DRIVER'S DROWSINESS DETECTION

INTRODUCTION

The purpose of this project is to investigate the development of a system for detecting the likelihood that a driver is about to fall asleep in control of the vehicle, and to sound an alarm or carry out some other function if this occurs. The system will be primarily based on the use of a small camera mounted on the vehicle dashboard which will locate and "track" the driver's eyes, and on this basis attempt to detect if the driver is about to fall asleep.

For example, if the eyes close and remain closed for a certain period of time, this may indicate that the driver has fallen asleep and that a crash is imminent. Alternatively, if the eyes start to fall towards the bottom of the image (in a video sequence), this might suggest that the driver's head is starting to droop. At the same time, the system should not react inappropriately to "natural" movement of the driver's eyes, e.g. if the driver turns his/her head to look out the side window.

Area of Application:

- Road users have long been known to fall asleep whilst driving. Driving long hours can induce fatigue causing lack of concentration and occasionally road accidents.
- This is even more critical on motorways where traffic travels at higher speeds and drivers can succumb to “motorway hypnosis” as the repetitive and somewhat passive experience of driving on long, wide, straight roads can cause the driver to relax and lose concentration from the road and traffic around them.
- This allows drivers who “legally” are fit to drive but physically are not, on the roads. Many of these drivers are unaware of their fatigue and danger they pose to themselves and other road users. A main application of this system is primarily to protect such people described by alerting them to their fatigue.

Design Details

Camera

High-resolution CMOS webcam with a manually variable focus lens. It has higher resolution of 1028 x 840.

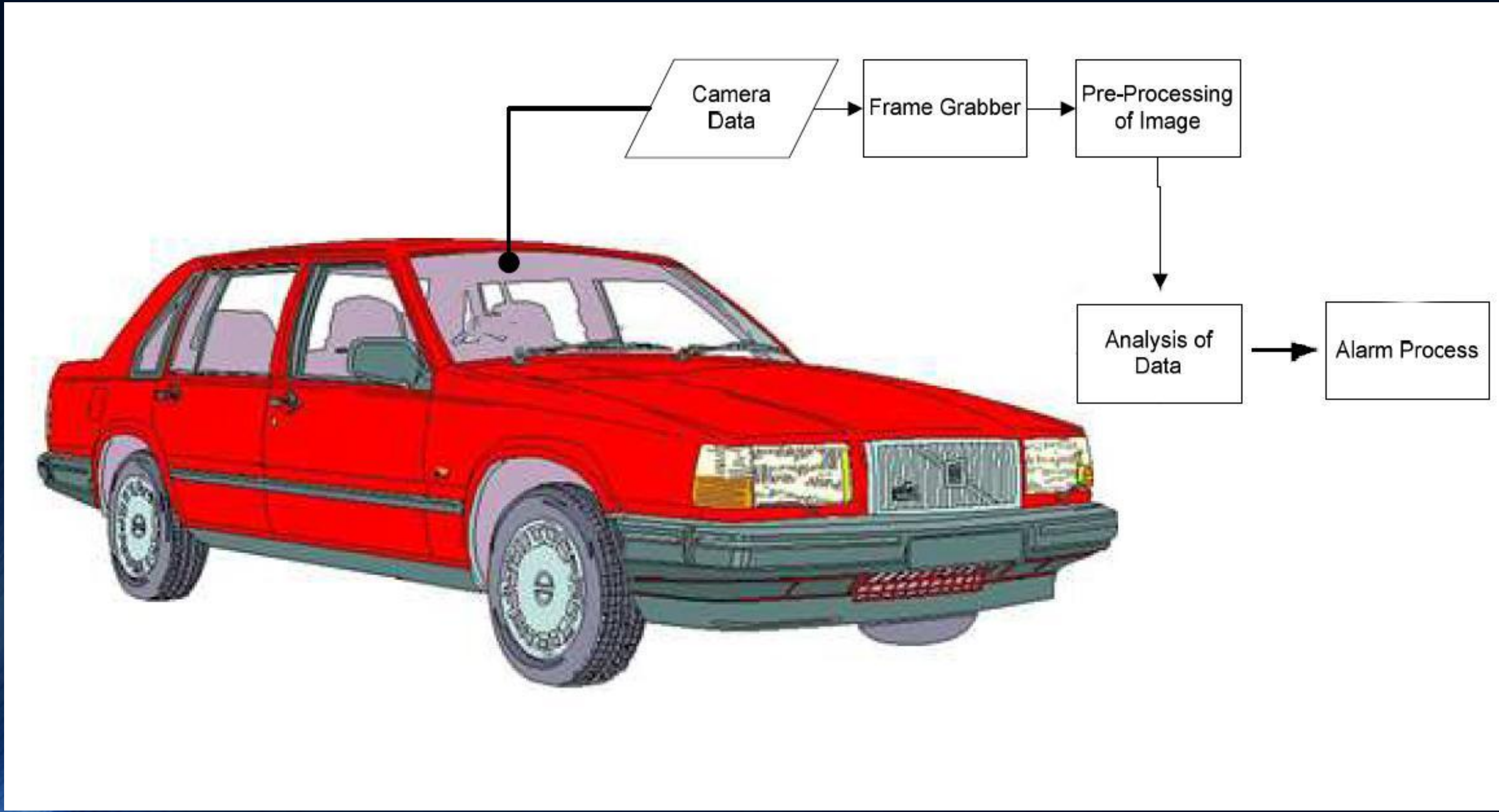
ADuC 831

The Analog Devices product, the ADuC831 was chosen for this project as it provided the embedded system functionality that was stipulated in the initial specification. Its core consists of an 8052 Microcontroller which provides the necessary processing power to compute the demands made on it by the requirements of this project.

Alarm

Alarm used is a standard device that is used in projects.

Implementation



Working

1. A standard CMOS (Complimentary Metal Oxide Semiconductor) camera is mounted in the front of the car to view the drivers face but not obstruct their observation of the road ahead.

2. The frame grabber receives the camera feed from which it takes in the current image data in digital form and allows access to the data for processing. This procedure repeats itself at the start of every cycle once the previous frame is processed.

