DROWSINESS DETECTION USING PYTHON

TABLE OF CONTENTS

ABSTRACT

Driver fatigue is one of the major causes of accidents in the world. Detecting the drowsiness of the driver is one of the surest ways of measuring driver fatigue. In this project we aim to develop a prototype drowsiness detection system. This system works by monitoring the eyes of the driver and sounding an alarm when he/she is drowsy. The system so designed is a non-intrusive real-time monitoring system. The priority is on improving the safety of the driver without being obtrusive. In this project the eye blink of the driver is detected. If the driver's eyes remain closed for more than a certain period of time, the driver is said to be drowsy and an alarm is sounded. The programming for this is done in OpenCV using the Haar Cascade library for the detection of facial features.

ACKNOWLEDGEMENT

We gratefully acknowledge with heartfelt thanks to the **Osmania University** to carry out the project **in the field of Computer Science** under the academic program of B.Sc. (Mathematics, Electronics and Computer Sciences)**.**

We express our sincere thanks to **Mr. J. Mathew George,** Principal, St. Mary's College, Yousufguda, Hyderabad, for his encouragement and for providing facilities for carrying out the project.

We convey our gratitude to **Ms. Jaimole Cross**, Vice Principal and Head, Department of Sciences, St. Mary's College, Yousufguda, Hyderabad, for her guidance, motivation and encouragement.

We express our deep sense of gratitude and profound thanks to our respected guide, **M**r. **J.Vidya Sagar**, Lecturer in Computer Science, Department of Sciences, St. Mary's College, Yousufguda, Hyderabad, for his guidance, amicable suggestions, constant encouragement and generous assistance given throughout the project.

We extend our sincere thanks to all the faculty members of th**e** Department of Sciences, St. Mary's College, Yousufguda, Hyderabad. We also express our sincere thanks to lab in-charges for their valuable help throughout the course of work.

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LIST OF FIGURES

LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
MIROS	Malaysia Institute Of Road Safety
ROI	Region Of Interest
LBPH	Local Binary Patterns Histogram
SVM	Support Vector Machine
CHT	Circular Hough Transform
ApEn	Approximate Entropy
SWA	Steering Wheel Angles
YA	Yaw Angles
BP	Back Propagation
EEG	Electroencephalogram
PPG	Photoplethysmography
ROC	Receiver Operating Curve
FFT	Fast Fourier Transfer
LF/HF	Low Frequency to High Frequency
USB	Universal Serial Bus
PSB	Power Spectral Density
IPP	Integrated Performance Primitives
ECG	Electrocardiography
GPL	General Public Licence
HRV	Heart Rate Variability
MLL	Machine Learning Library

1. INTRODUCTION

Drowsiness is a state of near sleep, where the person has a strong desire for sleep. It has two distinct meanings, referring both to the usual state preceding falling asleep and the chronic condition referring to being in that state independent of a daily rhythm [16]. Sleepiness can be dangerous when performing tasks that require constant concentration, such as driving a vehicle. When a person is sufficiently fatigue while driving, they will experience drowsiness and this leads to increase the factor of road accident.

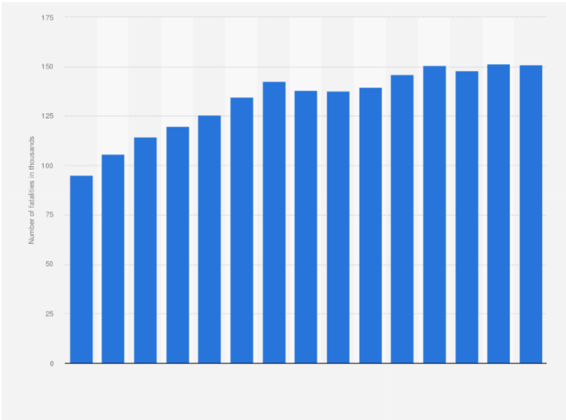

Figure 1.1: Statistic of Road Accident from 2020 to 2022

Figure 1 shows the statistics of road accidents in Malaysia from the year 2005 to 2009 provided by MIROS (Malaysia Institute of Road Safety). The numbers of vehicles involved in road accidents keep increasing each year. From Figure 1, car and taxi type of vehicles shows about nearly 400,000 cases of road accident has been recorded. It keeps increasing every year and by the year 2009, it shows the number of road accident were recorded by MIROS are nearly 500,000.

Figure 2 shows the difference between fatigue and drowsiness condition.

Figure 1.2: Examples of Fatigue & Drowsiness Condition

The development of technologies for detecting or preventing drowsiness while driving is a major challenge in the field of accident avoidance system. Because of the hazard that drowsiness presents on the road, methods need to be developed for counteracting its affects. The aim of this project is to develop a simulation of drowsiness detection system. The focus will be placed on designing a system that will accurately monitor the open or closed state of the driver's eyes and mouth. By monitoring the eyes, it is believed that the symptoms of driver's drowsiness can be detected in sufficiently early stage, to avoid a car accident. Yawning detection is a method to assess the driver's fatigue. When a person is fatigue, they keep yawning to ensure that there is enough oxygen for the brain consumption before going to drowsiness state. Detection of fatigue and drowsiness involves a sequence of images of a face, and the observation of eyes and mouth open or closed duration. Another method to detect eye closure is PERCLOS. This detection method is based on the time of eyes closed which refers to percentage of a specific time. The analysis of face images is a popular research area with applications such as face recognition, and human identification and tracking for security systems. This project is focused on the localization of the eyes and mouth, which involves looking at the entire image of the face, and determining the position of the eyes and mouth, by applying the existing methods in the image processing algorithm. Once the position of the eyes is located, the system is designed to determine whether the eyes and mouth are opened or closed, and detect fatigue and drowsiness.

2. LITERATURE SURVEY

In computer science, image processing is the use of computer algorithms to perform image processing on images. As a subcategory or field of digital signal processing, image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the buildup of noise and signal distortion during processing. Since images are defined over two dimensions digital image processing may be modelled in the form of multidimensional system.

2.1 DROWSINESS DETECTION THROUGH REGION OF INTEREST

Region of interest (ROI) can detect a driver's face. As can be seen in the blue rectangle is the region of interest. The way to create an ROI area is to first obtain the green rectangle area from the Haar Cascade Classifier in the first frame, which includes height, width. Then, the rectangle is scaled up to create region of interest. There are several steps to calculate the ROI area and we have to calculate ROI for each and every region of interest.

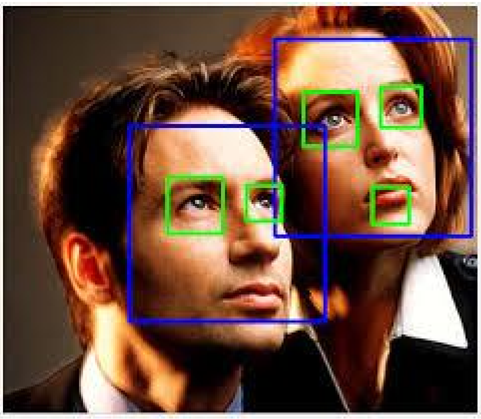

Fig 2.1 Region of Interest

DISADVANTAGES OF REGION OF INTEREST

1. It is uses extra frames or squares to detect face detection.
2. It can't find in low light.
3. Why to use again region of interest while Haar cascade classifier can do the same process?
4. It can't detect while using glasses in driving.

2.2 DETECTION OF DROWSINESS THROUGH LBPH

In this algorithm the faces are detected by using local binary patterns histograms (LBPH). The first computational step in lbph is to create an intermediate images that describes the original image in a binary format. The image is converted into matrix form and we need to take a central value of the matrix to be used as and threshold value. This value is used to define neighbouring values which can be set to to either 0 or 1. The values which are 1 in the matrix form are to be considered and the remaining values are discarded. The values represent each pixel. Through this the region of face can be detected.

DISADVANTAGES OF LBHP

1. It produces less urate results
2. The computational time is high.
3. This will work only if the data samples are less.

