Monitoring Driver Awareness Through Eye Tracking

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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at Brac University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
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Abstract

Driving is a task that requires a high level of focus for the security of not just the person driving but also other drivers and passengers out on the road. Hence, it is a difficult task, as a human being might not be able to maintain this focus continuously for a lot of reasons such as drowsiness. Drowsiness is a reason for a lot of accidents that occur around the world, as a result car manufacturers and researchers are looking for solutions to decrease these accidents as much as possible. One key way of decreasing these types of accidents is by monitoring a driver's eye to track whether a driver is drowsy or not. If a person is drowsy or is falling asleep, he/she will be alerted by means of sound. To solve this we approached this problem by setting up a camera on the driver's dashboard and then conduct image processing by using OpenCV library to identify whether a driver is fully focused or not and whether it is safe enough for a driver to continue driving. Fortunately, a pre-trained Viola-Jones classifier comes out-of-the-box with OpenCV library. Where, The Viola-Jones algorithm is a system for object recognition that enables real-time detection of image features. By going through four different phases this algorithm detects the face and tracks the eye really conveniently with an efficient accuracy rate. In Viola-Jones algorithm two pre-processing techniques, along with the three functions, were evaluated and compared.

Keywords: Driver awareness; Drowsy driving; Face detection; Viola-Jones; OpenCV;

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Nomenclature

The next list describes several symbols & abbreviation that will be later used within the body of the document

$CAMSHIFT$ Continuously Adaptive Mean Shift

CFV Central Field of View

$CLOSNO$ Symptoms related to Eye region

$ELDC$ Symptoms related to Eye region

$FPFV$ Peripheral Field Of view

FSM Finite State Automata

$GRNN$ General Relapse Neural System

$NPFV$ Near Peripheral Field of View

$PERCLOS$ Percentage of Eyelid Closure

ROI Region of Interest

ROT Symptoms related to Face region

Chapter 1

Introduction

1.1 Introduction

When a driver is driving on a road many considerable things play a vital role, where the main consideration of driving on the streets is the driver's awareness, focus and concentration, and once this awareness and attention is lost, significant mishaps could occur. Where focus and awareness is measurable through eyes. In addition, driving is a task that is impossible to do without eyes, and in order to understand whether a person is tired or drowsy, we shall use eye-tracking. Eye-tracking is a process that monitors the position of the eye relative to that of the head or measures the point of gaze. For Instance, if a driver feels sleepy during driving his eye gaze will start changing also his blinking ratio will change his eye movement will change. If we can track their eye movement we can then easily understand their present situation weather they are attentive or not. In solution to this many researchers try different methods and criteria, in this research of our's we are trying to modify some of the existing system and create a driver awareness system by tacking their eyes.

1.2 Problem Statement

Car accidents occur for a lot of reasons, and drowsy driving is one of those key reasons. It is a type of careless driving that affects a person's capability of driving safely and in turn puts other drivers on the road at risk[4]. Many people might associate the cause of drowsy driving to be the consumption of alcohol or drugs, but sleepiness or being tired is the prime reason. Even though the prime reason for drowsy driving is sleepiness, it necessarily does not mean that one will fall asleep while driving rather it is when a particular driver is less focused on his driving due to sleepiness. Hence, a lot of key elements for driving are compromised such as, driver alertness, attention, reaction time, judgment and decision-making which leads to a higher chance of accidents occurring.
Drowsiness or lack of attention while driving can lead to fatal accidents. Moreover, due to drowsiness and tiredness, a driver can fall asleep without him understanding. According to study the drowsiness of a driver can depend on many characteristics of the driver, such as the age of the driver, the profession of the driver, any medication the driver is taking, etc. Drivers who are mostly affected by drowsiness are commercial workers, who need to drive long distances and with a lack of sleep[1].

According to research, there are a lot of factors that contribute to drowsy driving. In a research conducted in 10 states of USA and Puerto Rico during 2011-2012[3], it was found that drowsy driving increases with the decrease of age, it was found that 1.8% of adults aged greater than 64 years fell asleep while driving whereas 5.9% of adults aged between 18–24 years fell asleep while driving. Moreover, the age adjusted prevalence of drowsy driving was higher in males(5%) than females(3%). Furthermore, those who are employed(4.5%) tend to fall asleep more in comparison to that of those who are unemployed(3.7%). Similarly, another research conducted in 19 states of the USA and the District of Columbia during 2009-2010[2], supports the later research. Here, 1.7% of adults aged greater than 64 years fell asleep while driving whereas 4.9% of adults aged between 18–24 years fell asleep while driving. Moreover, the age-adjusted prevalence of drowsy driving was higher in males(5.3%) than females(3.2%). Furthermore, those who are employed(5.1%) tend to fall asleep more in comparison to that of those who are unemployed(3.1%). If we go more in-depth to know the effects of drowsy driving, we can look at the research conducted in the United States between 2009-2013[5]. This study indicates that about 6% of all the incidents that occurred in which a car was towed from the crash site were due to drowsy driving. Moreover, the number of accidents for which people received injuries caused by drowsy driving was 7% and the percentage of accidents caused by drowsy driving for which people had to be hospitalized was 13%. Furthermore, alarmingly about 21% of accidents in which people were killed was caused by drowsy driving. To top it off, these statistics continue to improve as time goes by. Hence, the severity of drowsy driving can clearly be understood by the fatality caused according to the above statistics. From the studies stated above, it is a high necessity that a system should be developed that can reduce the fatalities caused by drowsy driving or drivers who are not paying attention on the road. Therefore, in order to reduce these fatalities, we can target the sense that is greatly used while driving, which are the eyes.

1.3 Aim of Study

In our research, as we are focusing on drivers awareness and attentiveness during the period they are driving cars on road our aim of this research is to reduces the mishaps that happened very often in our highways. If we can build a system in which we can determine whether a driver is attentive while he is driving the car. And if we find that the driver is not aware and his errors are in increasing rate we can create an alert system which will give notify the driver about the unawareness and also send notification to their relatives or car owner or close ones. Hence, road accident becomes a severe issue in our country we believe that this kind of study and research will help a lot to reduce the amount of significant accident happening around.

1.4 Research Objective

Our approach is to use a driver's eyes to understand whether a driver is focused and paying attention or not. In order to do this we will fix a camera on the dashboard of the car. This camera will constantly be recording the video of a driver's face. Hence, from this video each frame will be analyzed through image processing to see where the driver is looking at a particular instance. If a driver makes a right turn without looking in the mirror, this data will be stored and the driver will be made aware that he needs to pay attention through sound. If a driver consecutively does mistakes he or she will be alerted by a more serious means.
A driver will blink while driving, hence n is the threshold of frames for which he can close his eyes for. If a driver closes his eyes and keeps them closed for n number of frames, he will be alerted that it is not safe for him to carry on driving.
Moreover, by constantly monitoring a driver's eyes and storing the data of the mistakes a particular driver has made, we can evaluate how safely a person can drive and at what conditions or at what time he/she is more prevalent in doing mistakes that might lead to an accident.