3. The image is captured and taken into the system where it is pre-processed before the Hough Transform is applied; the image is reduced in size to the region surrounding the face, using cropping tools.

4. Then the cropped image is converted from RGB (Red Green Blue) color to a grey scale image with 255 levels of intensity. This reduces the amount of data in the image while retaining much of the critical information needed.

5. Then Hough Transform is applied to the cropped greyscale image and circular object data is referenced to a minimum threshold to remove spurious detections and interferences.

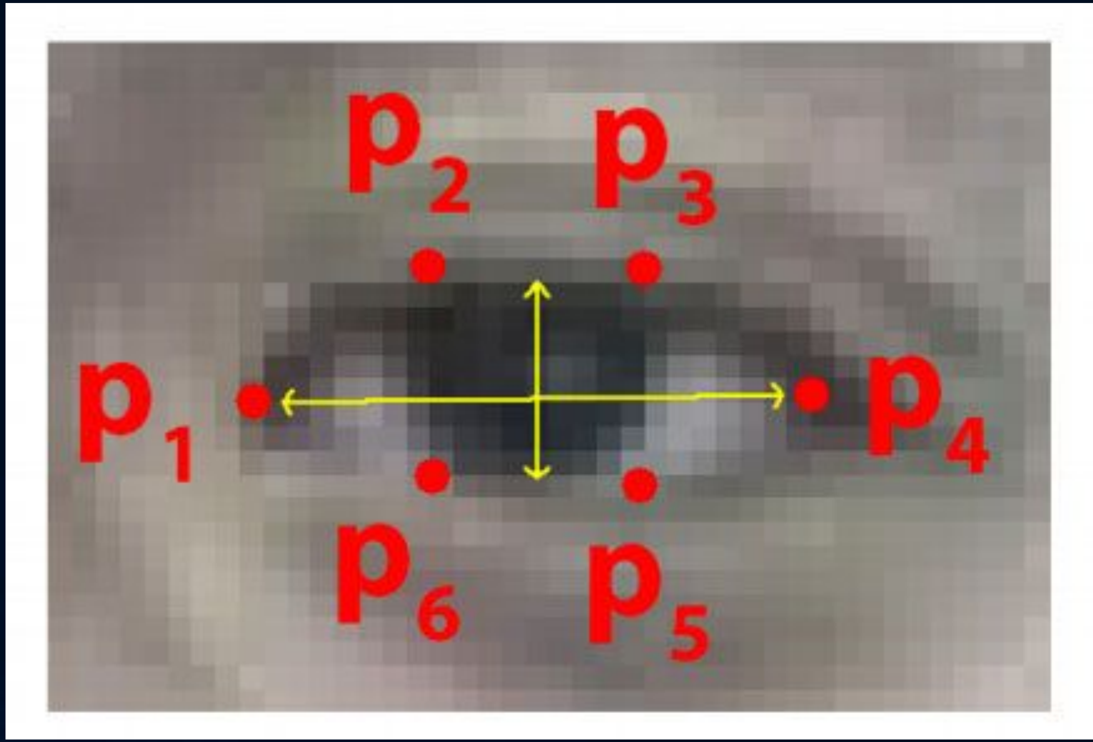
6. The data is analyzed further for the detection of eyes in the image. This involves the application of the geometric features of the eye to the data, resulting in a more accurate detection. Resulting data is then further analyzed to check if the points selected resemble eyes, using the color data from the original image.

7. Combining the resulting image information, the fatigue detection system is able to decide whether the alarm procedure is activated or returns to the start where it re-initialises and the process starts over again. The functionality of this system should be unobservable to the driver during normal conditions and the driver should only be aware of the system, should the alarm procedure be activated

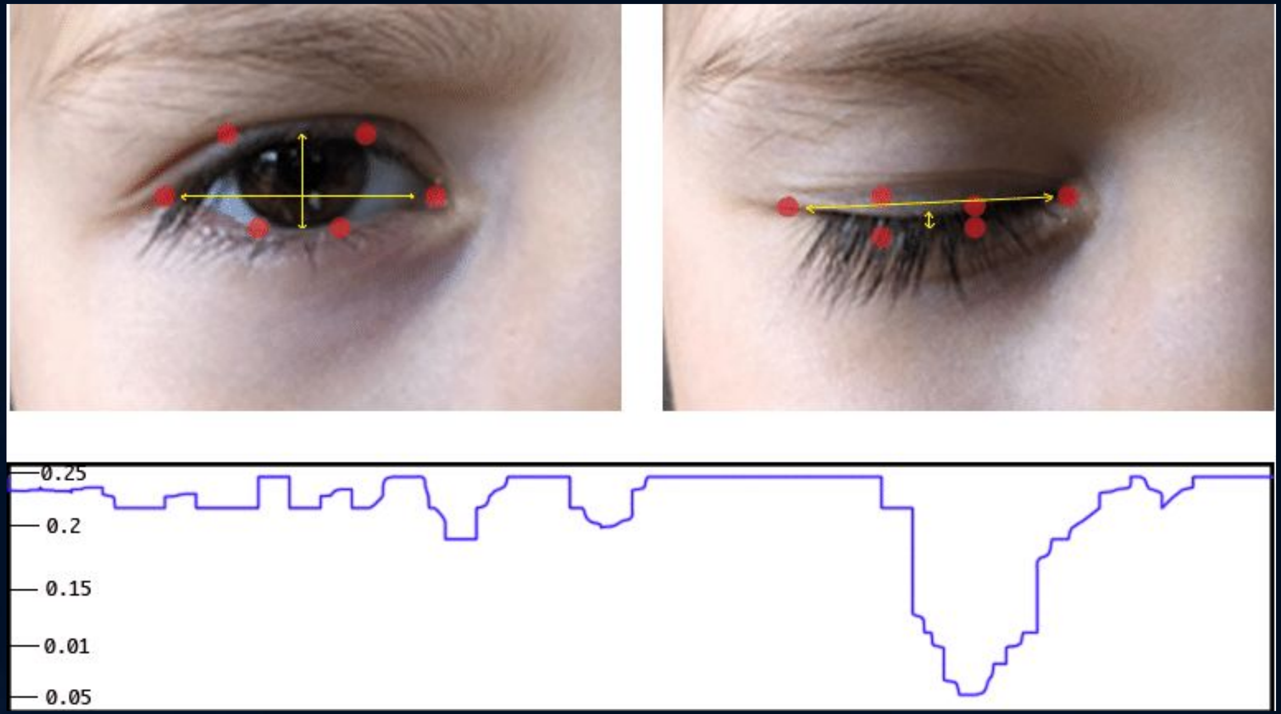
Eye Aspect Ratio

The Eye Aspect Ratio is an estimate of the eye opening state.

$$\text{EAR} = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|}$$



"The Eye Aspect Ratio is a constant value when the eye is open, but rapidly falls to O when the eye is closed." Figure Below shows a person's Eye Aspect Ratio over time. The person's eyeblinks are obvious.



