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A Prototype Design For Detection Of Drowsiness With Autonomous Safety Features In A Vehicle

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***Abstract*—**Road accidents claim millions of lives every year. Road accidents claimed 19 lives in India every hour in 2022, govt report says that 1.68 lakh killed last year out of which, most of them were due to the sleeplessness of the driver. This statistics calls for a drowsiness detection system that can aid in detecting a lousy driver and help save thousands of lives every year. With increased work load and unsuitable work shifts to survive in the fast paced world of today, people tend to lose sleep. Irregular sleep patterns and lack of sleep leads to drowsiness and fatigue. Driver's drowsiness is represented as a state which varies between sleep and wakefulness that decreases cognitive skills and impacts the capability of performing the task of driving. Drowsiness is perilous for the driver himself and for other drivers on the road and must be avoided for example by noise alerts in the car. In this paper, a method has been proposed to detect the drowsiness of the driver after implementing eye-tracking and mouth shape tracking in real-time. Viola-Jones algorithm is used to detect facial landmarks in real-time. This approach uses the detected facial landmarks (i.e. eyes and mouth) based on Supervised Descent Method and Coordinate set of dlib to find the blinking rate of a driver as well as for yawning detection and implementing them for vehicle autonomous safety features for that time-being. The vehicle can be made autonomous for that time by using deep learning and image processing. To minimize the effects of latency, throughput, and packet losses, edge computing is performed using commercial off-the-shelf embedded boards. The system uses camera for capturing images from the surrounding and with it, we train our model and make the vehicle autonomous by estimating the current speed and behavior of the vehicle. The Autonomous vehicle can be controlled using the Convolution Network concepts which would make the vehicle more accurate and stable in the real time condition. This is very important because the accidents can happen within a fraction of a second and acting at the correct time is the most important task in this. So, our immediate response is very important for the successful operation of our project. So, the decision whether the driver is vigilant or not is the first condition to be checked and then the rest of the operations to take place.

***Keywords*—**Drowsiness Detection, Yawning Detection, Viola-Jones, Supervised Descent Method, Facial landmarks, Blinking Rate of eye, Identification, Digital Image Processing

I. INTRODUCTION

The Importance of proper sleep is the inevitable reason for the enhanced focus of research in this domain. According to World Health Organization, more than 1.2 million people die every year in road accidents making it the sixth leading cause of death globally among young people aged between 21 to 30 years [1]. The main reason for this, is the different ways of driving, which includes carelessness, health issues, fatigue, lack of road safety awareness, inconsistent and improper law enforcement, drowsiness and sleeping tendency [2],[3].