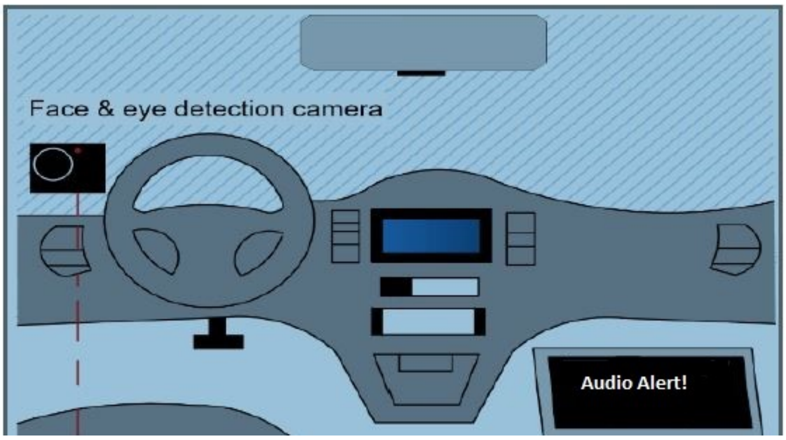

Figure 1.1: Sketch of the Eye Tracking System

Chapter 2

Related Work

In their paper HoseynSigari, Fathy Soryan explained, The eye tracking system is a comprehensive program that utilizes machine vision techniques to detect fatigue and disturbance. One of the reports implemented detection of fatigue and distraction associated with chemotherapy associated with the face and eye regions . In their system, they used face images to extract fatigue from face and eye. From those face images, the extracted symptoms from eye region are (1) percentage of eye closure, (2) eyelid distance changes, and (3) eye closure rate. They used these extracted symptoms to determine fatigue and distraction. They used Haar Classifier features and adaptive boosting methods for face and eye detection. In their system two types of symptoms are extracted: (1) symptoms related to eye region, for this extraction they use horizontal projection of face images and use a spatiotemporal approach. (2) symptoms related to the face region, for this they extracted face images to determine head rotation. In their method, using a fuzzy expert system, driver exhaustion and distraction detection are calculated. An expert scheme that uses inductive reasoning instead of Boolean logic is a fuzzy expert method. In other words, a fuzzy expert system of experts is a collection of involvement functions, a system of reasoning, including rules that are used to explain inputs and generate proper results. Four data sources are calculated by the fluffy master system and deliver two yields. The inputs are (1) PERCLOS, (2) ELDC, (3) CLOSNO and (4) ROT, and outputs are (1) fatigue estimation and (2) distraction estimation [6].
One of the other papers, Kong, Lingxiao Zhao and Wang used a system based on machine vision and Adaboost algorithms. In this system, they trained face and eye classifiers by Adaboost algorithm in advance. Firstly, front face and deflected face classifiers effectively detect face. Then, according to the geometric distribution of the facial organs, the region of the eye is calculated. Finally, professional classification methods of open eyes and closed eyes are used to identify eyes in the field. Their system is composed of four parts, which is, (1) image preprocessing, (2) face detection, (3) eye state recognition, (4) fatigue evaluation. Photos are shot in their device by an external camera, which is located on the drivers' front left. After denoising the images and detecting the face region, it is possible to obtain eye positions and states dependent on the detected face region. In order to be easily used in classifiers for feature extraction pictures, they are normally converted to greyscale images. With this algorithm, the Adaboost algorithm is based on Haar features and qualified frontal face classifier. Integral mapping, Hough transition, prototype matching, and principal component analysis are the typical eye localization approaches. A

well-recognized and effective measure of the level of neurophysiological fatigue is PERCLOS. At the end of detection, a result will be output for each frame. The 4 findings could be the state of open eyes, the state of closed eyes, the exception of the face and the exception of eyes [7].
In this paper, Smith, Shah, and Niels presented a system for driver distraction and fatigue using motion and colour statistics of face. Their system is fully automated using one camera. They detect occlusion of the eyes, eye blinking and closure of the eyes and recover the eyes' 3D gaze. Because of eye blinking and eye closure, their system is able to track both through occlusion. They used a video camera for extracting data from video sequences which was placed on the car dashboard. For the eye initialization they used colour prediction, since eyes are not skin color they show up as holes, the system finds out two holes and satisfies them. In their method, eye tracking is performed in a multi-strategy fashion, One of which is that the eye pupil is identified by the system and then scans around the eye center in the previous frame and locates the center of mass of the eye region's pixels. Another is that the eyes are searched for a window by their device and each non-skin is an eye. The eye-black-hole tracker is the name for these two techniques. The last technique is the affine tracker, their device measures the affine transition around both eyes between the windowed sub-images and then, as it knows the eye center in the previous frame, to locate the new eye center, it warps the sub-image in the current frame. Eye occlusion is calculated in their system as the eye area includes white pixels, so the eye is open, otherwise it is closed. Their device identifies the brightest pixel in the eye region in the first frame of each series to calculate the eye-white color, using this approach to measure blinks and also eye closure. For the 3D gaze tracking they used a single camera. The technique they used is to provide parallel rays of the eye's gaze. All that is needed are the eye locations, the points lying on the top of the head and the back of the head immediately behind the eyes. Since the camera faces the driver, as the driver looks ahead, his/her face is roughly parallel to the plane and the axis comes out of the face. To measure eye gaze direction, these methods are calculated. They used PERCLOS, Finite State Automata (FSM) to determine driver visual attention. FSM monitors eye closure metrics and blinking. By using these methods, they determine driver's attention and fatigue [8].
We reviewed another paper by TayabKhan, HafeezAnwar, FarmanUllah , AtaUr-Rehman, and others in which they used real-time videos to implement driver drowsiness identification, whether the eyes of a person are open or closed. First, the face was extracted from the image. With an extended Sobel operator, the eyes are centered and filtered to detect the curvature of the eyelids in those detected faces. We researched another paper in which they used real-time videos to implement driver somnolence identification, whether the eyes of a person are open or closed. Second, the face was removed from the image. In the faces described, the eyes are centered and filtered to detect the curvature of the eyelids with an extended Sobel operator. They evaluated this method using three image datasets. In their system they detected faces using Viola-Jones object detection algorithm. As this framework is likely to detect multiple faces the camera is set closer to the driving seat which will occupy a greater number of pixels of the face. Within the first frame, they took the Region of Interest (ROI) and exploited the rest of the driving session. Their next step was to remove the eyes and remove the eyebrows from the face of the named