A program can determine if a person's eyes are closed if the Eye Aspect Ratio falls below a certain threshold.

Hough Transform

The Hough transform is a technique of finding any shape in a digital image. It is usually used to find lines and curves or shapes that can be described by a set of parameters.

Representation of Lines in the Hough Space

Equation of line $y = a \cdot x + b$

Equation in Normal Form

$$y = -\frac{\cos\theta}{\sin\theta} \cdot x + \frac{r}{\sin\theta}$$

All lines can be represented in this form when θ [0, 180[and r belongs to R. The Hough space for lines has therefore these two dimensions; and r, and a line is represented by a single point, corresponding to a unique set of parameters (θ, ro).

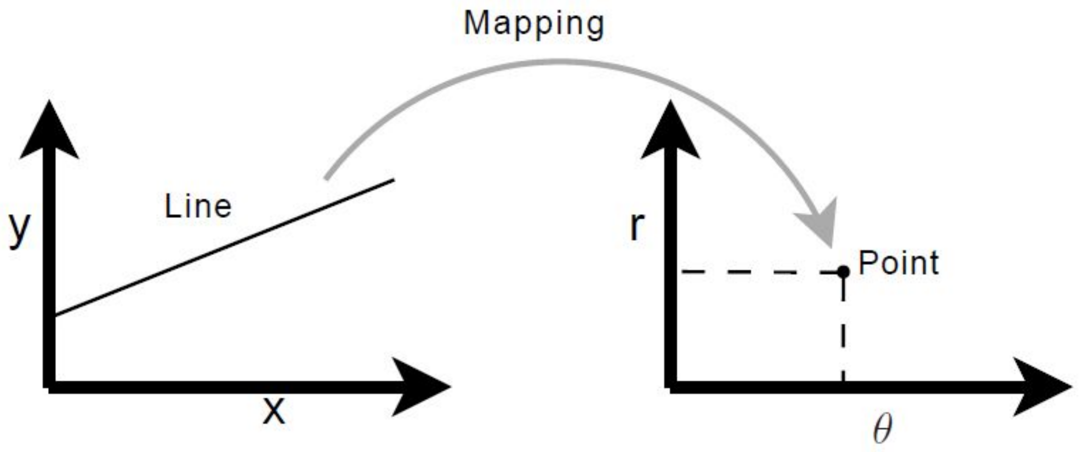
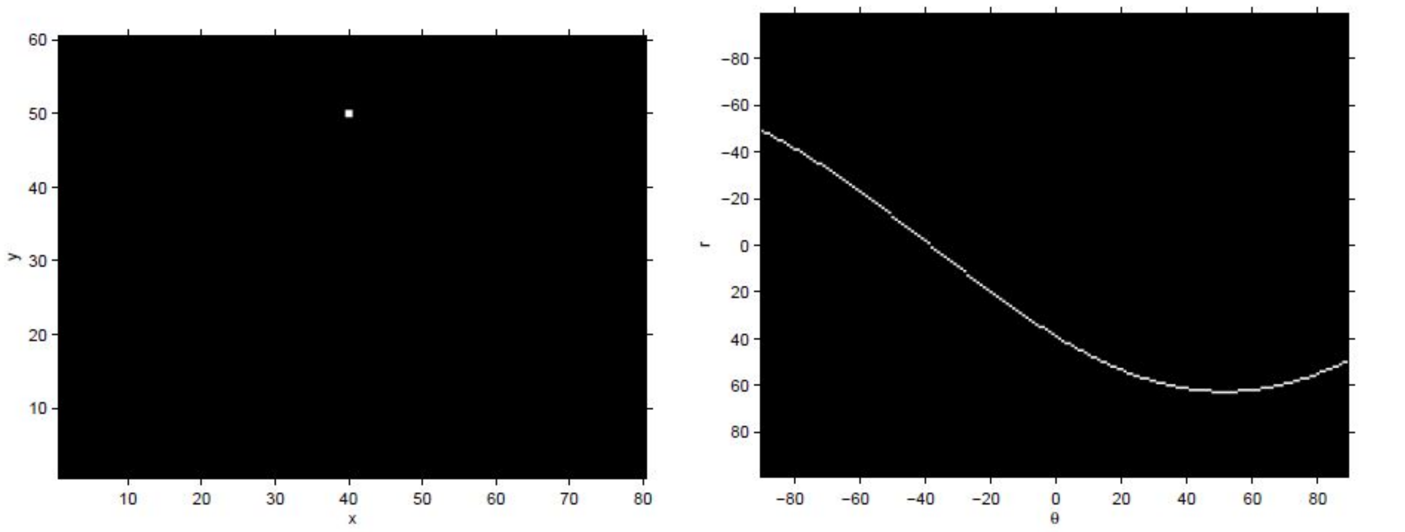


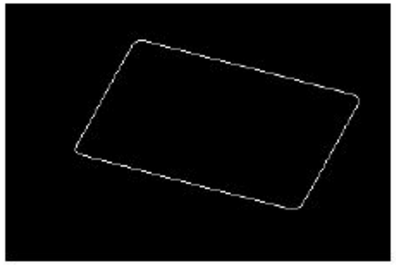
Figure 1: *Mapping of one unique line to the Hough space.*



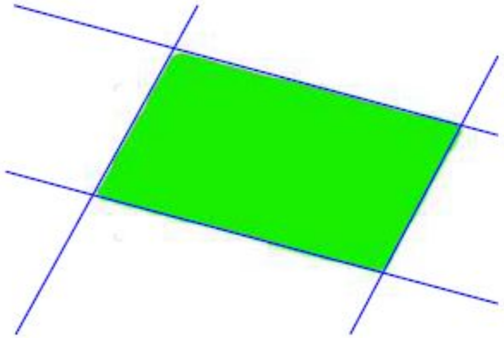
(a) Point p_0.