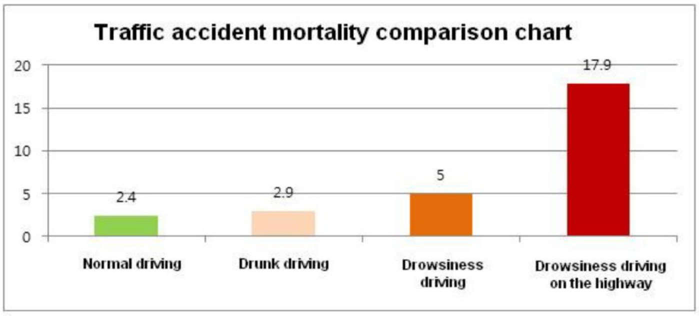

Figure 1. Major types of Accidents

According to the statistics by the National Highway Traffic Safety Administration (NHTSA), United States in 2017, 91000 police-reported vehicle crashes involved by drowsy drivers [4]. Surveys have shown that 80 per cent of such crashes happen during the night and also among single ride drivers [5]. The number of accidents due to fatigue and drowsiness is escalating because people tend to miss sleep due to lifestyle and behavioral choices. Car manufacturers have been testing many new technologies which include lane assist and 360 degree parking assist using sensors and camera to detect the surrounding of the car for the safety of the passengers. These new technologies have the potential to judge and make the driving much safer, helping protect the other driver to detect the sleeping mood driver and issue warning sign to protect co drivers in the road. Drowsiness detection with Autonomous Safety Features is one such technology with which we will be able to protect the driver from sleeping asleep and to judge the motion of the vehicle to some extent. Simple, efficient and more important fast methods, therefore, are required to reduce these accidents by monitoring the drowsiness level in a no-obstructive way in real-time by measuring the blinking rate of the eye and at the same time detecting the yawning action. Current measures adopted to serve this purpose include studying change in the behavior of the drowsy driver by analyzing various factors such as head movement eye closure, eye blinking or yawning. Many different methods have been developed and derived from facial characteristics and the authors [6] have done a very extensive research work on different papers connected to driver distraction using visual-based sensors and algorithms. They point to the key requirements that an algorithm for drowsiness must accomplish: reliability, real-time performance, low computational cost and flexibility. In the recent papers [7, 8 and 9] the authors propose different types of drowsiness detection systems either based on yawning detection either on blinking ratio.

In this Research work we concentrated our efforts in using the drowsiness detection system with the existing developed autonomous features of a motor vehicle which can be implemented and executed in real-time [10]. The proposed system works in real-world with the application of a standard camera. Using a standard trained model of faces as reference, the identification of the state of driver becomes much more accurate.

The rest of the paper is organized as follows: the next section will give a small detailing of drowsiness detection system. Section III details about the autonomous features for the motor vehicle by the use of digital image processing and deep learning. The final section depicts the conclusion and suggests the scope of future work.

II. Drowsiness Detection System

A. *Drowsiness Detection :*

This behavior is the detection and tracking of facial features which is very effective, fast and economical. The biggest advantage of this system is that it does not affect or disturb the driver in any way and it is also non-obstructive. Detection works by tracking the eye-lids of the eye or the pupil or both. So, the device which achieves this goal is the real time camera. The image, which is actually a face, is used for tracking the eye-lids. The face is considered as a collection of landmarks or points with which it will determine the face. The driver when not active or if he is tired, automatically he stars to express facial expressions and feel sleep. Thus, while driving, it eventually becomes difficult for the driver to keep his eyes open.

Figure 2. Drowsy state of a driver

The above picture shows the sleeping state of the driver. Initially the driver will feel drowsy which is defined as the tired and the tendency to feel sleepy but he is not yet slept. After this phase, he will begin to sleep intermittently and slowly. At this time, he will have a low-blinking rate. This analysis has been experimentally verified with different type of faces and has used that information as reference.

In addition to this, we have another reflex to drowsiness, which is yawning. Yawning is also considered as the tendency to feel sleepy. This happens because our brain cells lack sufficient amount of oxygen. So, we yawn to gather a large amount of oxygen for brain cells to function properly. Our body induces yawning to draw in more oxygen or remove a build-up of carbon-dioxide. In order to make the body processes faster, we intake sufficient amount of oxygen by yawning. During this action, we open our mouth wide open which is actually a change in the facial geometry of a normal and active driver. Thus, the drowsiness detection system will be a combination of the tracking of the eye-lid as well as the yawning action. Once, it is confirmed, then the motor vehicle can be made autonomous by controlling the steering of the car and continuous detection of the surroundings will help the car to move safely while the driver in sleep mood. The vehicle can be made either to reduce its speed or move to a side, and to park the vehicle with the help of digital image processing and deep learning. This is what the entire research is all about.