2.3 BEHAVIOURAL BASED TECHNIQUES

The different techniques used in behavioural based parameters are:

2.3.1. EYE TRACKING AND DYNAMIC TEMPLATE MATCHING

To avoid road accidents, real time driver fatigue detection system based on vision is proposed. Firstly, system detects the face of driver from the input images using HSI color model. Secondly, Sobel edge operator is used to locate the eyes positions and gets the images of eye as the dynamic template for the tracking of eye. Then the obtained images are converted to HSI colour model to decide that whether the eyes are close or open to judge the drowsiness of driver. The experiments use four test videos for the tracking of eyes and face detection. The proposed system is compared with the labelled data which is annotated by the experts. The average correct rate of proposed system reaches up to 99.01 % and the precision to 88.90 %.

2.3.2. MOUTH AND YAWNING ANALYSIS

Fatigue is the major reason for road accidents. To avoid the issue, Sarada Devi and Bajaj proposed the driver fatigue detection system based on mouth and yawning analysis. Firstly, the system locates and tracks the mouth of a driver using cascade of classifier training and mouth detection from the input images. Then, the images of mouth and yawning are trained using SVM. In the end, SVM is used to classify the regions of mouth to detects the yawning and alerts the fatigue. For experiment, authors collect some videos and select 20 yawning images and more than 100 normal videos as dataset. The results show that the proposed system gives better results as compared to the system using geometric features. The proposed system detects yawning, alerts the fatigue earlier and facilitates to make the driver safe.

2.3.3. FACIAL EXPRESSIONS METHOD

Laboratory condition using Finite Element Analysis is used by the researchers which is a complex system that contains the database of facial expression as a template and detect the drowsiness on the basis of results from database. Similarly, Assari and Rahmati present the hardware-based Driver Drowsiness Detection system based on facial expressions. The hardware system uses infrared light as it has giving many benefits like ease of use, independent of lightning conditions of environment. The system firstly uses the technique of background subtraction to determines the face region from the input images. Then using horizontal projection and template matching, facial expressions are obtained. After that in the tracking phase, elements found earlier are followed up using template matching and then investigates the incidence of sleepiness using the determination of facial states from the changes of the facial components. Changing in the three main elements such as eye brow rising, yawning and eye closure for the certain period are taken as the initial indications for drowsiness and the system generates the alert. The experiment is performed in the real driving scenario. For testing, images are acquired by the webcam under different conditions of lighting and from different people. The results investigate that the system produces appropriate response in the presence of beard or glasses and mustache on the face of driver.

2.3.4. YAWNING EXTRACTION METHOD

Fatigue or drowsiness is the major reason for road accidents. To prevent the issue, Alioua proposed the efficient system for monitoring the driver fatigue using Yawning extraction. Firstly, face region is obtained from the images using Support Vector Machine (SVM) technique to reduce the edge required cost. The proposed method is used to localize the mouth, detection technique is used to detects facial edges, then compute vertical projection on the lower half face to detect the right and left region boundaries and then compute the horizontal projection on the resulting region to detect the upper and lower limit of mouth and mouth localized region is obtained. Finally, to detect the yawning, Circular Hough Transform (CHT) is executed on the images of mouth region to identify the wide-open mouth. If the system finds notable number of continuous frames where the mouth is widely open, system generates the alert. The results are compared with the other edge detectors like Sobel, Prewitt, Roberts, Canny. The experiment uses 6 videos representing real driving conditions and results are presented in the form of confusion matrix. The proposed method achieves 98% accuracy and outperforms all other edge detection techniques.

2.3.5. EYE CLOSURE AND HEAD POSTURES METHOD

Teyeb proposed the Drowsy Driver Detection using Eye Closure and Head postures. Firstly, video is captured using webcam and for each frame of video, following operations are performed. To detect the ROI (face and eyes), viola-jones method is used. The face is partitioned in to three areas and the top one presenting the aye area is browsed by the Haar classifier. Then to detect the eye state, Wavelet Network based on neural network is used to train the images then the coefficients learning images is compared with the coefficients of the testing images and tells which class it belongs. When the closed eye is identified in the frames then the eye closure duration is calculated, if the value exceeds the predefined time then the drowsiness state is detected. Then the developed system estimates the head movements which are: left, right, forward, backward inclination and left or right rotation. The captured video is segmented into frames and extract the images of head and determines the coordinates of image. Then the images are compared to determine the inclined state of head and same case with other head postures. Finally, the system combines the eye closure duration and head posture estimation to measure the drowsiness. To evaluate the system, experiment is performed on 10 volunteers in various situations. And results show that the systems achieve the accuracy of 80%.

2.3.6. REAL TIME ANALYSIS USING EYE AND YAWNING

Kumar proposed the real time analysis of Driver Fatigue Detection using behavioural measures and gestures like eye blink, head movement and yawning to identify the drivers' state.

The basic purpose of the proposed method is to detect the close eye and open mouth simultaneously and generates an alarm on positive detection. The system firstly captures the real time video using the camera mounted in front of the driver. Then the frames of captured video are used to detect the face and eyes by applying the viola-jones method, with the training set of face and eyes provided in OpenCV. Small rectangle is drawn around the centre of eye and matrix is created that shows that the Region of Interest (ROI) that is eyes used in the next step. Since the both eyes blink at the same time that's why only the right eye is examined to detect the close eye state. If the eye is closed for certain amount of time it will be considered as closed eye. To determine the eye state, firstly the eye ball colour is acquired by sampling the RGB components on the centre of eye pixel. Then the absolute thresholding is done on the eye ROI based on eye ball colour and intensity map is obtained on Y-axis that show the distribution of pixels on y-axis which gives the height of eye ball and compared that value with threshold value which is 4 to distinguish the open and close eye. After that, if the eye blink is detected in each frame it will be considered as 1 and stored in the buffer and after the 100 frames, eye blinking rate is calculated. Then to detect the yawning motion of the mouth, contour finding algorithm is used to measure the size of mouth. If the height is greater than the certain threshold. It means person is taking yawning. To evaluate the performance of the proposed system, system has been measured under different conditions like persons with glasses, without glasses, with moustache and without moustache for 20 days in different timings. The system performs best when the drivers are without glasses.

2.3.7. EYE BLINK DETECTION METHOD

Ahmad and Borolie proposed the Driver Drowsiness System based on non-intrusive machine-based concepts. The system consists of a web camera which is placed in front of the driver. Online videos as well as saved videos for simulation purposed are considered. Firstly, camera records the facial expressions and head movements of the driver. Then the video is converted into frames and each frame is processed one by one. Face is detected from frames using Viola-jones algorithm. Then the required features like eyes, mouth and head from face are extracted using cascade classifier. Region of interest on face is indicated by rectangles. Here the main attribute of detecting drowsiness is eyes blinking, varies from 12 to19 per minute normally and indicates the drowsiness if the frequency is less than the normal range. Instead of calculating eye blinking, average drowsiness is calculated. The detected eye is equivalent to zero (closed eye) and non-zero values are indicated as partially or fully open eyes. The equation (2) is used to calculate the average.

%d = No. of closed eyes found / no. of frames ------ Eq: (2)

If the value is more than the set threshold value, then system generates the alarm to alert the driver. Moreover, yawning is also considered to generate the alert. Online and offline are videos are used for experiments which are performed on two different systems. The results show that the system achieves the efficiency of up to 90%.

2.3.8. EYE CLOSENESS DETECTION METHOD

Khunpisuth creates an experiment the calculates the drowsiness level of driver using Raspberry Pi camera and Raspberry Pi 3 model B. Firstly Pi camera captures video and to detect face regions in the images, Haar cascade classifier from Viola-Jones method is used. Several images are trained in different lights. The percentage of 83.09 % is achieved based on the case study with 10 volunteers. Blue rectangle shows the Region of Interest (ROI) that is face. Again, Haar cascade classifier is applied on the last obtained frame which reduces the size ofROI. After The face detection, drowsiness level is calculated using eye blink rate. Eye region is detected using template matching on the face and authors uses three templates to check the eye blink and aye area. CV_TM_CCOEFF_NORMED from OpenCV is considered as it gives improved results than other methods of template matching. The integration of eyes and face detection permits the checking of an eye blinking and closeness rate. If the eyes are closed, then the value of closed eye is higher than the open the eyes and opposite case if eyes are open. Authors assumed that Haar cascade classifier will work if the face is front facing position. That why authors proposed the method to rotate the tilted face back in to the front-facing position. Firstly, determines whether the head is tilt or not then calculates the degrees of rotation (angle). After the accurate detection of face and eyes, drowsiness level of driver is determined. If the drivers blink eyes too frequently, he system indicates he drowsiness. When the level reaches to one hundred, a loud sound will be generated to alert the driver. The proposed method is compared with Haar cascade and results shows that the proposed method achieves the accuracy of 99.59 %.It works in all lighting conditions and able to detect the face wearing glasses.