drivers. The eyebrows have a similar orientation, because their technique is based on the curvature of the eyelids. Therefore, in order to get correct results, the eyebrows must be cut. In their systems the eyelids are extracted from the curvature. They assumed if the curvature of the eyelids' edge is greater for open eyes otherwise close. They used the Sobel operator for the detection of edges, which can detect the curved edges in the 5 eyes observed. After getting results they considered the contour with the largest areas as the eyelid. If the eyelids were located, the next step was to decide if the curve was upward or downward in order to determine whether it was open or close to the eye. If the curve is concave down then the eyes are open and concave up for close eye, they use two extreme points and their midpoints in both axes. Using this method, they determine if the driver is feeling drowsiness. [9]
As we are intended to determine whether a driver is attentive during his/her driving a vehicle. To detect and control the focus of the driver's attention by using his/her eye gaze and direction of head motion by the author Debnath P, Hassan R, And Das in their paper. If the driver adjusts his/her eye gaze, the pupil's corresponding synchronization often changes. And according to this research paper can detect eye gaze by two efficient procedures, they are Gaze Detection Using the Coordinate of the Pupil. Where, if they can effectively track the eye pupil, they can detect which direction they are focusing on from the variation of the pupil coordinate of the driver. An eye rectangle is created from the facial points around the eye region. They should assume the coordination of only the left eye for ease, because they realize that the pupil of the two eyes is moving at the same time. Three regions are divided into the width of the eye rectangle: left, center, and right. The corresponding x-coordinate of both pupils frequently shifts as the driver moves its focus from a central field of view (CFV) to a near-peripheral field of view (NPFV). The eye's x coordinate decreases on every region within the eye rectangle and thus the gaze of the driver will be known. In the left, display and right areas, the following are different approaches to determining the threshold for gaze recognition using the head rectangle. And positional knowledge for those who need drivers exists in the far peripheral field of view (FPFV) or near this zone. They can not quite accurately detect the eyes for gaze estimation in this situation. So they decide on which object, based on the head movement, the driver is searching for. To accomplish this, the width of the head rectangle is divided into four areas: the front, left side and right side. From the facial points found, the center of the face is identified and it is basically the middle of the eye's rectangle. Now, if their head moves, the middle line of their face often moves with respect to the rectangle of the head. Depending on the head region in which the middle line of the face falls, they determine whether the driver looks on the left, front or right. [10]
Eye Gaze Tracking System is still in its developing stage mentioned by Malvely A. G., Judith J.E., Sahal P.A. and Kuruvilla in their paper. It has so many uses, such as human-computer interaction, augmented reality, diagnosis of eye disorders, etc. By observing the gaze movement of a person, it provides much information about his/her thoughts. In this paper they investigate and establish a method of eye gaze tracking that they are saying is really efficient and can monitor a driver's activity during the driving period. It is an appearance-based visible imaging gaze tracking method. In feature-based gaze tracking method, the eye region features that is the center of the iris is extracted. They proposed a strategy to play out the extraction of a component from a picture of force. Utilize a preset eye edge channel, the eye

corners are evacuated. The eye corners and the eye iris focuses are distinguished, and a straight mapping capacity decides the heading of the look. Otherwise the author mentions that, one of the principle confinements of this technique is that the head must be kept stable. By the client since the look course is delicate to the head present. To acquire geometric highlights, they utilized the iris and corner location strategy, and utilized the general relapse neural system (GRNN) to outline to the screen. The disadvantage of this framework is that, if a blunder happens 6 with any information vector of GRNN, the precision of the framework diminishes. The authors also discuss another technique in this paper to get the eye gaze that conducts pupil center detection based on deformable eye and motion decision algorithms based on shape and intensity. The weakness of this proposed technique is that the precision of the outcome is delicate to head posture and framework execution is diminished for low-goals video arrangements. By applying a few other techniques, the author's come with an efficient method of algorithm that can detect the eye gaze perfectly to monitor the driver's attention as they said. The algorithm they used is CAMSHIFT (Continuously Adaptive Mean Shift) algorithm is used for extracting the ROI (Region of Interest). Where they identify each eye's region is separately and shown inside squares. When Eye pupil is detected it is marked inside a circle. The eye detection algorithm detects whether the eyes are opened this helps as in determining the user's drowsiness. The fundamental objective of this framework is that traffic security can be improved and, in this manner, decrease the quantity of mishap rates. It cautions the driver while driving when he/she is languid. An admonition signal is given to the client by creating an immense sound and vibrating the guiding. It tends to be worked in any light condition. It is more proficient than the current observing frameworks. [11]
If the eyes are closed or open, this can be determined by template matching [13]. For the identification of driver fatigue, a non-intrusive vision-based system was proposed by Papanikolopoulos and Singh [14]. The machine that focuses on the driver's face and constantly watches the driver's eyes to detect micro sleep is using a graphics video camera.
In the Paper, Nunes explained The secondary duties that take drivers' eyes off the forward roadway lessen visual tests [16] and growth cognitive load can be specifically risky. Where, Klauer, Simons-Morton in their paper use one instance, the use of mobile phones even as driving, consistent with naturalistic studies [17], causes heaps of fatalities inside the US each year explained by Bergmark,Gliklich [18].

Chapter 3

Model Used to Collect Data and Results Analysis

The approach we used to collect our data is by monitoring the eye in real time, and analyzing the data collected in background. In summary, we took input from a camera and analyzed each frame one by one, to get outputs such as where the driver is looking, whether he is blinking or not, whether he made an error or not, and in which direction is the car moving. The analysis of the video was done frame by frame to extract data, this was done using the OpenCV library [12] of python. This library and its functions allow the model to detect face, detect eyes and also track the eye movements.

3.1 System Components

The process of collecting data first starts with the component selection, for this model the component that were used are laptop web camera, keyboard and laptop speaker. The camera is the most essential component of all, the better the camera the better the accuracy of the data collected. Furthermore, the camera needs to have a decent fps, which is the number of frames the camera can capture per second. For the data that was collected, two laptops with identical camera were used which had a decent fps of 30.

Device Type	Web Camera
Resolution	480p (640×480)
FPS (Frames per Second)	30
Digital Video Format	Color

Figure 3.1: Specifications of the Camera

The other two components are also part of the laptops being used, which are the speaker and the keyboard. Specific keys of the keyboard are being used as the inputs for steering wheel in real life scenarios. These keys include, “W”, “A”, “S” and “D”, “W” indicates the car is moving forward, “A” indicates the car is steering to the right, “D” indicates that the car is steering to the right, and “S” indicates the car is moving backward. The speakers of the laptops were used in order to alarm the driver about the errors made.

3.2 Algorithm of the Model

The model needs to first detect the face and proceed on with the next steps of tracking the eye gaze to get the direction at which the driver is looking at. In order to detect face in a frame and further analyze it, the model uses OpenCV library in python and implements the Viola Jones and Haar Cascade Classifier algorithms to detect face and eyes. The Viola-Jones algorithm is an object-recognition framework that allows the detection of image features in real-time. Viola-Jones has been designed for frontal faces, so that it can detect the best of frontal faces rather than the faces looking sideways, upwards or downwards. The image is converted to a grayscale before the face is detected, as it is easier to work with and there are fewer data to process. The Viola-Jones algorithm first detects the face of the grayscale image and then finds the location of the colored image. Viola-Jones outlines a box and searches for a face inside the box. Essentially, it searches for these hair-like features.