B. *Detection System Flowchart:*

The detection system works on the facial geometry and the yawning action. The flowchart of the entire process is shown below:

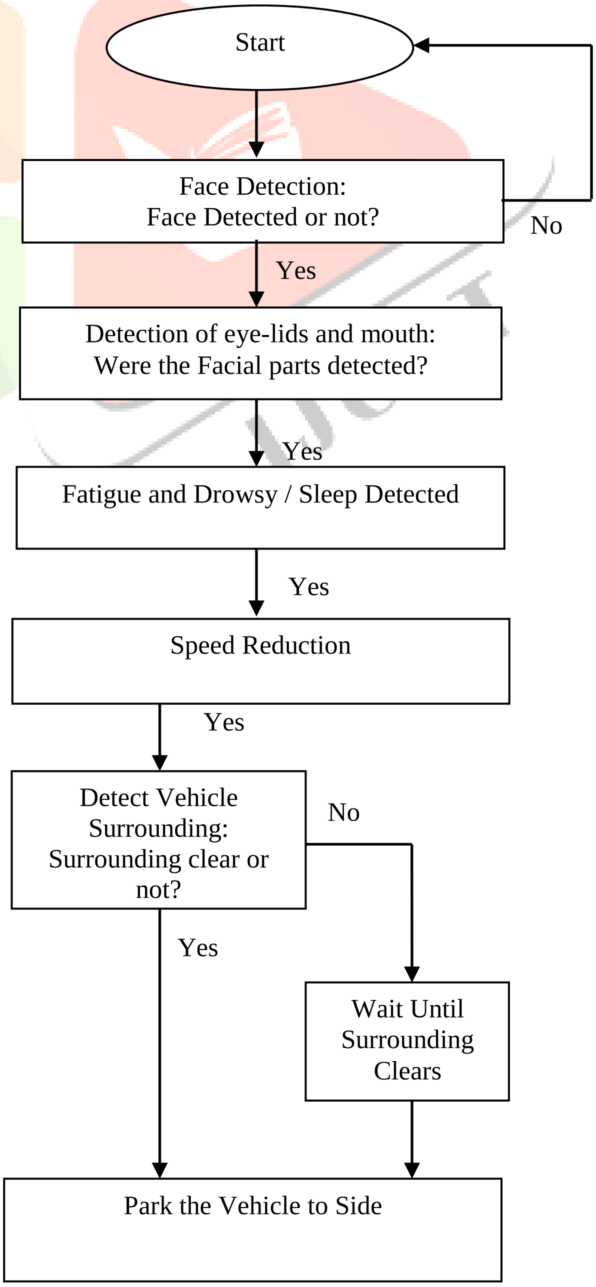

Figure 3. Flowchart of the Proposed System

C. *Drowsiness Dectection Algorithm :*

Initially, in the system the face is detected using the detector technique so that we only extract our area of interest from the background and exclude the false alarms which can arise in backgrounds with complex texture. In order to achieve this area of interest, we have the facial landmarks which will focus our face and analyze it simultaneously along with our head movements. These principal facial features allows us to gather only the minimum information and describe the state of the facial muscles and hence the facial geometry at certain point of time. The set of facial points which determine the state is given below:

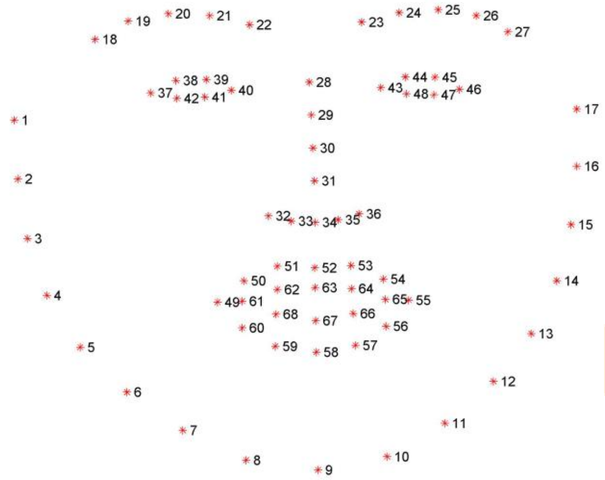

Figure 4. Set of points that are referred as coordinates on the face by the SDM algorithm

The above given points are taken as the landmarks for the face detection and drowsiness. These coordinates are taken from the dlib library for a reference with which we have worked for experimentation. The decision making for drowsiness we utilize in this work is the structured SVM classifier [11]. This classifier is well suited for sequence labeling and can take the references which we have experimentally verified.