(b) All possible lines through p_0 represented in the Hough space.

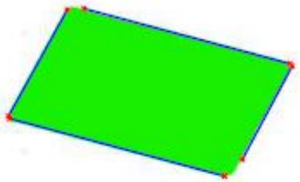
(a) Original



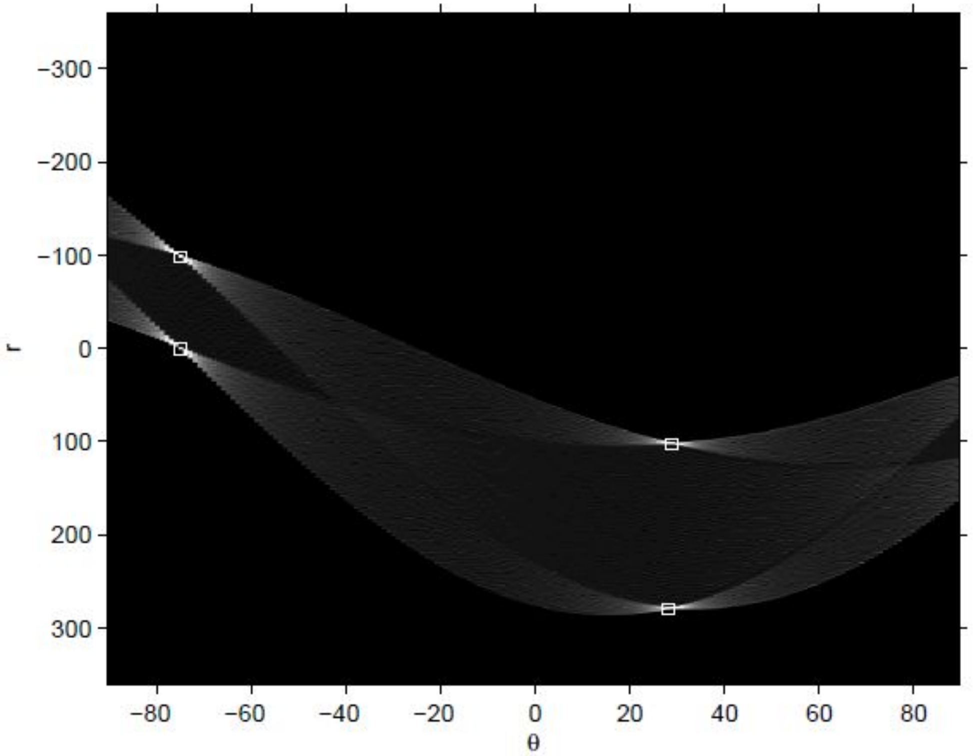
(b) Edges



(c) Infinite Lines



(d) Finite Lines



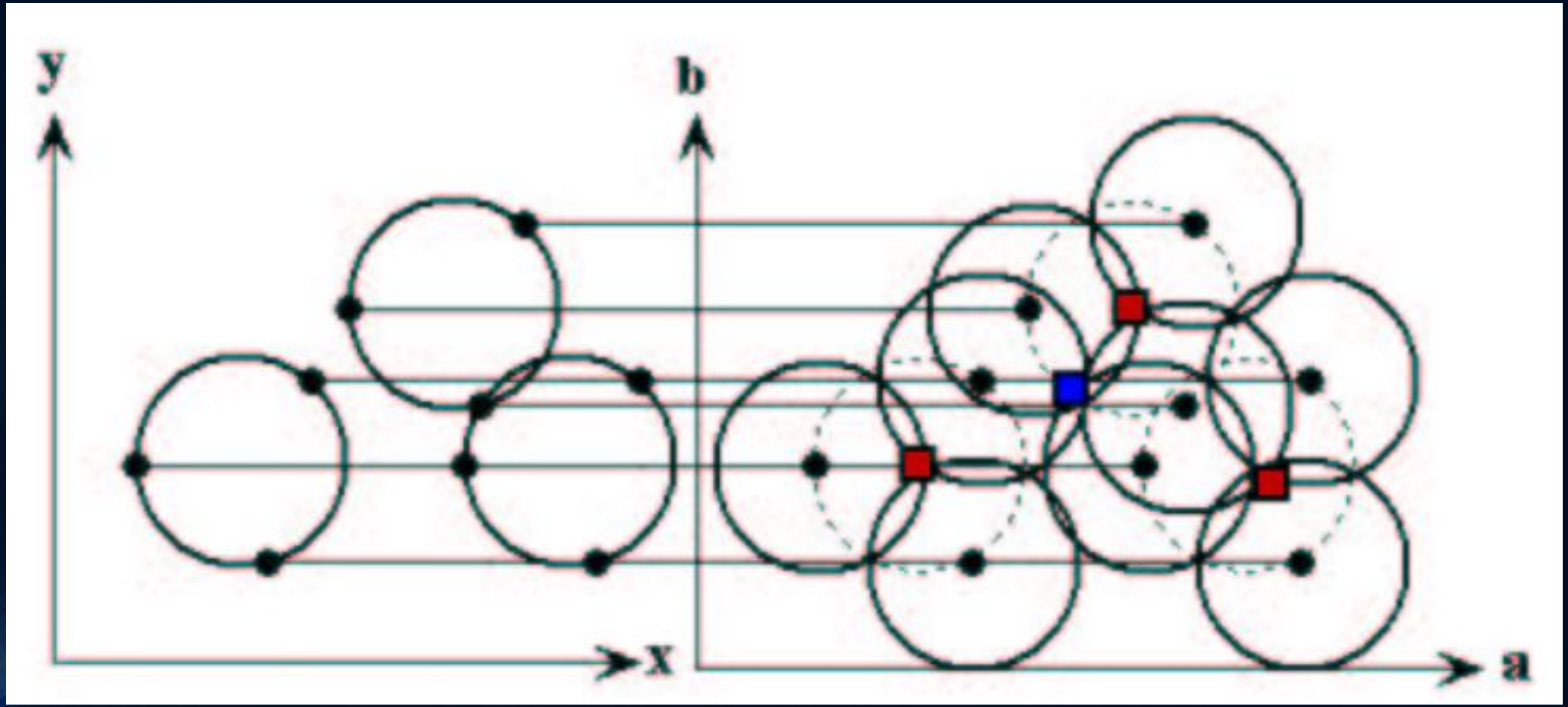
(e) Hough Transform