Viola-Jones algorithm consists of four main phases, haar features, integral image, AdaBoost, and cascade. To begin with, the detection of haar features can be grouped into three main steps. Firstly, after converting colored, RGB, images to grey-scale images, the Integral images are generated. The integral image is the sum of the pixel values of the original image. The sum of the pixels is calculated by choosing the coordinates (x,y) and summing all the values to the top left of the point, including the point itself. In the second phase, to obtain the Haar wavelets, different levels of integral images are used. Haar-like features are a combination of two or more rectangles with different contrasts; they can be two rectangles, three rectangles, or four rectangles, and so on.

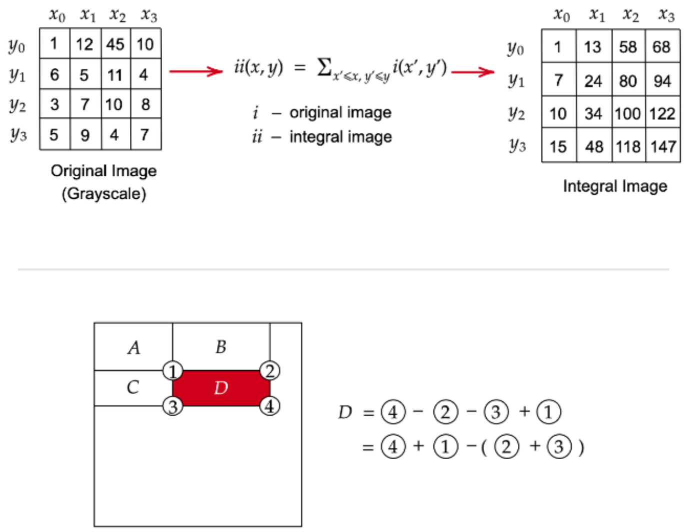

Figure 3.2: Conversion of original image to integral image (top) and how to calculate a rectangular region using an integral image (bottom)

The third and the last step is the AdaBoost, The AdaBoost (Adaptive Boosting) Algorithm is a machine learning algorithm for selecting the best subset of features among all available features. AdaBoost is an algorithm that looks at the relevant features and is used to detect objects, in this case, the face and the eye. When the features are extracted, the stage comparator will sum up all the features and compare them to the threshold value.

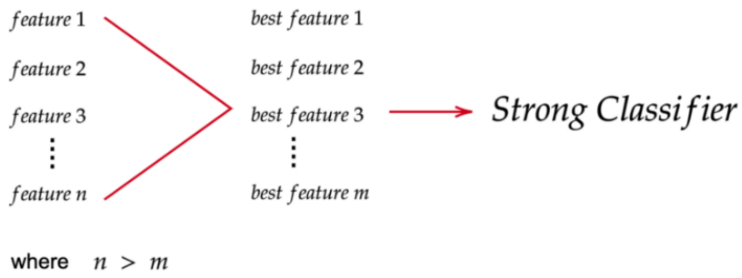

Figure 3.3: The goal of using the AdaBoost algorithm is to extract the best features from n features. Note: best features are also known as weak classifiers.

At the end, after completing all the three steps, there is a cascade step; and in this step, the steps are cascaded to eradicate any non-face candidates to enhance the data processing time and accuracy of the identification. Alongside the detection algorithms, the model consists of a measurement algorithm that calculates certain attributes and realizes whether the person is blinking or not and in which direction is the person looking at. Both the detection and measurement algorithm need to act as a single unit of algorithm where as soon as face and eyes are detected the measurement algorithms are used to measure and store the results. The measurement algorithm for the model is sequential, one section needs to be fulfilled in order to move to the next section. The algorithm is run on each of the frame captured by the camera. Therefore, for each frame the algorithm first detects whether there is a face in the frame or not, if the car is moving and no face is detected, it means the driver is not looking on the road, hence, error made and a warning message through sound is used to alert the driver. If face is detected, then eyes will also be detected simultaneously. After the eyes are detected the algorithm extracts the eyes and puts both the eyes in grayscale window, from the grayscale window the algorithm counts the number of pixels that are white which indicates the sclera (white part of the eye), and the number of pixels that are black which indicates the Iris. This black and white pixel counts are then used in equations to get a ratio, which indicates the direction at which the driver is looking at. Alongside this, the algorithm also detects whether a person has blinked or not. Now, if the driver makes a left turn, the algorithm analyses the previous data it has processed and searches whether the driver has looked left or not 3 seconds prior to taking the left turn, if the driver has not then the driver will be warned through sound, if the driver has looked left before taking the turn then no error will be recorded, same is done for taking a right turn as well.

```
While camera is on
    Capture Image
    if Face detected
        Detect Eyes
        Draw vertical and horizontal lines on the eyes
        calculate the ratio of horizontal line length/vertial line length
        if length ratio > 4.5
            Blink Detected
        else
            No Blink
        Extract eyes to separate windows
        make the windows grayscale
        break the window in half
        count the pixels that are white
        calculate ratio of white pixels on the left/on the right
        if ratio of white pixels>1.4
            looking direction is left
        else if 0.6<=ratio of white pixels<=1.4
            looking direction is center
        else if ratio of white pixels<0.6
            looking direction is right
        store the looking direction along with time stamp
    if key pressed "A"
        check previously stored 3 seconds of data
        if looking direction is left in has been "left"
            No error made
        else
            error made
    if key pressed "D"
        check previously stored 3 seconds of data
        if looking direction is left in has been "left"
            No error made
        else
            error made
```

Figure 3.4: Pseudo Code of the Algorithm being used

3.3 Image Processing with Algorithm Implementation of the Model

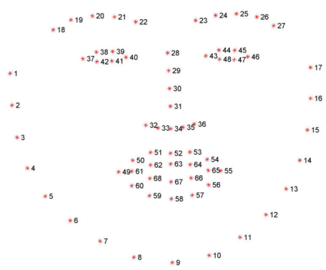

Figure 3.5: Land Marks of the Face

Fig 3.5 shows the landmarks of each component of the face, we use these landmarks to extract the eyes and use them to get certain information. When a person blinks, his/her eye lids close, hence what happens is, considering the left eye, the region enclosed by landmarks 37-42 gets smaller. In order to measure this decrease in area, we draw a vertical line from the mid-point of landmark 38 and 39 to the midpoint of landmark 42 and 41. The length of these lines are calculated. Now, when a person blinks the length of the vertical line changes as the eye lid moves vertically. Hence, the difference in eye area can be measured by monitoring the vertical line length, but the vertical line length changes with distance of the face from the camera. In order to overcome this, a horizontal line is drawn from landmark 37 to landmark 40, and the algorithm measures the length of this line, then calculates the ratio of horizontal line length by vertical line length.

$$Ratio = \frac{Horizontal\ Line\ Length}{Vertical\ Line\ Length} \tag{3.1}$$

This ratio remains almost constant with the change of face distance from the camera, this ratio is calculated for both eyes and then the average ratio is calculated, calculating average decreases any chance of error taking place. At the end, a threshold of 4.5 is set, if ratio is greater than 4.5 the algorithm states the person has blinked, if not the person did not blink.