Detection of eyes with camera is a non-obstructive technique that does not require any physical contact with the driver or does not disturb the driver in any way. The implementation of this system is also very easy and maintenance is also very less. The parameters describing the dynamics of eye-lid movements include eye-blinking, blink duration and number of blinks of the eye-lid. During a drowsy state, the blinking rate of a person changes [12]. This system can be used to detect the level of drowsiness of the driver using the verified results and threshold. Since, each person has a different blinking rate, we have experimentally verified with lot of people and it has been found that the average blinking rate will be about 3 to 4. The rate is then verified as soon as the driver is seated in the vehicle, as during the initial few minutes the driver is vigilant.

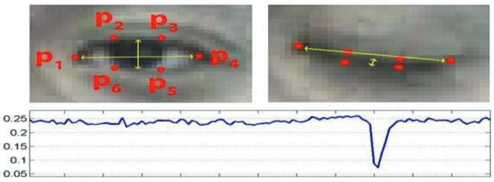

Figure 5. EAR Graph

From the above landmark detection coordinates set, each measuring parameter which is the eye-lid, blinking rate and yawning is calculated based on the coordinates situated on the eye, from 37 – 42 [13]. Here we use the Euclidean theorem for the threshold values. Eye-lid fully open, partially closed and fully closed is the three stages involved in sleep detection. Similarly, for the yawn detection, the mouth wide opens which will create a degree of opening and we measure the distance for the action using the coordinates from 49 – 62. In order to achieve scale invariance, the distances are normalized against the detected facial box.

Regarding the yawning detection part, the degree of mouth opening as well as the number of times the action repeats is taken into account. The driver is said to be "yawning" if the mouth opening (i.e. the normalized distance between the points 61 – 65 exceeds a specific threshold) for around 3 times (or number of frames).

From the figure 5, we can find that there are two finite states, "Lip Opened" and "Lip Closed". The Mn_Dist is the mean distance between the points of the upper lip and lower lip which we take into account. Then, Ywn is the class and Thr_Dist is the Threshold value which we experimentally obtained and if the mouth opens, the distance increases and we find that the distance is greater than the threshold value. So, we check for the next successive frames and increment it. In this way we can say that the person is in drowsy state.

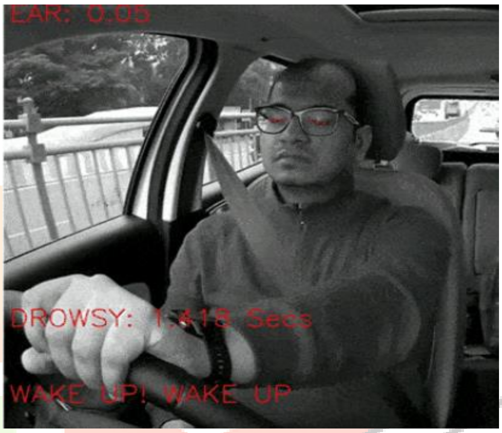

Figure 6. Drowsiness Detection Result

The same principle can be used for detecting the blinking rate of the eye. The number of times the eye is blinked is analyzed and we can say that the person is in drowsy state, if it exceeded the threshold value. From the analysis of the experiments we have verified that the person's eyes blink around 3 – 4 times at the maximum. Since, it is all about the driver's life, we don't want to take any chance. Immediately we conclude that the person is feeling sleepy, if both the conditions are satisfied.