2.4 VEHICULAR PARAMETER-BASED TECHNIQUES

2.4.1. REAL TIME LANE DETECTION SYSTEM

Road accidents have become common in the present era, causing the severe damage to the property and also to the lives of people travelling. There are many reasons of road accidents like: rash driving, inexperience, ignoring signboards, jumping signal etc. To address the issues, Katyal et al. proposed the Drivers' Drowsiness Detection system. The system works in two phases: firstly, detectslane based on Hough transform. Secondly, detects the drivers' eyes to detect the drowsiness. For eye detection, firstly use viola jones method to detect face, then do the image segmentation, after that otsu thresholding is done and canny edge detection is applied. The obtained results is integrated with the circle detection hough transform method to detect eyes to detect the fatigue level. It will also work in low lightning conditions. Result shows that the proposed system is useful for the drivers travelling on lengthy routes, driving late night, drivers who drink and drive.

2.4.2. TIME SERIES ANALYSIS OF STEERING WHEEL ANGULAR VELOCITY

To avoid the road accidents, Zhenhai proposed the Driver Drowsiness Detection method using time series analysis of steering wheel angular velocity. The method firstly analyses the behaviour of steering below the fatigue, then temporal detection window is used as the detection feature to determine the angular velocity of steering wheel during time-series. In the temporal window, if the detection feature satisfies the variability constraints and extent constraints, then the state of drowsiness is detected accordingly. The experiment based on real testers is performed, and results shows that the proposed method outperforms the previous methods and useful in the real world.

2.4.3. STEERING WHEEL ANGLE FOR REAL DRIVING CONDITIONS FOR DDT

To avoid road accidents, Li proposed the online detection of Drowsiness Detection System to monitor the fatigue level of drivers under real conditions using Steering Wheel Angles (SWA). The data of SWA is collected from the sensors attached on the steering lever. The system firstly extracts the features of Approximate Entropy (ApEn) from fixed sliding windows on time series of real time steering wheel angles, then the system linearizes the features of ApEn using the deviation of adaptive linear piecewise fitting method. After that the system calculates the warping distance between the series of linear features of sample data. Finally, system determine the drowsiness state of drivers using warping distance according to the designed decision classifier. The empirical analysis uses the data collected in 14.68 hrs. driving under real road conditions and evaluated on two fatigue levels: drowsy and awake. Results show that the proposed sys- tem is capable for working online with an accuracy of 78.01 % and useful for the prevention of road accidents caused by drivers' fatigue.

2.4.4. AUTOMATIC DETECTION OFDRIVER FATIGUE

To address the issue of drivers' fatigue, an online detection of drivers' fatigue using the Steering Wheel Angles (SWA) and Yaw Angles (YA) information in the real driving conditions is proposed. The system firstly investigates the operation features of SWA and YA in the different states of fatigue, after that calculates the ApEn features on time series of shot sliding window, then using the dynamic time series of non-linear feature construction theory and taking features of fatigue as input, designs a 2-6-6-3 multi-level Back Propagation (BP) neural network classifier to deter- mine the fatigue detection. For empirical analysis, 15 hours long experiment is performed in real road conditions. The experts evaluated the retrieved data and categorized in three levels of fatigue: drowsy, very drowsy, and awake. And the experiment achieves the average accuracy of 88.02% in fatigue detection and valuable for the engineering applications.

2.5 DROWSINESS DETECTION THROUGH PHYSIOLOGICAL APPROACH

Physiological measures have much of the time been utilized for drowsiness discovery as they can give an immediate and objective measure. Conceivable measures are EEG, eyelid closure, movements of eye, heart rate, size of pupil, skin conductance and creation of the cortical. Among these procedures, the systems that are best, in light of precision are the ones in view of physiological experience of human. There are two ways for implementing this procedure. Measurement of changes in physiological signs for example, waves of human brain, blinking of eyes and heart rate; and physical changes measurement for example, drooping stance, leaning of the head of driver and the open/close conditions of the eyes.

2.5.1. EEG-BASED DRIVER FATIGUE DETECTION

EEG is a technique for measuring the electrical action created by the nerve cells of the human brain, basically the cortical movement. The EEGaction is available all the time and recording show both arbitrary and periodic behaviour. The fundamental inception of the EEG is the neuronal action in the cerebral cortex; however some action like wise starts from the thalamus and from subcritical parts of the human brain. The EEG speaks to the summation of excitatory and inhibitory postsynaptic possibilities in the nerve cells. The musical movement is because of the synchronous actuation of the nerve cells. The drivers' fatigue detection system using Electroencephalogram (EEG) signals is proposed to avoid the road accidents usually caused due to drivers' fatigue. The proposed method firstly finds the index related to different drowsiness levels. The system takes EEG signal as input which is calculated by a cheap single electrode neuro signal acquisition device. To evaluate the proposed method, data set for simulated car driver under the different levels of drowsiness is collected locally. And result shows that the proposed system can detect all subjects of tiredness.

DISADVANTAGES

1. High cost
2. Sensors Required
3. Can't see behind objects
4. Takes longer time

2.5.2. WAVELET ANALYSIS OF HEART RATE VARIABILITY & SVM CLASSIFIER

Li and Chung proposed the driver drowsiness detection that uses wavelet analysis of Heart Rate Variability (HRV) and Support Vector Machine (SVM) classifier. The basic purpose is to categorise the alert and drowsy drivers using the wavelet transform of HRV signals over short durations. The system firstly takes Photo PlethysmoGraphy (PPG) signal as input and divide it into 1- minute intervals and then verify two driving events using average percentage of eyelid closure over pupil over time (PERCLOS) measurement over the interval. Secondly, the system performs the feature extraction of HRV time series based on Fast Fourier Trans- form (FFT) and wavelet. A Receiver Operation Curve (ROC) and SVM classifier is used for feature extraction and classification respectively. The analysis of ROC shows that the wavelet-based method gives improved results than the FFT-based method. Finally, the real time requirements for drowsiness detection, FFT and wavelet features are used to train the SVM classifier extracted from the HRV signals. The performance of classification using the wavelet-based features achieve the accuracy of 95%, sensitivity to 95% and specificity to 95%. The FFT-based results achieve the accuracy of 68.85. The results show that wavelet-based methods perform better than the FFT-based methods.

2.5.3. PULSE SENSOR METHOD

Mostly, previous studies focus on the physical conditions of drivers to detect drowsiness. That’s why Rahim detects the drowsy drivers using infrared heart-rate sensors or pulse sensors. The pulse sensor measures the heart pulse rate from drivers’ finger or hand. The sensor is attached with the finger or hand, detects the amount of blood flowing through the finger. Then amount of the blood’s oxygen is shown in the finger, which causes the infrared light to reflect off and to the transmitter. The sensor picks up the fluctuation of oxygen that are connected to the Arduino as microcontroller. Then, the heart pulse rate is visualizing by the software processing of HRV frequency domain. Experimental results show that LF/HF (Low to high frequency) ratio decreases as drivers go from the state of being awake to the drowsy and many road accidents can be avoided if an alert is sent on time.