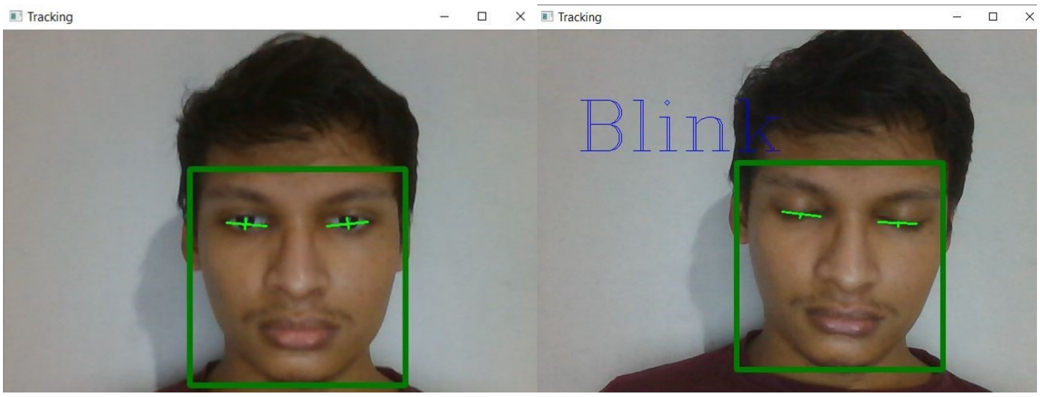

Figure 3.6: Blinking and not blinking

Fig 3.6 shows how the changes in line length shows whether someone is blinking or not. On the next stage, the model detects in which direction the driver is looking through image processing. In order to detect where a person is looking at, the model processes the image to track the iris of the eye. Therefore, the model first separates the eyes from the face and then analyzes them, this is done by using the landmarks as shown in Fig. 2. The model first extracts the eye using the landmarks, for the left eye landmarks 37-42 are used and for the right eye landmarks 43-48 are used. After the eyes have been extracted, they are kept on separate windows. The color of these windows are changed to grayscale, hence the contents within this window are in black or white.

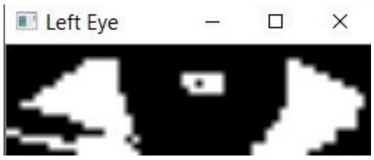

Figure 3.7: Extracted Left Eye in Grayscale

After the model has achieved the figure shown above, it starts to further analyze it. When a person looks left his/her iris moves left, which means the iris at the center of fig. 3.7 will move right of the picture. As a result, the picture will have more black pixels on the right side in comparison to the left side. The model uses this concept of comparison to find where the iris is located at, if a pixel is non-zero it means it is white, and if the pixel is zero it means the pixel is black. Therefore, to compare the right side of the window to the left side, the model first breaks the window in half from the center, and then counts the number of non-zeros(white) there are on each side and calculates the ratio of left side to the right side.

Figure 3.8: Divided Left Eye in Half

As Fig 3.8 shows the left eye is divided into two equal width windows and from these windows, the model calculates the count of non-zeros using image processing and the algorithm uses this count of pixels to calculate the ratio given below.

$$Ratio\ of\ White\ Part = \frac{Count\ of\ white\ pixels\ on\ the\ left\ side}{Count\ of\ white\ pixels\ on\ the\ right\ side} \tag{3.2}$$

The same procedure is repeated for the right eye and Ratio of White Part is calculated for the right eye as well. After the calculation Ratio of White Part of both eyes is complete, average value of Ratio of White Part is calculated to reduce any numerical error, this average value is now used to understand in which direction is the person looking at.

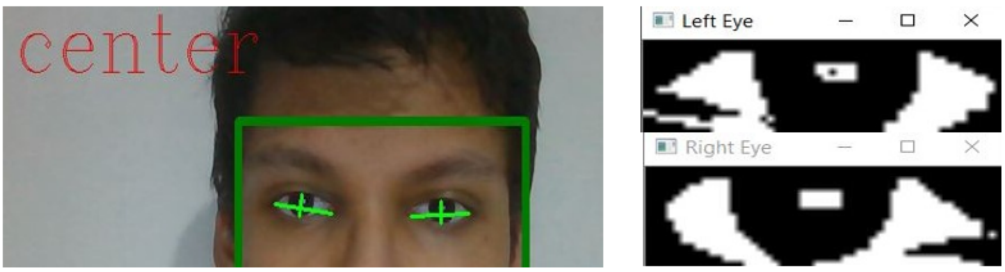

Figure 3.9: Looking at the Center

If the Ratio of White Part is approximately 1, this means the person is looking at the center or is just looking forward. From fig 3.9 it can be seen that the iris of left and right eye are both close to center, the iris of the left eye is a bit towards right and the iris of the right eye is a bit towards left, in order to cancel this small error out the algorithm calculates the average value of the Ratio of White Part of both eyes.

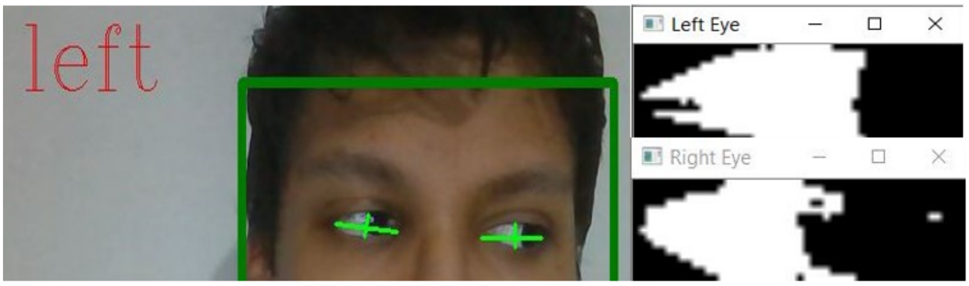

Figure 3.10: Looking Left

If the Ratio of White Part is greater than 1.4, the algorithm detects the driver to be looking left. In fig. 3.10 it can be seen that when the person looks left major part of the right side of the eye images turn black hence the pixel values are zero.