Representation of Circles in the Hough Space

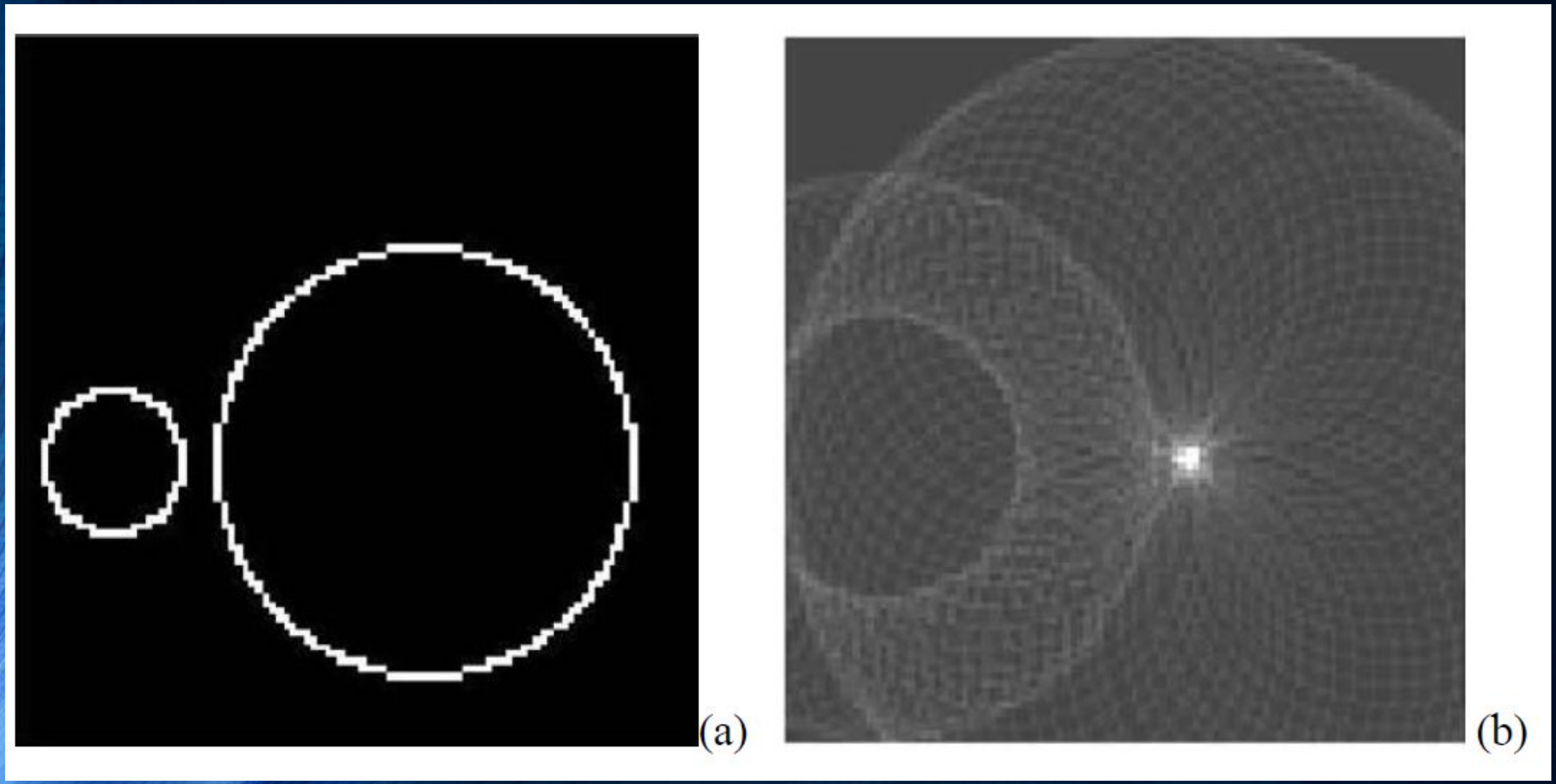
Normal Form of a Circle

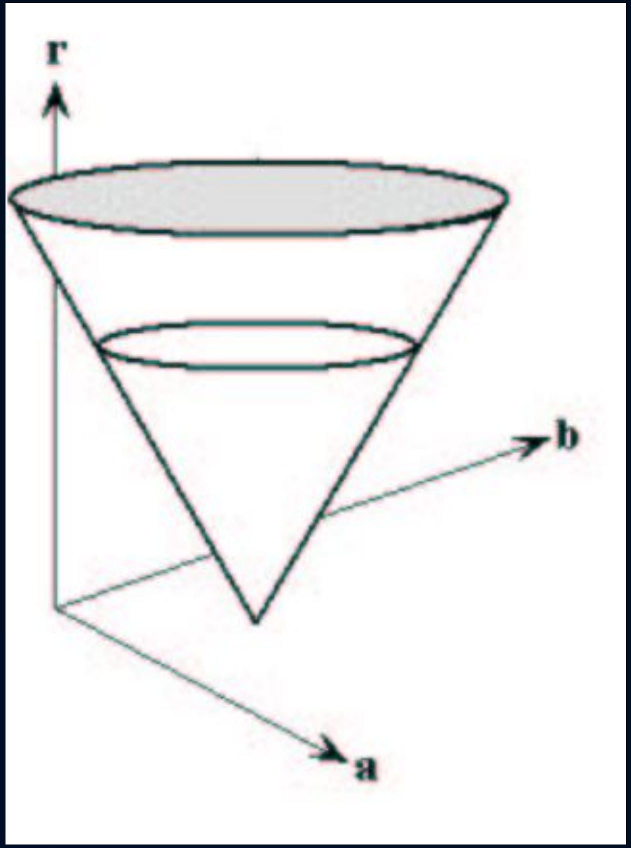
$$x = a + R\cos(\theta)$$
$$y = b + R\sin(\theta)$$

The locus of (a,b) points in the parameter space fall on a circle of radius R centered at (x,y).