2.5.4. WEARABLE DRIVER DROWSINESS DETECTION SYSTEM

Mobile based applications have been developed to detect the drowsiness of drivers. But mobile phones distract the drivers' attention and may cause accident. To address the issue, Leng proposed the wearable-type drowsiness detection system. The system uses self-designed wrist band consists of PPG signal and galvanic skin response sensor. The data collected from the sensors are delivered to the mobile device which acts as the main evaluating unit. The collected data are examined with the motion sensors that are built-in in the mobiles. Then five features are extracted from the data: heart rate, respiratory rate, stress level, pulse rate variability, and adjustment counter. The features are moreover used as the computation parameters to the SVM classifier to determine the drowsiness state. The experimental results show that the accuracy of the proposed system reaches up to 98.02 %. Mobile phone generates graphical and vibrational alarm to alert the driver.

2.5.5. WIRELESS WEARABLE METHOD

To avoid the disastrous road accidents, Warwick proposed the idea for drowsiness detection system using wearable Bio sensor called Bioharness. The system has two phases. In the first phase, the physiological data of driver is collected using bio-harness and then analyses the data to find the key parameters like ECG, heart rate, posture and others related to the drowsiness. In the second phase, drowsiness detection algorithm will be designed and develop a mobile app to alert the drowsy drivers.

2.5.6. DRIVER FATIGUE DETECTION SYSTEM

Chellappa presents the Driver fatigue detection system. The basic of the system is to detect the drowsiness when the vehicle is in the motion. The system has three components: external hardware (sensors and camera), data processing module and alert unit. Hardware unit communicates over the USB port with the rest of the system. Physio- logical and physical factors like pulse rate, yawning, closed eyes, blink duration and others are continuously monitored using somatic sensor. The processing module uses the combi- nation of the factors to detect drowsiness. In the end, alert unit alerts the driver at multiple stages according to the severity of the symptoms.

2.5.7. HYBRID APPROACH UTILISING PHYSIOLOGICAL FEATURES

To improve the performance of detection, Awais proposed the hybrid method which integrates the features of ECG and EEG. The method firstly extracts the time and frequency domain features like time domain statistical descriptors, complexity measures and power spectral measures from EEG. Then using ECG, features like heart rate, HRV, low frequency, high frequency and LF/HF ratio. After that, subjective sleepiness is measured to study its relationship with drowsiness. To select only statistically significant features, t-tests is used that can differentiate between the drowsy and alert. The features extracted from ECG and EEG are integrated to study the improvements in the performance using SVM. The other main contribution is to study the channel reduction and its impact on the performance of detection. The method measures the differences between the drowsy and alert state from physiological data collected from the driving simulated-based study. Monotonous driving environment is used to induce the drowsiness in the participants. The pro- posed method demonstrated that combining ECG and EEG improves the performance of system in differentiating the drowsy and alert states, instead of using them alone. The analysis of channel reduction confirms that the accuracy level reaches to 80% by just combining the ECG and EEG. The performance of the system indicates that the proposed system is feasible for practical drowsiness detection system.

2.6 OTHER METHODOLOGIES

Every year a large number of deaths occur due to fatigue related road accidents. According to study around 20% accidents are occurring yearly with an average of 90 deaths per day due to drowsiness. Drivers who drive continuously will have a chance of getting tiredness. Hence detection of drivers drowsiness and its indication can significantly decrease number of accidents. To decrease these type of accidents some image processing techniques like viola jones, Adaboost, haar cascade, gobar features, facial land mark detection . The following are some of the methodologies for detecting the drowsiness M.A. Assari & M. Rahmati proposed a system in which the drowsiness of the driver is detected by detecting the face through horizontal projection on the image and tracking the face components via template matching technique which comprised of eyebrows and eyes along with mouth. The proposed method has been implemented in simulation environment of MATLAB (Simulink). Addition of the IR lighting as sources of light helped in better detection of faces in this system. Tianyi Hong presented a system which used face-detection method basing on the cascade of classifiers trained through Adaboost technique. Optimization in this system is performed by applying the integral image of the original image to develop a canny filter for cascade processing and improve the performance. Integrated performance primitives(IPP) have been used for better and faster computational results. This system is validated in GENE-8310 embedded platform. B. Warwick proposed a system that is based on physiological approach in which the driver wears a wireless biosensor called BioHarness, a wearable device capable of collecting the physiological data and then transmitting to a smartphone. This data is then analysed through Fast Fourier Transform (FFT) and Power Spectral Density (PSD) which provide the desired vectored inputs that can be fed into a Neural Network. This system is run on a drowsiness detection mobile app by the researchers. K. Dwivedi developed a system which identifies drowsiness of the driver using representational learning. A Haar-like face detector feeds the images to a 2-layer convolutional neural network for extracted features which are then used to train a softmax layer classifier for detecting whether a driver is drowsy or not drowsy. This system was able to yield a satisfactory result of 78% accuracy in detecting the drowsiness and alerting the driver. J.J. Yan developed a system in which the images captured are converted into grayscale using the Sobel operator for edge detection. The position of the eyes are calculated using template matching. To determine the states of the eyes, the binarization and quick sort techniques are used which also confirm the distribution of the black pixels in the grayscale image. In this study, P80 is taken as the important criterion of the driver's physical state. If the amount of black pixels is lower than this threshold value then it is considered as the driver in drowsy state.

2.7 EXISTING SYSTEM

The current drowsiness detection systems include the usage of the devices that detect the respiration rate, heart rate, blood pressure, etc. These devices can cause the driver to be uncomfortable for driving. Cannot be assured that the drivers wear these devices all the time while driving. May get lost or improper functioning which may lead to low accuracy in the result. The existing system does not produce good results in low light conditions. If the light conditions are dark or too low it is unable to detect the face and eyes of the driver which results in lower accuracy.

3. PROBLEM STATEMENT

Current drowsiness detection systems monitoring the driver's condition requires complex computation and expensive equipment, not comfortable to wear during driving and is not suitable for driving conditions; for example, Electroencephalography (EEG) and Electrocardiography (ECG), i. e. detecting the brain frequency and measuring the rhythm of heart, respectively. A drowsiness detection system which use a camera placed in front of the driver is more suitable to be use but the physical signs that will indicate drowsiness need to be located first in order to come up with a drowsiness detection algorithm that is reliable and accurate. Lighting intensity and while the driver tilt their face left or right are the problems occur during detection of eyes and mouth region. Therefore, this project aims to analyze all the previous research and method, hence propose a method to detect drowsiness by using video or webcam. It analyzes the video images that have been recorded and come up with a system that can analyze each frame of the video.

4. OBJECTIVES

The project focuses on these objectives, which are:

- To suggest ways to detect fatigue and drowsiness while driving.
- To study on eyes and mouth from the video images of participants in the experiment of driving simulation conducted by MIROS that can be used as an indicator of fatigue and drowsiness.
- To investigate the physical changes of fatigue and drowsiness.
- To develop a system that use eyes closure and yawning as a way to detect fatigue and drowsiness.

