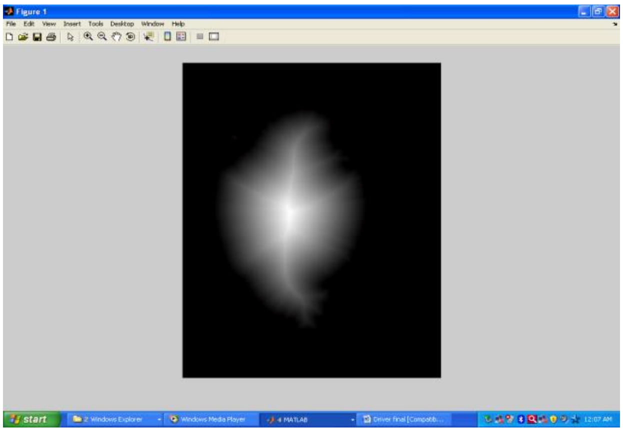

Fig. 14:- Face Area of open eye face

(5e) Fig shows the output of head movement. head movement is based on traditional face geometry, which is denoted as total d, and divided into three parts which is already shown.

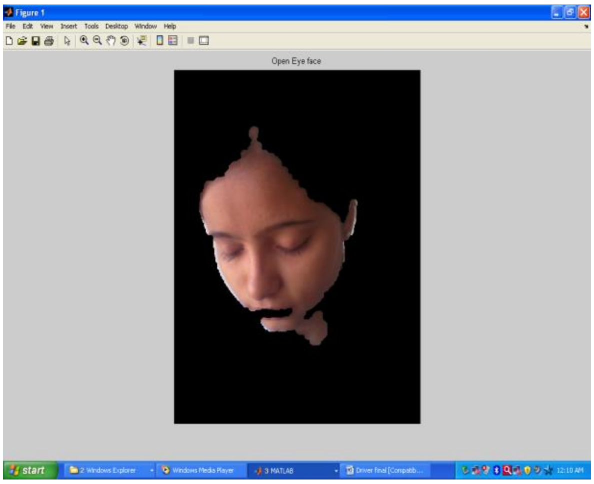

Fig. 15:- Head Movement

VI. CONCLUSION

In this work own generated database are used for driver fatigue detection. A system to localize the eyes and monitor fatigue was developed. Information about the head and eyes position is obtained through various self-developed image processing algorithms and some mathematical commands. Initially template was created for eyes and face. This was done by using MATLAB software. this method applicable to both frame as well as videos. This was achieved by interfacing a webcam to a PC and recording test videos and frame database under different lighting condition. During the monitoring, the system is able to decide if the eyes are opened or closed. The following conclusions were made:

- Image processing achieves highly accurate and reliable detection of drowsiness.

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- A drowsiness detection system developed around the principle of image processing Judges the driver's alertness level on the basis of continuous eye state.

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