If the radius is not known, then the locus of points in parameter space will fall on the surface of a cone. Each point (x,y) on the perimeter of a circle will produce a cone surface in parameter space. The triplet (a,b,R) will correspond to the accumulation cell where the largest number of cone surfaces intersect.

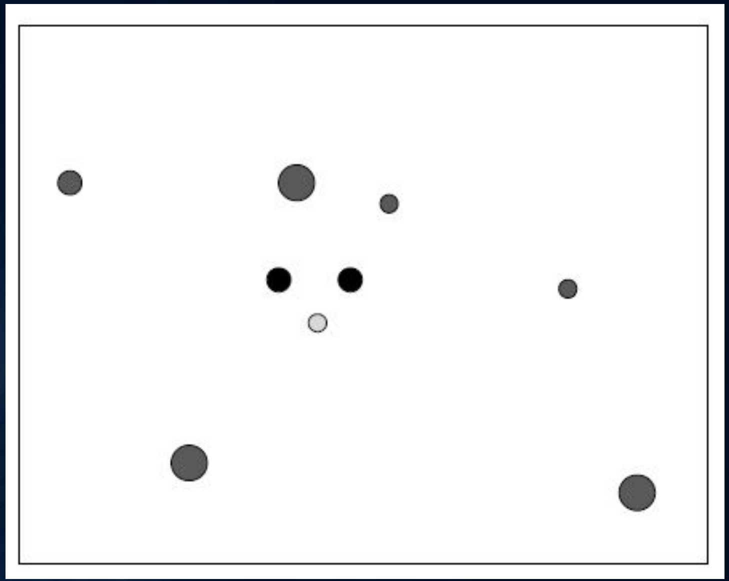




Eye Detection Algorithms

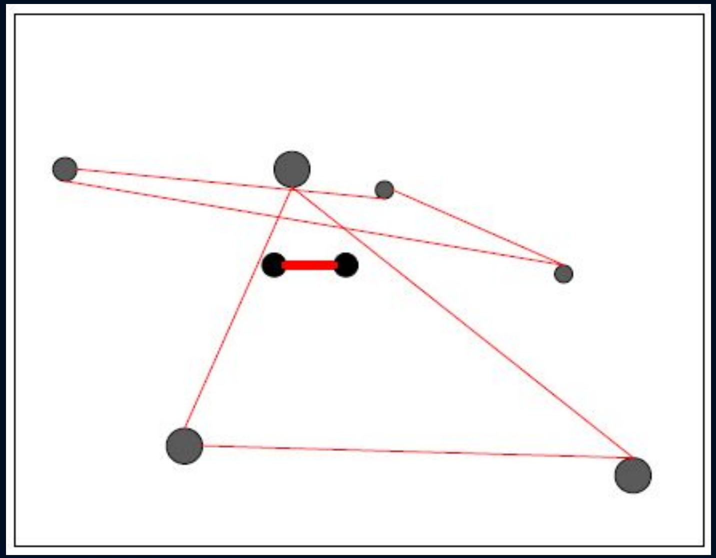
Data returned from the Hough transform function takes the form of two arrays, one a 2xN matrix containing the co-ordinate information and the other a column vector with the corresponding radii of the circles. The purpose of this screening of points is to improve the reliability of the detection of the eye.

1.



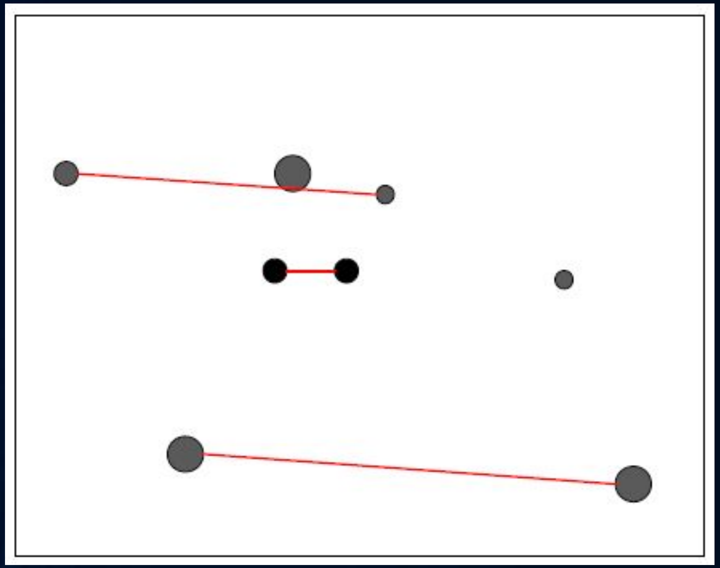
Initially the points are screened based on color information, setting a threshold to ignore points that have a greyscale value towards the white end of the spectrum removes any shadows on the face or light source reflections from the returned data.

2.



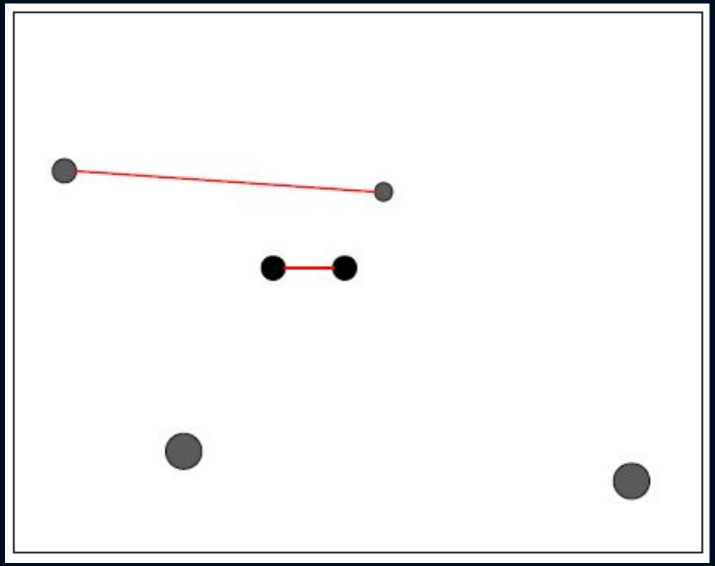
Pairing data points of the same radius allows for the identification of probable matching pairs of eyes. Healthy pupils should be of the same size and react together to any changes in light

3.