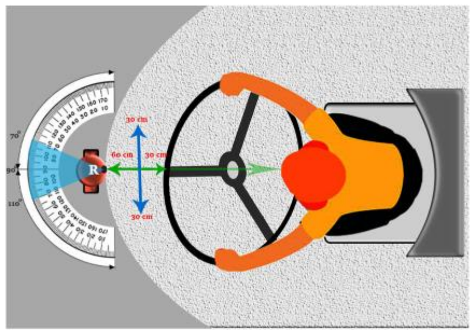

Figure 7. Visualization of the camera setup within a vehicle

The above figure 7 [14] shows us the camera setup by how the face can be detected to predict the state of the driver.

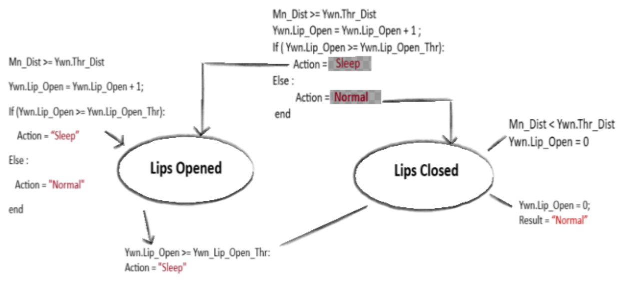

Figure 8. State diagram representing the Yawning Detection

III. AUTONOMUS FEATURES

A. *Vehicle Autonomous Features :*

After finding whether the driver is sleepy or not, we step into the autonomous features of the motor vehicle. As soon as the person is sleeping, we make the car autonomous for the time-being. The vehicle immediately checks the surrounding and makes a judgment as to reduce the speed or to move to the surrounding. This decision is to be made very fast as soon as the driver falls asleep in order to avoid meeting with any accident because, the motor vehicle would be running at a high speed. So, the decision is to be made as fast as possible.

In order to make this happen, we need to implement it using camera which detects the surrounding and then, search for other objects which include humans, cars, bikes, trucks and other similar objects. After tracking the objects, we estimate the speed of them using sensors like Ultrasonic and Laser Ranging (ToF) which gives us the distance of, how far the object is. Using this distance, we can estimate the speed of the object. With this, it is possible to implement the system and make the car reduce its speed at first and then we can change the direction of the car.

The complexity is involved in checking the surrounding of the car which will require a lot of algorithms. So, a combination of all these will be the autonomous movement of the car. Therefore, the flow chart of the autonomous movement of the car can be modeled as shown below:

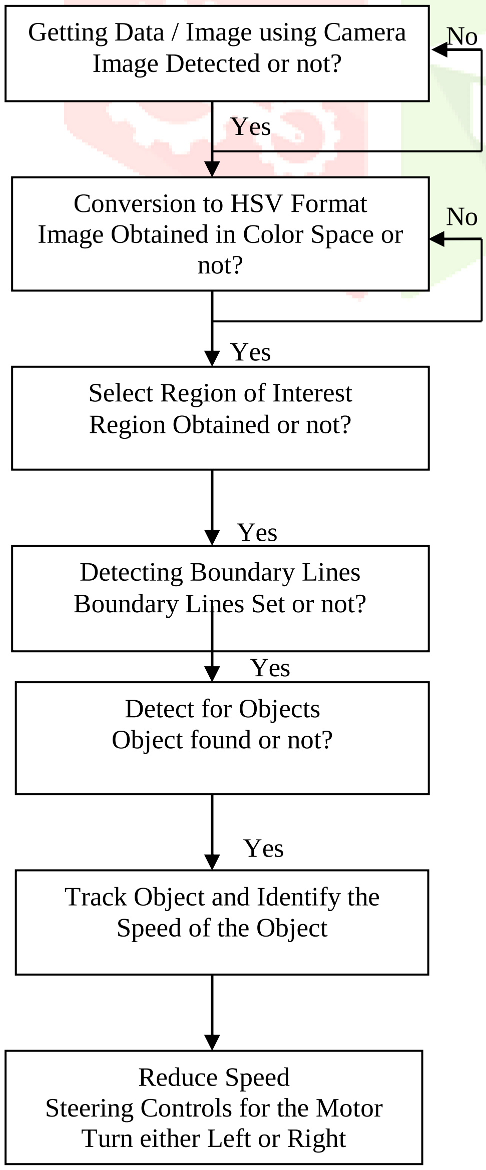

Figure 9. Flowchart of the Autonomous Vehicle

From the model, we can understand the procedure. In order to steer left or right, we can use "Hough Transform" to detect the lines or curves. Then, it is easy to find the slope of the line and keep a threshold value as our limit. After that we set the left and right lanes and select our "Region of Interest" and using the PID Controller we move our vehicle left or right based on the angle 'Theta' using tan and arc tan. The steering was not very accurate but using the PID controller we calculate the error and take the sum of all the errors as gain and then provide it as a feedback to the loop with which it becomes more stable and accurate. Each type of error will be proportional, derivative or integral. The figure shown below is the steering controls of the autonomous vehicle. The value 10 is the degree of error which I had experienced during the steering.

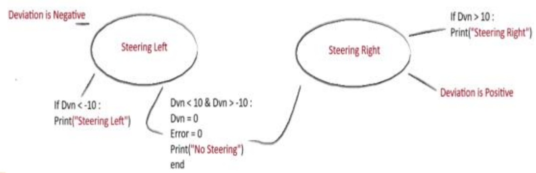

Figure 10. State Diagram representing the Steering of Vehicle

After the vehicle moves, the next objective is to track and focus the object from the surrounding. For that, we capture the image and focus on the other vehicles by giving each vehicle a specific 'id' so that it can be tracked continuously. Each object will be differentiated by the color of the box, which means each color will represent a particular type of motor vehicle.

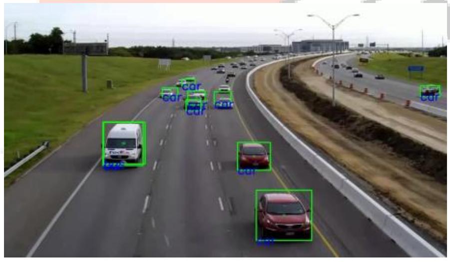

Figure 11. Tracking Objects Using Camera

So, the above picture shows how the vehicles like truck and bikes get detected and tracked.

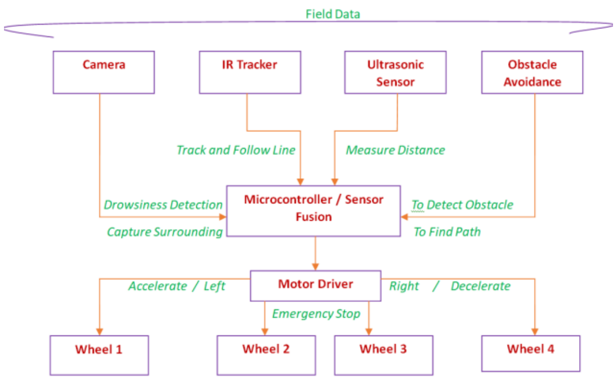

Figure 12. Flowchart of the Entire Setup

B. *Conclusion :*

To check the accuracy of the yawn detection, we utilized the YawDD dataset [15]. It provides 322 videos in 30fps of color images of 640x480 of both male and female drivers. The drivers are from different ethnicities, with and without specs/sunglasses. With the threshold value we provided which we verified was given to the video of the dataset. The accuracy of yawning detection obtained on the data base is 82% and is better to the results provided in [15]. The figure 6 shows us the result performed on the database. The system detects the features according to the coordinate set shown in figure 4. In this way, we have verified about the result of the drowsiness detection and the autonomous features of the vehicle was checked with the microcontroller and camera connected to it. The camera captures the surrounding and provides immediate response by either decelerating or turning left or right according to the condition. Thus, in this paper we have developed this system to make the driver safe to the highest level in every possible ways such that we could protect the driver as well as other drivers on the road by using a cautionary visible mechanism.

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