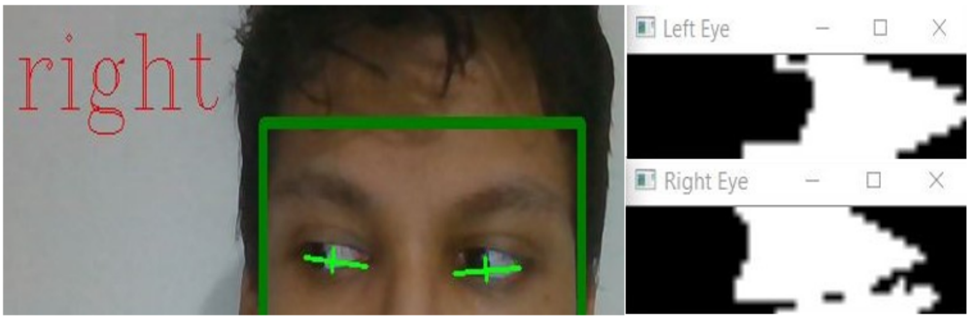

Figure 3.11: Looking Right

If the Ratio of White Part is less than 0.6, the algorithm detects the driver to be looking right. In fig. 3.11 it can be seen when the person looks right major part of the left side of the eye images turn black hence the pixel values are zero. Alongside these data, the algorithm also gets the time at which the frame has been recorded and stores it. Furthermore, to understand in which direction the car is moving, the algorithm takes in keypress of keyboard to understand the car travelling or turning direction. The algorithm can now check for error made during taking a turn, for example if a keypress is made that indicates the car is turning left, the algorithm checks the data collected for the past 3 seconds, if the driver has looked in the left mirror, hence looking direction left within the past 3 seconds the algorithm deduces that the driver did not make any error, whereas if the driver did not check the left mirror, hence did not look left in the past 3 seconds, the algorithm deduces the driver has made an error and this data is stored.

Chapter 4

Data Collection and Reliability Analysis

The data that was collected using the model, was collected in a closed environment with appropriate lighting conditions. The data was collected from five peoples, playing the simulator at two different times, at morning and at night. Among the peoples who volunteered to give data, two were female and three were male.

4.1 Data Collection

In order to collect data, a driving simulator was run and the drivers had to sit in front of the laptop facing the camera. The model was running on the background and continuously recording the drivers face and analyzing each frame one by one. The results of the analyzed frames were stored in an excel sheet. Each driver played the simulator for exactly 15 minutes.

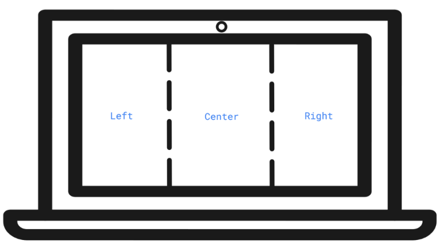

Figure 4.1: Laptop used to collect data and the looking direction

When a driver is playing the simulator, his eye iris position depends on which part of the screen he is looking at, as Fig. 4.1 shows when the driver looks at the part labelled center the looking direction is set as center, when the driver looks at the part labelled right the looking direction is set as right and finally when the driver looks at the part labelled left the looking direction is set as left. The participants for data collection were 5 peoples, 3 male and 2 female, all of them had similar ages. Each participant played the simulator once in the morning for exactly fifteen minutes between 10:00 AM – 11:00 AM and once at night for exactly fifteen minutes between 10:00 PM – 11:00 PM. The participants were given the same route with equal number of left and right turns to drive on.

Drivers	Age	Gender	Iris Color	Any Medical Conditions of the eye
Driver 1	23	Male	Brown	No
Driver 2	25	Male	Brown	No
Driver 3	22	Female	Brown	No
Driver 4	23	Female	Brown	No
Driver 5	24	Male	Brown	No

Table 4.1: Information about the participants

The model works perfectly and stores all the data collected to an excel file. The table shown below is a sample of the data that was collected.

Time	Ratio	Looking Direction	Blinking	Driving Direction	Error
12:51:29	0.837376	center	0	forward	0
12:51:29	0.994464	center	0	forward	0
12:51:29	0.947043	center	0	right	1
12:51:30	0.901694	center	0	forward	0
12:51:30	0.919422	center	0	forward	0
12:51:30	0.832913	center	0	forward	0
12:51:30	0.448768	right	0	forward	0
12:51:30	0.350146	right	0	forward	0
12:51:30	0.334735	right	0	forward	0
12:51:31	0.350329	right	1	right	0
12:51:31	0.438881	right	1	forward	0
12:51:31	1.025249	center	1	forward	0
12:51:31	0.820704	center	0	forward	0
12:51:31	0.786052	center	0	forward	0
12:51:31	0.791323	center	0	forward	0
12:51:31	0.309568	right	0	left	1

Table 4.2: Sample of data set collected from driving simulation

In table 4.2, there are 6 headers, these headers indicate the type of data that are being collected. The first header which is "Time", contains the exact time to seconds at which the particular frame was recorded and analyzed. The second header "Ratio", is the average value of Ratio of White Part of both eyes. The third header "Looking Direction", is the direction the driver is looking at which was derived from the average value of Ratio of White Part of both eyes. The fourth header "Blinking", contains either 0/1, 0 indicates that the driver did not blink and 1 indicates that the driver blinked. The fifth header "Driving Direction", indicates the direction at which the car is moving according to the key-press of the keyboard. The last header "Error", contains either 0/1, which indicates whether the driver has made any error while turning or not, if the value is 0 it indicates no error was made while turning, whereas if the value is 1, it indicates there was an error while turning. The table 4.2 comprises of 3 seconds of data, in which we can see on the third row that an error was made, if we look closely the driver took a right turn but in previous seconds he did not check right. Similarly, the next right turn the driver took no error was made, as the driver checked right before taking the turn. Furthermore, at the very end the driver took a left turn but in the previous 3 seconds he did not check left hence an error occurred which is shown by the value "1" on the error column.

4.2 Data Analysis

The data that was collected were all stored in separate excel files and the analysis was done using these data. The data was collected twice, once in the morning and the other one at night. From these data-sets different analysis are done, to get how safe the drivers are.

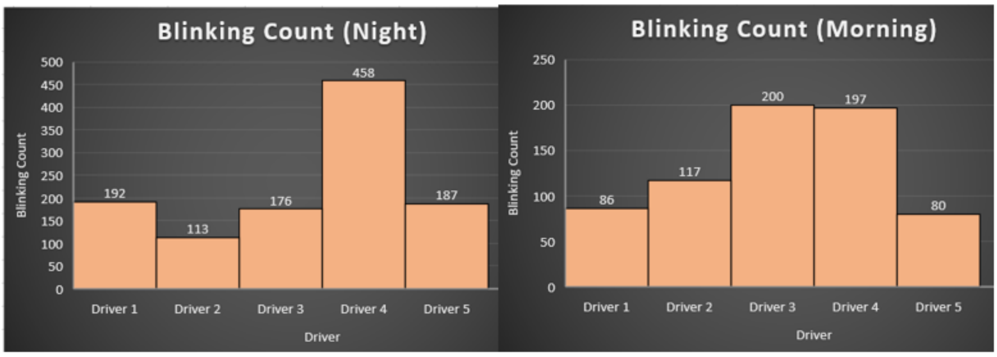

Figure 4.2: Blinking count of the drivers at night and at morning

Fig 4.2 shows the amount of time each driver blinked during the fifteen minute drive at night and at morning. It can clearly be seen that most of the drivers, Driver 1, Driver 4 and Driver 5 had a much higher blinking rate at night in comparison to that in the morning the most likely reason for this is being tired and sleepy, study shows that blinking increases with respect to sleepiness [15]. Whereas, Driver 2 and Driver 3 had almost similar blinking count both at night and at morning.