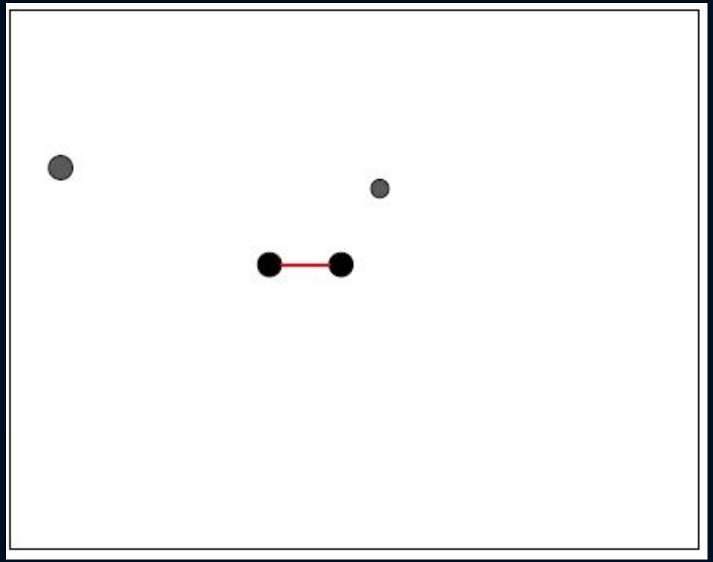
The angle condition to be applied, this involves removing pairings from the selection that fail to have a relatively small angle with the horizontal

4.



Now the distance condition is applied to the pairings, this is used as the distance between the eyes is fixed and can be said to lie within a maximum and minimum distance range for the majority of people, i.e. most people's eyes are greater than 2cm apart but less than 20cm.

5.



A final check on the color data is made, pairs should have similar color information. The selection of the best matching pair to the defined colors of the pupil is made at this point.

Explanation of the Algorithm

The video is from which frames are taken which are coloured and then these are converted to gray scale using this function.

```
frame = vs.read()
frame = imutils.resize(frame, width=450)
gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
```

The face detector function present in the dlib library uses Hough Transform to detect the shapes in the shape.

```
detector = dlib.get_frontal_face_detector()
predictor = dlib.shape_predictor("68 face landmarks.dat")
```

Following function marks the start and end of left and the right eye and this data is passed in the ear function.

```
(lStart, lEnd) = face_utils.FACIAL_LANDMARKS_IDXS["left_eye"]
(rStart, rEnd) = face_utils.FACIAL_LANDMARKS_IDXS["right_eye"]
```

The following code shows EAR function that returns the value of ear calculated from the coordinates of the eyes.

```
def eye_aspect_ratio(eye):
    A = dist.euclidean(eye[1], eye[5])
    B = dist.euclidean(eye[2], eye[4])
    C = dist.euclidean(eye[0], eye[3])
    ear = (A + B) / (2.0 * C)
    return ear
```

```
leftEye = shape[lStart:lEnd]
rightEye = shape[rStart:rEnd]
leftEAR = eye_aspect_ratio(leftEye)
rightEAR = eye_aspect_ratio(rightEye)
ear = (leftEAR + rightEAR) / 2.0
```

Initializing the threshold value for the ear and setting the minimum number of frames after which if the ear value remains below threshold ear then the alarm will go on

```
EYE_AR_THRESH = 0.3
EYE_AR_CONSEC_FRAMES = 48
```

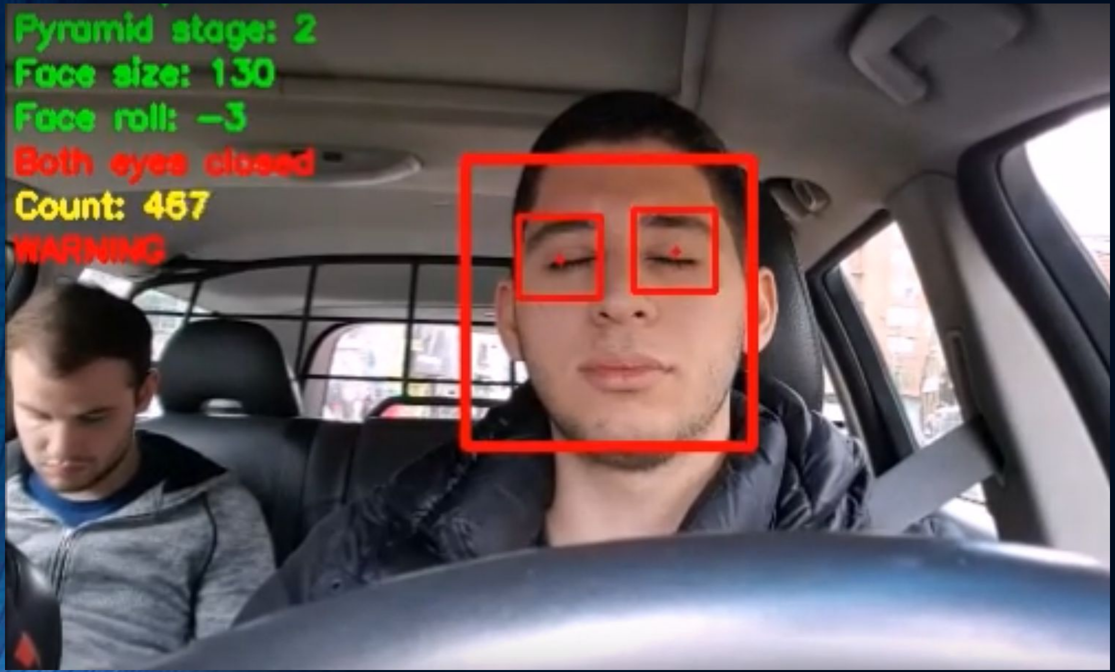
Each frame is checked with following condition and if the number of frames crosses the threshold