5. METHODOLOGY

5.1 PROPOSED SYSTEM

5.1.1 ARCHITECTURE

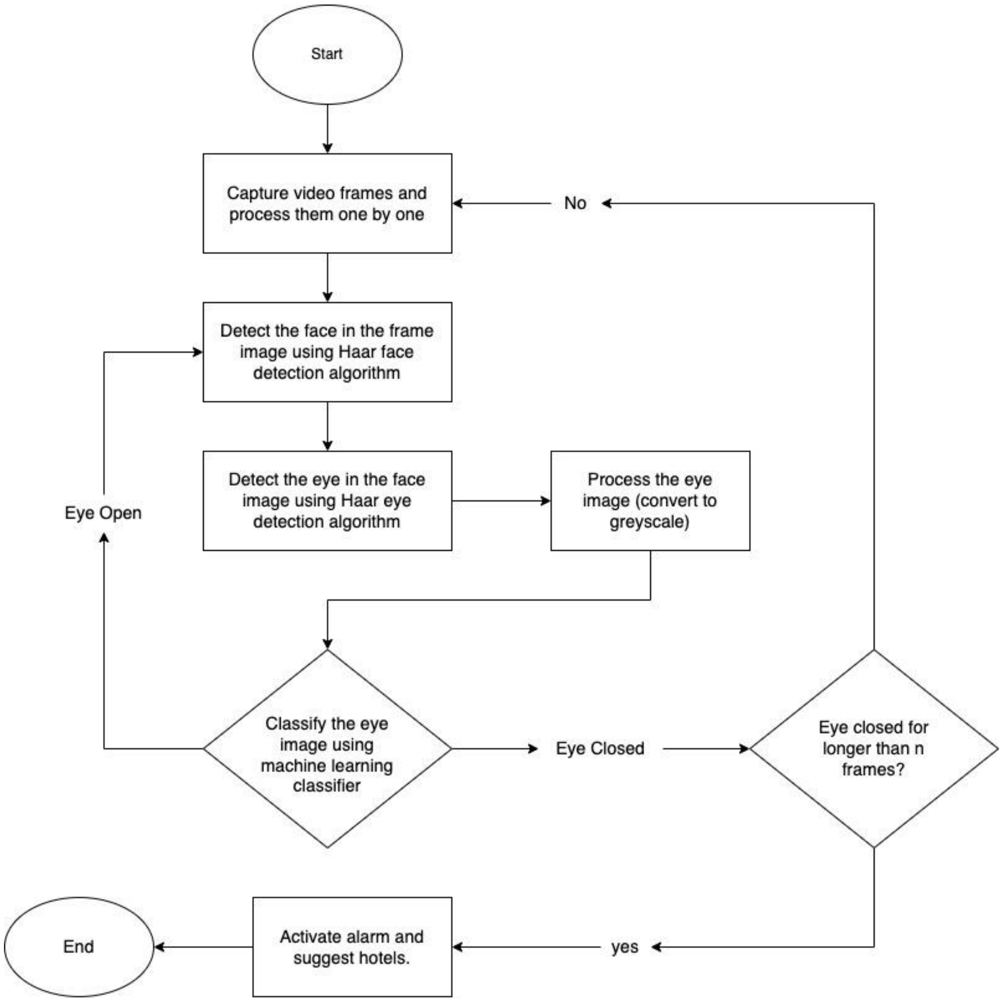

Fig 5.1 Architecture of the driver drowsiness detection system

This is the architecture for detecting the drowsiness of the driver. First of all the system captures images through the webcam and after capturing it detects the face through haar cascade algorithm. It uses haar features which can detect the face. If the system founds it as face the it will proceed for next phase i.e eye detection. The eye is also detected using haar cascade features and it is used for blink frequency. The state of eye will be detected using perclos algorithm. Through this algorithm we can find the percentage of time the eye lids remains closed. If it found eyes in closed state then it detects driver in drowsy state and alerts him by an alarm. In some cases distraction can be measured by continuous gazing. The drivers face is analysed continuously to detect any distraction. If found then alarm is activated by the system.

5.2 MODULAR DIVISION

The entire architecture is divided into 6modules.

1. Face Detection
2. Eye Detection
3. Face Tracking
4. Eye Tracking
5. Drowsiness Detection
6. Distraction Detection

Face Detection: This module takes input from the camera and tries to detect a face in the video input. The detection of the face is achieved through the Haar classifiers mainly, the Frontal face cascade classifier. The face is detected in a rectangle format and converted to grayscale image and stored in the memory which can be used for training the model.

Eye Detection: Since the model works on building a detection system for drowsiness we need to focus on the eyes to detect drowsiness. The eyes are detected through the video input by implementing a haar classifier namely Haar Cascade Eye Classifier. The eyes are detected in rectangular formats

Face Tracking: Due to the real-time nature of the project, we need to track the faces continuously for any form of distraction. Hence the faces are continuously detected during the entire time

Eye Tracking: The input to this module is taken from the previous module. The eyes state is determined through Perclos algorithm.

Drowsiness detection: In the previous module the frequency is calculated and if it remains 0 for a longer period then the driver is alerted for the drowsiness through an alert from the system.

Distraction detection: In the face tracking module the face of the driver is continuously monitored for any frequent movements or the long gaze of the eyes without any blinks which can be treated as lack of concentration of the driver and is alerted by the system for distraction.

5.2.1 HAAR CASCADE

Haar Cascade is based on the concept of features which are proposed by Paul Viola and Michael Jones in their paper “Rapid Object Detection using a Boosted Cascade of Simple Features” in 2001. It is a machine learning based approach where a cascade function is trained from a lot of positive and negative images. It can be used to detect objects from an image or a video.

This algorithm comprises of four stages:

Haar Feature Selection

Creating Integral Images

Adaboost Training

Cascading Classifiers

Though Haar Cascade is used for detecting almost all objects, it is popular for detecting faces in images. Adaboost which both selects the best features and trains the classifiers that use them. This algorithm constructs a “strong” classifier as a linear combination of weighted simple “weak” classifiers.

A Haar feature considers adjacent rectangular regions at a specific location in a detection window, sums up the intensities of the pixels in each region and calculates the difference between these sums. During the detection phase, a window of the target size is moved over the input image, and for each subsection of the image and Haar features are calculated. This difference is then compared to a learned threshold that separates non-objects from objects. Because each Haar feature is only a "weak classifier" i.e. its detection quality is slightly better than random guessing and a large number of Haar features are necessary to describe an object with sufficient accuracy and are therefore they are organized into cascade classifiers to form a strong classifier.

Haar-like features are digital image features used in object recognition. They owe their name to their intuitive similarity with Haar wavelets and were used in the first real-time face detector. A Haar-like feature considers adjacent rectangular regions at a specific location in a detection window, sums up the pixel intensities in each region and calculates the difference between these sums. This difference is then used to categorize subsections of an image. For example, with a human face, it is a common observation that among all faces the region of the eyes is darker than the region of the cheeks. Therefore, from the fig 5.2, a common Haar feature for face detection is a set of two adjacent rectangles that lie above the eye and the cheek region. The position of these rectangles is defined relative to a detection window that acts like a bounding box to the target object.

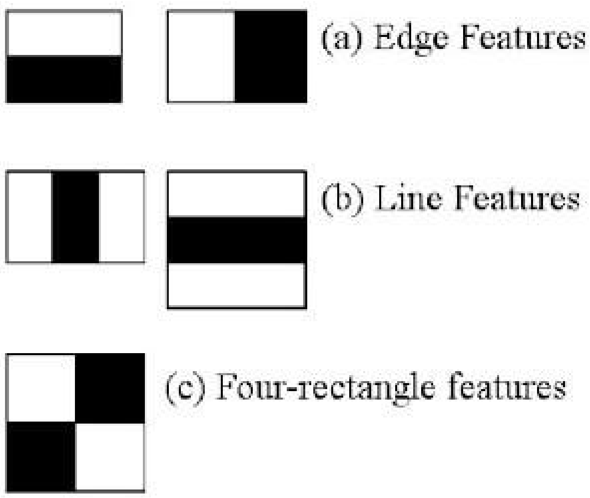

Fig 5.2 Different types in feature extraction

In the detection phase of the viola jones object detection framework, a window of the target size is moved over the input image, and for each subsection of the image the Haar-like feature is calculated. This difference is then compared to a learned threshold that separates non-objects from objects. Because such a Haar-like feature is only a weak learner or classifier a large number of Haarlike features are necessary to describe an object with sufficient accuracy. In the Viola–Jones object detection framework, the Haar-like features are therefore organized in something called a classifier cascade to form a strong learner or classifier. The key advantage of a Haar-like feature over most other features is its calculation speed. Due to the use of integral images a Haar-like feature of any size can be calculated in constant time.

Integral image is a data structure and algorithm for generating the sum of values in a rectangular subset of a grid. The goal is reducing the number of computations needed to obtain the summations of pixel intensities within a window. The idea is transforming an input image into a summed-area table, where the value at any point (x, y) in that table is the sum of all the pixels above and to the left of (x, y), inclusive:

$$I(x,y) = \sum_{\substack{x' \le x \\ y' \le y}} i(x',y') \qquad \text{---- Eq: (3)}$$

Where I(x,y) is the value of the integral image pixel in the position (x,y), while i(x,y) is the corresponding intensity in the original image. It is a recursive formula, hence, if we start from one corner of the input image, we will have the same result in the integral image.