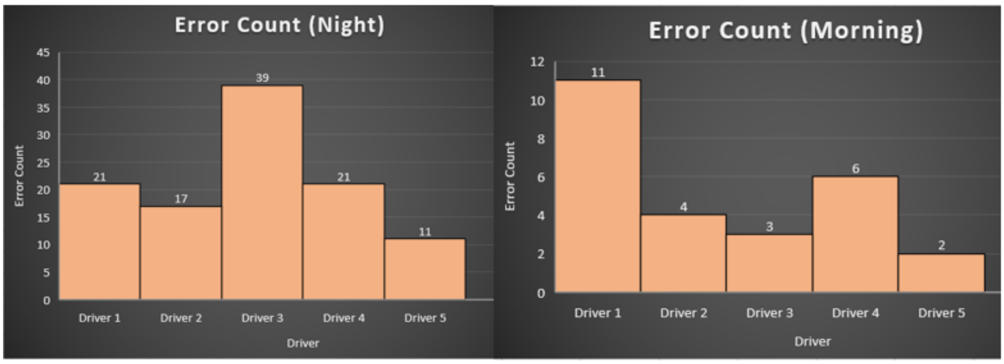

Figure 4.3: Error count of the drivers at night and at morning

Fig 4.3 shows the number of errors the drivers did during the driving time at night and at morning. It can be seen that the drivers committed more errors during the night in comparison to that in the morning, errors are mainly caused due to the lack of focus which is in turn caused by tiredness, and this can be clearly seen that errors at night are greater due to the participants being drowsy.

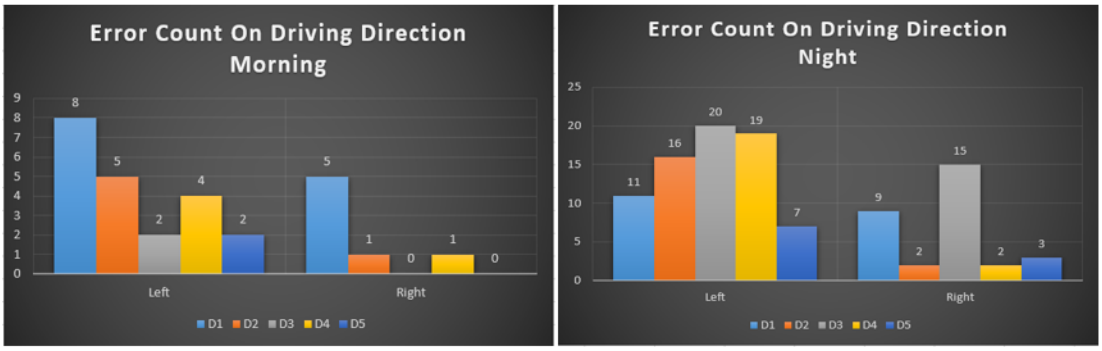

Figure 4.4: Error count with respect to Driving Direction of the drivers at night and at morning

Analysis done on Fig 4.4 shows that, almost all the drivers are more prone to making errors while turning left than that of turning right both at day and night. Only Driver 1 and Driver 3 had similar number of errors while turning left and right. This is a useful information for the drivers to make them aware of the errors they do while taking a turn.

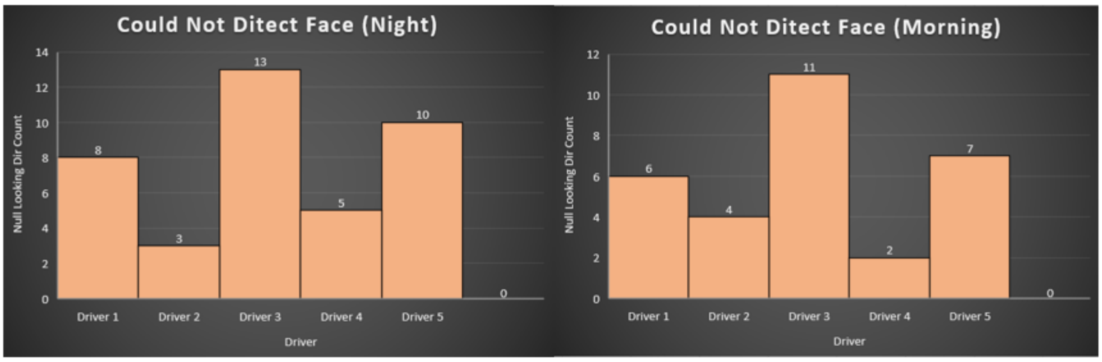

Figure 4.5: Number of times the face could not be detected for more than two seconds

The model detects face only when the driver is looking straightforward, if the driver is looking sideways the Viola-Jones algorithm cannot detect the face. Hence, if a driver does not look straight or is not looking at the road for more than 2 seconds, it shows that the driver is not focused, and from the Fig 4.5 it can clearly be seen that this data is consistent both at night and morning and some of the drivers such as Driver 1, Driver 3 and Driver 5 are very unfocused in comparison to Driver 2 and Driver 4.

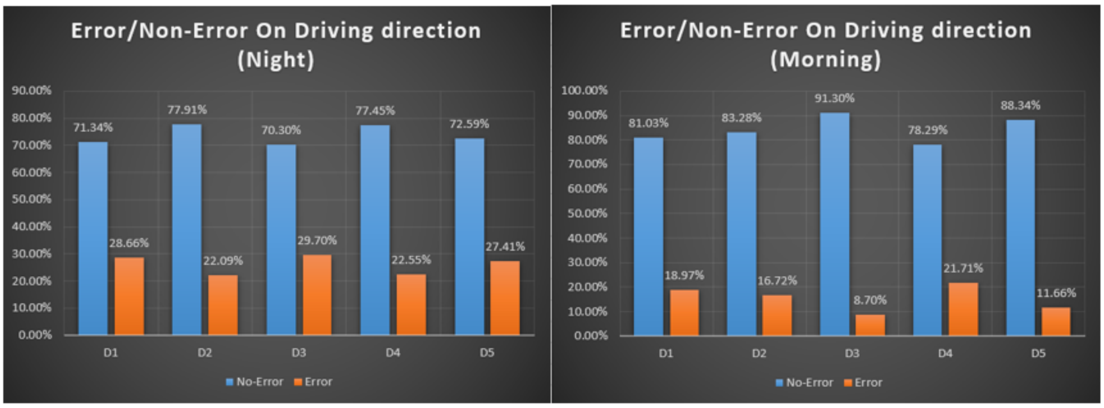

Figure 4.6: Percentage Error and No-error of drivers taking a turn at morning and night

Fig 4.6 shows the percentage of error and no-error each driver is doing during night-time driving and morning driving. It can be clearly seen that all the drivers commit higher number of errors during the night in comparison to that of the day. All drivers perform almost the same at night, but at morning, the most safest driver is Driver 3, with a very low percentage of errors. From the above data analysis, the most conclusive point is that almost all drivers tend to commit more errors and are more unfocused during the night in comparison to the morning, as most of them tend to be tired and sleepy. The most important part is that, these data allow the driver to understand better and be more aware of the mistakes or errors they tend to make unknowingly, for example making more errors while turning left. Hence, it helps the drivers to be more aware of the situation and there driving skills.