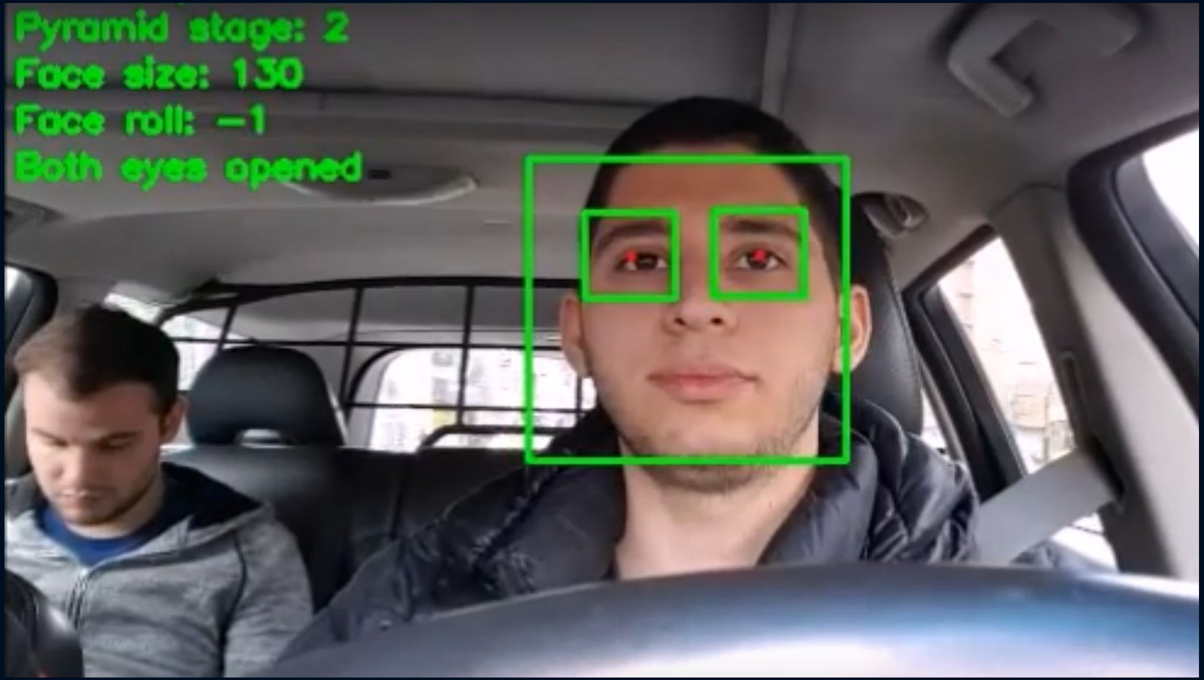
```
if ear < EYE_AR_THRESH:
    COUNTER += 1

    if COUNTER >= EYE_AR_CONSEC_FRAMES:
        if not ALARM_ON:
            ALARM_ON = True
            if args["alarm"] != "":
                t = Thread(target=sound_alarm,
                    args=(args["alarm"],))
                t.deamon = True
                t.start()

        cv2.putText(frame, "DROWSINESS ALERT!", (10, 30),
            cv2.FONT_HERSHEY_SIMPLEX, 0.7, (0, 0, 255), 2)
    else:
    COUNTER = 0
    ALARM_ON = False
```

Expected Outcomes





Alert!

Research Gaps

Another way to implement this project is by Open CV algorithm using Haar cascade classifier.

1. OpenCV is used for gathering the images from camera and feed them into a ***Deep Learning*** model which will classify whether the person's eyes are 'Open' or 'Closed'.
2. This Deep Learning model consists of a dataset which has 7000 images of people's eyes under different lighting conditions. Further classification is made using this dataset
3. From the images face is detected and ROI is created.
4. Then Eye Detection is used and this information is passed to classifier which then detects whether the eyes are closed or open.

Further Development

1. To increase the accuracy of the alarm we can use pressure sensors in the steering wheel so that more information can be gathered. Based on this the code will be modified and the alarm will go on when the pressure on the steering is less.

2. Primarily the project could be developed further to include “Night Vision” or low light cameras; this would improve low minimum light conditions for the detection of the eyes. This can be implemented by using appropriate cameras.

3. Also a real time clock could be integrated into the system. This would allow the system to increase its sensitivity during peak times for fatigue.

4. The specification of the project could be broadened to include a tracking and learning element into the system. This would track and monitor the body movements of the driver and build up a database of their normal behavior to which the system could reference against fatigued behavior as abnormal and warn the driver they may be suffering from fatigue, should they show any of the tell tale signs not covered by the specification of this project.

Conclusion

In today's world there are more vehicles on the roads than ever before at all hours of the night and day. This increase in road usage is a factor in the rate of traffic accidents on roads.

Road safety is a topic discussed almost every day in the papers and on our airwaves in this country and worldwide, unfortunately though this is usually because of the lack of safety and precaution taken by road users.

In addition, especially in India, hundreds of thousands travel over long distances to work, day in, and day out. This long daily starts very early in the morning and end late in the evening can fatigue the driver thus inhibiting their ability to react to non-expectant events and even worse, it can cause the driver to fall asleep at the wheel.

The critical points at which driver fatigue related collisions happen are between 2am and 6am and mid afternoon between 2pm and 4pm when our body clock is at its lowest point. Males aged 18 to 30 are in the high risk category. They tend to be over confident about their driving ability and believe they can handle the situation. Women are less likely to be involved in sleep related crashes

If a driver persists in fighting sleep while driving, the impairment level is the same as driving while over the drink drive limit. Eventually a driver will drift in and out of consciousness and experience "micro sleeps" which can last for up to 10 seconds. In this time a driver has no control of the vehicle. Drivers can experience such a micro sleep with their eyes wide open.

So we can understand that there is serious need for some mechanism to deal with this problem and this driver alert system will provide a accurate and effective results. Use of this device will certainly help in reducing the number of accidents and
Providing better experience to the driver.

Literature Review

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