1	3
7	9

0	0	0
0	1	4
0	8	20

Fig 5.3 Calculation of integral image from an actual image

We add one row and column of zeros, since we need one step backward in order to start the recursive formula. Hence, if actual image is w pixels wide and h pixels high, then the integral of this image will be w+1 pixels wide and h+1pixels high. Moving to the computations, let's start from the first pixel in the original image from fig. 5.3 with intensity 1: the integral image returns exactly the same value, since it is computing (1+0+0). Then, pixel '3' becomes '4', since it is 3+1+0+0. With the same procedure, we obtain an '8' (7+1+0) and a '20' (9+3+1+7). Now, we have a new image. This image is useful in an unique property of the integral image. Indeed, it turned out that if you need to compute the summation within a window in the input image, hence that summation is equal to a linear combination of the corresponding window's corner in the integral image, as follows:

$$\sum_{\substack{x_0 < x \leq x_1 \\ y_0 < y \leq y_1}} i(x, y) = I(D) + I(A) - I(B) - I(C)$$

------ Eq: (4)

Where A, B, C and D are the corners of the corresponding window in the integral image of fig. 5.4.

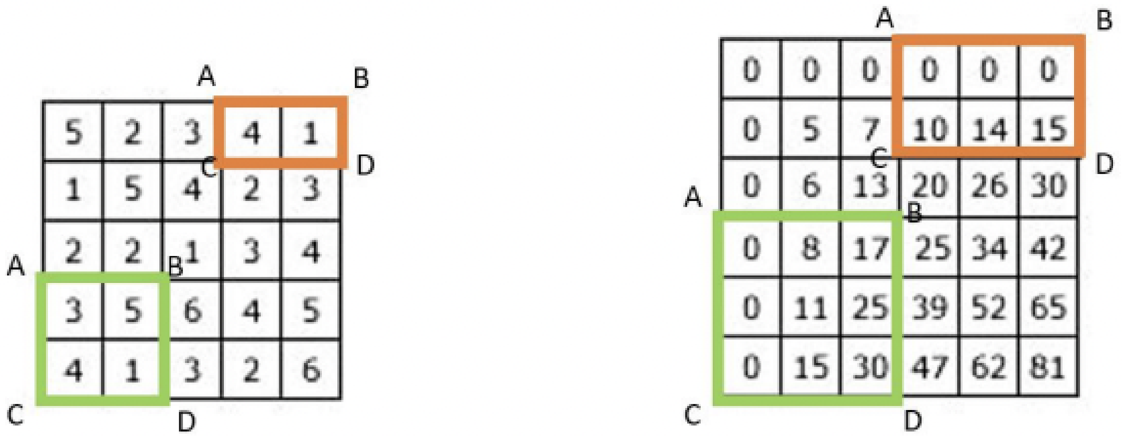

Fig 5.4 Converting a 5x5 image to a 6x6 integral image

This reduces the number of computations. To give you an idea, consider a 100×100 image with a 9×9 window. We want to compute the sum of the pixel intensities within that window, which requires 8 operations. If we repeat this procedure 100 times, we obtain 800 operations. Now let's see the integral image approach. First, we compute the summed-area table, which requires 56 operations. Then, considering the same 9×9 window, to compute the sum of pixel intensity we just need the above formula, which is made of 3 operations. Hence, the total number of operations is 56+3*100=356. As you can see, it is less than a half. This procedure is widely used in computer vision and Haar Cascade algorithm is based exactly on that.

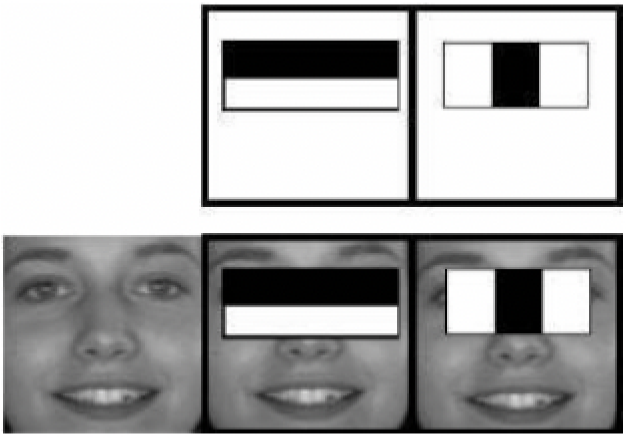

Fig 5.5 Extracting different features

The fig 5.5 is the cascade classifiers for the eyes region. In second picture eyes region is in black colour or both the eyes will have white colours. If the system founds the same pixel intensity at both the places then it detects them as the eyes. The detection is based on the intensity of the pixels around a particular object. The eyes region is white in colour and the region around the eye is black in colour. If there are white pixels found then it detects the region as eye.

Selecting the most relevant features is performed through Adaboost technique which selects the best features and trains the classifiers that use them. This algorithm uses “Haar Cascade Frontal Face” classifier for detecting the faces since we need to detect only the frontal part of the face.

5.2.2 PERCLOS

PERcentage of eye CLOSure (PERCLOS) is defined as the proportion of time for which the eyelid remains closed more than 70-80% within a predefined time period. Level of drowsiness can be judged based on the PERCLOS threshold value.

Perclos is a drowsy detection measure used to calculate the percentage of eyelid closure over the pupil over time. It is used by various real-time drowsiness detection systems and is able to yield effective results. Developers use different set of hardware to capture the closure movement of the eyelids for developing the accuracy of the system. This project uses camera mounted on the dashboard of the vehicle and is set up in such a way that the driver is visible on the camera. This helps in better detection of the face and calculating the eyelid closure frequency using Perclos measure. A total of six points are marked for each eye and the Euclidean distance is calculated for each eye. The eye aspect ratio for each eye are then calculated for average eye-aspect ratio.

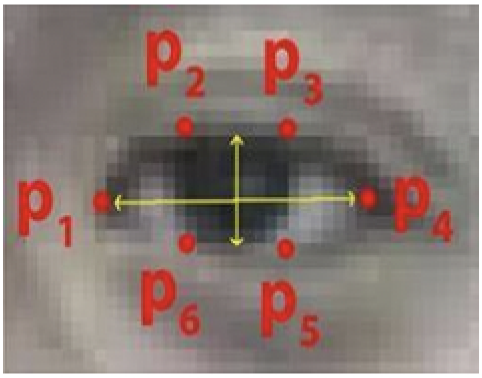

Fig 5.6 Perclos algorithm

ear = (A + B) / (2.0 * C) -------Eq: (5)

where

A is the distance between the 2-points (p2 and p6)

B is the distance between the 2-points (p3 and p5)

C is the distance between 2-points (p1 and p4)

The number of frames are 20 for this system with a threshold value of 0.25. Based on this value, the alarm is made to sound. If the eye aspect ratio is less than the threshold value for given number of frames then it will detect the driver as drowsy and alert is given through an alarm.

6. SYSTEM SPECIFICATIONS

6.1 SYSTEM REQUIREMENTS

6.1.1 H/W REQUIREMENTS

Processor : Any Processor above 500 MHz.

Ram : 4GB

Hard Disk : 250 Gb.

Input device : Standard Keyboard and Mouse.

Output device : High Resolution Monitor.

6.1.2 S/W REQUIREMENTS

Operating System : Windows Family.

Programming : Python 3.9 and related library files

6.2 BRIEF OVERVIEW OF SOFTWARE TOOLS

6.2.1 PYTHON

Python is a general-purpose interpreted, interactive, object-oriented, and high-level programming language. It was created by Guido van Rossum during 1985- 1990. Like Perl, Python source code is also available under the GNU General Public Licence (GPL). This tutorial gives enough understanding on Python programming language.

Python is a high-level, interpreted, interactive and object-oriented scripting language. Python is designed to be highly readable. It uses English keywords frequently where as other languages use punctuation, and it has fewer syntactical constructions than other languages.

6.2.2 OPENCV

OpenCV [OpenCV] is an open source (see http://opensource.org) computer vision library available from http://SourceForge.net/projects/opencvlibrary. OpenCV was designed for computational efficiency and having a high focus on real-time image detection. OpenCV is coded with optimised C and can take work with multicore processors. If we desire more automatic optimization using Intel architectures [Intel], you can buy Intel's Integrated Performance Primitives (IPP) libraries [IPP]. These consist of low-level routines in various algorithmic areas which are optimised. OpenCV automatically uses the IPP library, at runtime if that library is installed.