4.3 Reliability Analysis

In order to understand whether the model works correctly or not, an analysis of the results need to be done. The analysis is conducted by screen recording on the laptop in the background, which captures the drivers face along with the errors that are made at that specific moment. There are two errors that the model does, firstly if the model records False Blinking (FB), which is the driver did not blink or did blink but the model recorded that the driver has done vice versa, another error is False Looking (FL), which is the driver looked in one direction but the model recorded that the driver was looking at another direction. Similarly, the analysis also needed to record the correct values without any error, which are True Blinking (TB), which means that the driver blinked and the model also recorded that the driver has blinked, and True Looking (TL), which is the driver is looking in one direction and the model recorded the correct direction the driver was looking at. The analysis was conducted on 8 persons and the results are shown below:

Drivers	Looking Direction Center	Looking Direction Right	Looking Direction Left	Blinking detected by model	TL	FL	TB	FB
Driver 1	139	43	66	15	198	50	14	1
Driver 2	133	50	36	20	189	30	18	2
Driver 3	146	33	21	23	156	44	21	2
Driver 4	120	64	51	18	195	40	15	3
Driver 5	131	66	45	19	213	29	16	3
Driver 6	134	47	20	26	153	48	23	3
Driver 7	111	66	62	31	198	41	26	5
Driver 8	160	32	25	25	174	43	21	4

Table 4.3: Real-time eye monitoring Data with TL, Fl, TB, FB

The data of all the 8 drivers were collected in a closed environment with identical and appropriate lighting conditions. From table 4.3, the to total number of TL for all drivers were 1476 and FL was 325. The average percentage of TL and FL can be measured through using these values using the equation:

$$Average\ Percentage\ of\ TL = \frac{1476}{1476 + 325} * 100 \tag{4.1}$$

$$Average\ Percentage\ of\ FL = \frac{325}{1476 + 325} * 100 \tag{4.2}$$

The average percentage of TL is 82% and the average percentage of FL is 18%. This is shown in Fig 4.7.

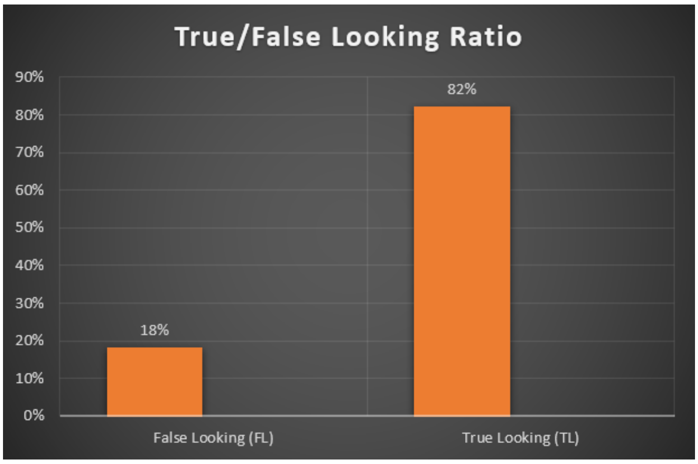

Figure 4.7: Average Percentage of FL and TL

Using the same procedure average percentage of TB and average percentage of FB can be measured, the total number of TB is found to be 154 and the total number of FB is found to be 23.

$$Average\ Percentage\ of\ TB = \frac{154}{154+23} * 100 \tag{4.3}$$

$$Average\ Percentage\ of\ FB = \frac{23}{154+23} * 100 \tag{4.4}$$

The average percentage of TB is 87% and the average percentage of FB is 13%. This is shown in Fig 4.8.

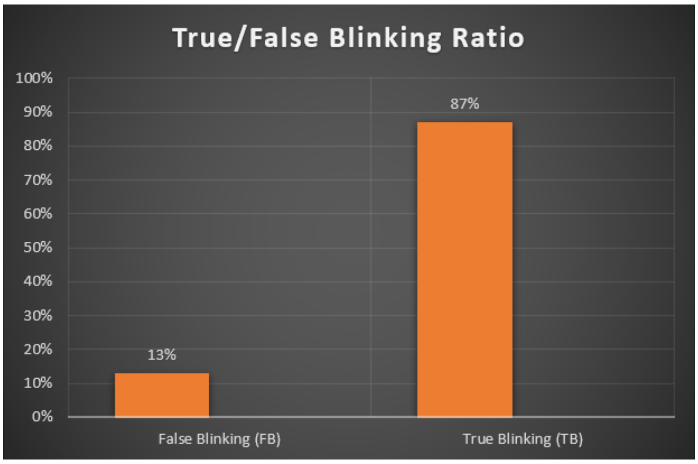

Figure 4.8: Average Percentage of FB and TB

The average percentage of TB, FB, TL and FL indicates that the model works with a very decent accuracy of TB being 87% and TL being 82% this accuracy is directly proportional to the quality of hardware (WebCam) being used. To conclude from the reliability analysis, it can be clearly understood that the model and the algorithms used to create this is greatly accurate and is reliable to be used in real-life scenarios.

Chapter 5

Future Works and Conclusion

The model implemented in this paper have a lot of possibilities for the future to be used in different applications, primarily, to save the drivers on road from accidents by making them aware of their mistakes in real time as well as making them aware of the common mistakes they do and further improve their driving skills. The model implemented in this paper is using a real time data collection and analysis system, which allows it to monitor the drivers eye and make the drivers aware of every turning error the driver makes and can give a detailed analysis of the error the driver does.
Adding to this model there can be many more applications that can be created, as this is a real time data collection model it will be collecting huge data sets that can be used alongside machine leaning algorithms to make the model learn about the errors that the drivers are prone to make and make drivers aware in real-time prior to the error even taking place. Moreover, using machine learning a feature can also be implemented that uses the data of blinking and learns about the persons blinking rate and understand whether a person is about to fall asleep or not, hence reducing the likeliness of the driver falling asleep behind the wheels. The model can also be used for helping drivers in driving schools to understand their mistakes better or even using it on driving tests, as this model will be reducing the human errors that are incorporated in driving tests and also the model will be storing the entire data, so the data can be analyzed to see the driver's actions in certain scenarios and also understand how safe the drivers are from the percentage of errors the driver makes. Alongside using it in driving tests, this model can also be used under private corporations who provide ride sharing services as a review system for the drivers, which will show how safe the drivers are and how much errors they make while driving, the implementation of this model in ride sharing platforms not just ensures safety by warning the drivers of the errors they make but also motivates them for being more careful while driving.
To conclude, there are limitless applications where this model can be implemented and used for ensuring safety of not just the drivers but also everyone on the road. It is a model that concentrates on the prevention of an accident through making the drivers aware of their own state by warning them about their mistakes on real time and also showing them through data collection and analysis the mistakes they are more prone to make and hence, making them better understand and improve their driving skills.

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