One of OpenCVs goals is to provide a simple-to-use computer vision infrastructure which helps people to build highly sophisticated vision applications fast. The OpenCV library, containing over 500 functions, spans many areas in vision. Because computer vision and machine learning often goes hand-in-hand, OpenCV also has a complete, general-purpose, Machine Learning Library (MLL). This sub library is focused on statistical pattern recognition and clustering. The MLL is very useful for the vision functions that are the basis of OpenCV's usefulness, but is general enough to be used for any machine learning problem.

6.2.3 DLIB

Dlib is a modern C++ toolkit containing machine learning algorithms and tools for creating complex software in C++ to solve real world problems. It is used in both industry and academia in a wide range of domains including robotics, embedded devices, mobile phones, and large high performance computing environments. Dlib's open source licensing allows you to use it in any application, free of charge.

6.2.3.1 DLIB'S 68 FACE LANDMARK FEATURES

The computer engineer researching how they identify the face of a human in an image. For this, we need to identify first where the human face is located in the whole image. The face detector is the method which locates the face of a human in an image and returns as a bounding box or rectangle box values.

After getting the face position in an image and next we have to find out small features of the face like eyebrows, lips, etc. The facial landmark detection tells all the required features of a human face which we want.

The below image is an example of a Dlib's 68 points model. There we can see that points from 1 to 68. But sometimes we don't need all 68 feature points, then for that, we will do in the next post, how we can customize those points according to our requirements. In this post, we only going to see about 68 Dlib's points for clear understanding.

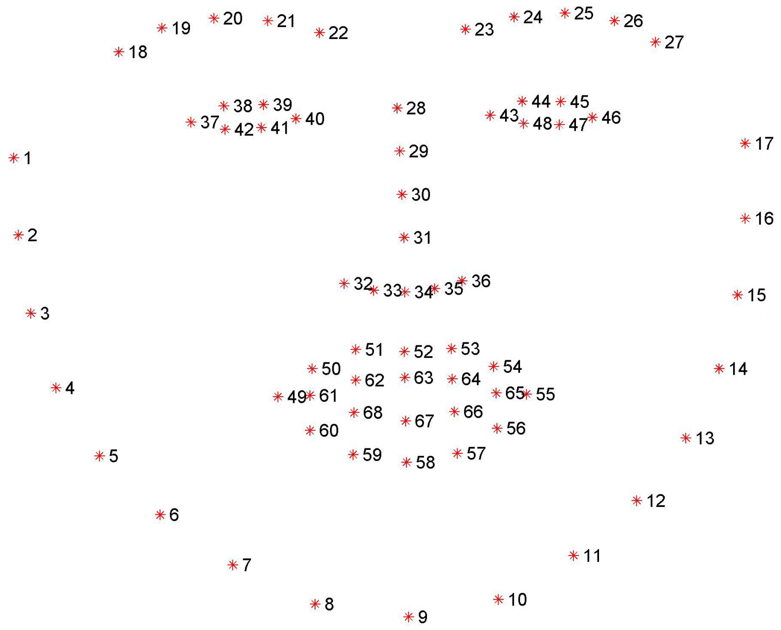

Fig 6.1 Dlib's 68 Face Landmark

6.2.4 NUMPY

NumPy is a basic level external library in Python used for complex mathematical operations. NumPy overcomes slower executions with the use of multi-dimensional array objects. It has built-in functions for manipulating arrays.

We can convert different algorithms to can into functions for applying on arrays.NumPy has applications that are not only limited to itself. It is a very diverse library and has a wide range of applications in other sectors.

Numpy can be put to use along with Data Science, Data Analysis and Machine Learning. It is also a base for other python libraries. These libraries use the functionalities in NumPy to increase their capabilities.

6.2.5 IMUTILS

A series of convenience functions to make basic image processing functions such as translation, rotation, resizing, skeletonization, and displaying Matplotlib images easier with OpenCV and both Python 2.7 and Python 3.

Compared with the original CV, using imutils can directly specify the translated pixels without constructing the translation matrix

Opencv also provides the implementation of image translation. First calculate the translation matrix, and then realise the translation by affine transformation. The image can be translated directly in imutils.

7. RESULT

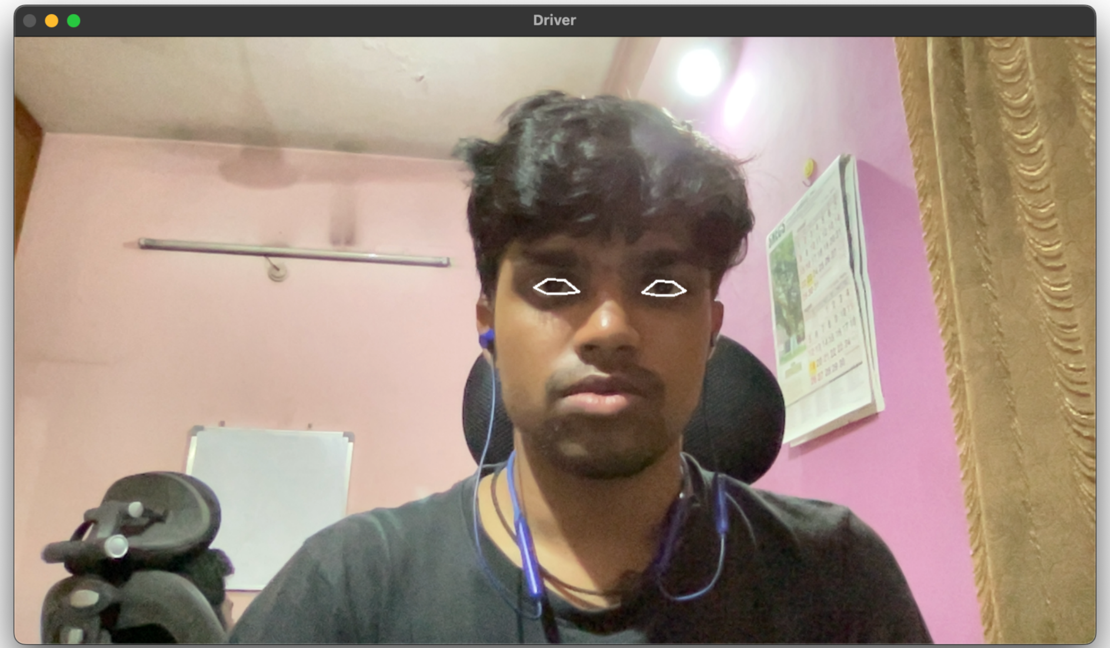

Fig 7.1 Output for eye detection

The system detects eyes in the given particular frame in rectangular frames. The algorithm used for detecting the eyes is haar cascade. It uses haar features which are used for detecting the eyes in rectangular frames.

Fig 7.2 Output for Yawn detection

The system detects Yawn in the given particular frame in rectangular frames. The algorithm used for detecting the yawn is haar cascade. It uses haar features which are used for detecting the yawn in rectangular frames.

Fig 7.3 Output for Drowsy(Normal) detection

The system detects Drowsy(Normal) in the given particular frame in rectangular frames. The algorithm used for detecting the Drowsy(Normal) is haar cascade. It uses haar features which are used for detecting the Drowsy(Normal) in rectangular frames.

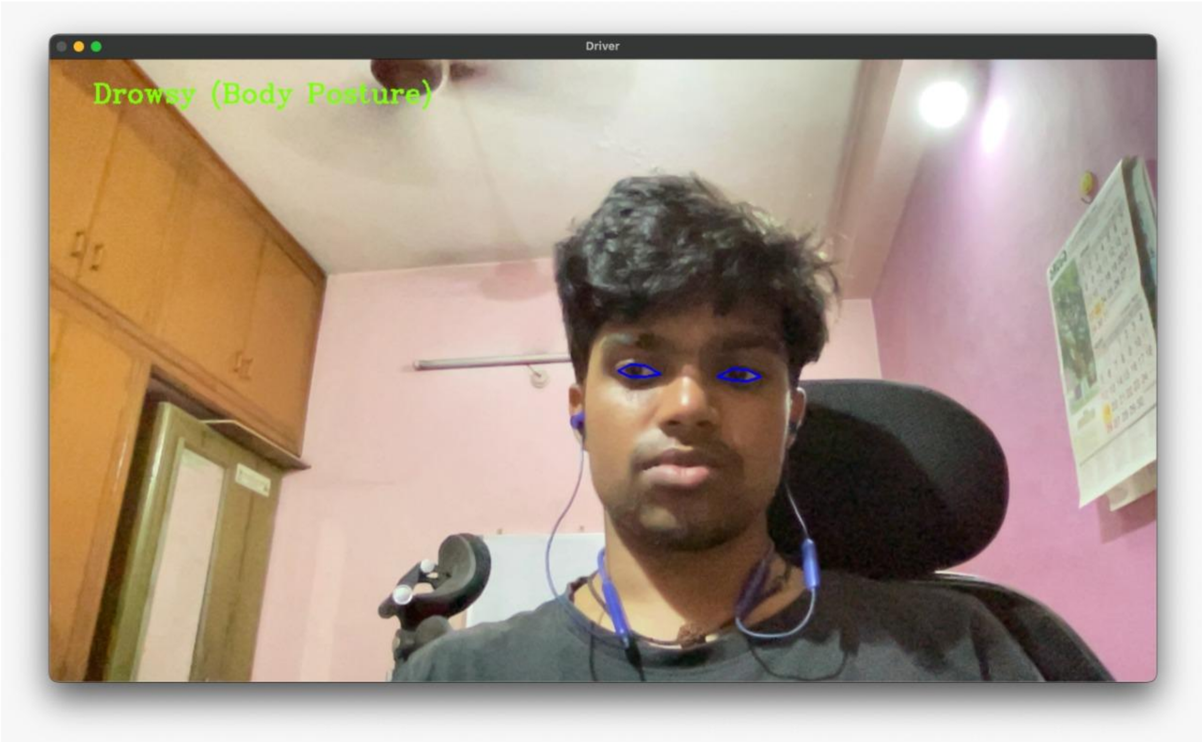

Fig 7.4 Output for Drowsy(Body Posture) detection

The system detects Drowsy(Posture) in the given particular frame in rectangular frames. The algorithm used for detecting the Drowsy(Posture) is haar cascade. It uses haar features which are used for detecting the Drowsy(Posture) in rectangular frames.

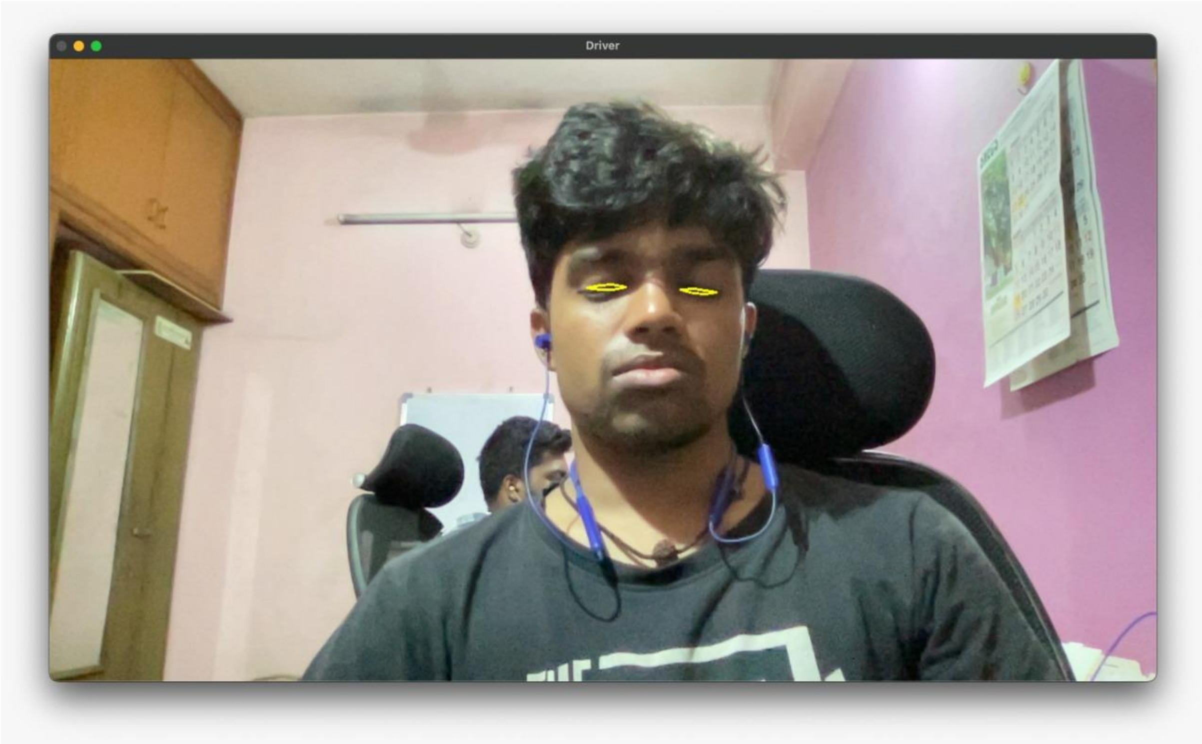

Fig 7.5 Output for Drowsy detection

The system detects Drowsy in the given particular frame in rectangular frames. The algorithm used for detecting the Drowsy is haar cascade. It uses haar features which are used for detecting the Drowsy in rectangular frames.

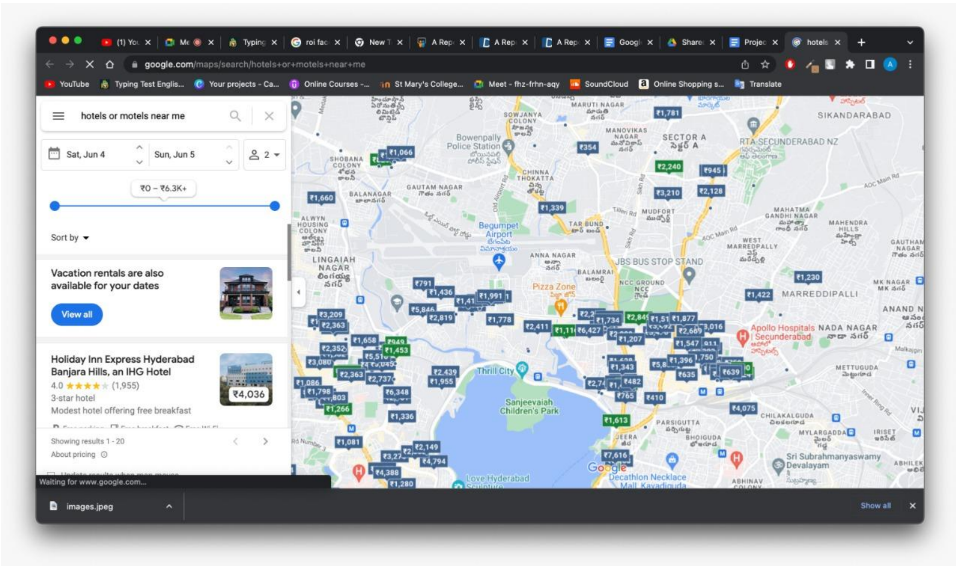

Fig 7.6 Output for Suggesting nearby Hotels

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9. CONCLUSION

The current study developed an automated system for detecting drowsiness of the driver. The continuous video stream is read from the system and is used for detecting the drowsiness. It is detected by using haar cascade algorithm. The haar cascade algorithm uses haar features to detect face and eyes. Haar features are predefined are used for detecting different things. The haar features are applied on the image and blink frequency is calculated using perclos algorithm. If the value remains 0 for some amount of time then it detects as sleepy and alerts driver by activating an alarm. If the value remains constant for longer periods then the drive is said to be distracted then also an alarm is activated.