Artificial & Computational Intelligence / Published Online : June 2020
https://acors.org/ijacoi/VOL1_ISSUE3_06.pdf

Artificial & Computational Intelligence

Development of IoT based Smart System for Safety & Security of Driver and Vehicle

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Abstract

Safety for a vehicle and its driver is a major issue. The domain is board but some of the issues are at priority. So we have come up with a system to deal with the primary safety measures. The authentication of driver is one the major aspect. Along with that the probability of traffic accidents would be more if a person does not have a proper sleep or rest especially a driver. So, in order to reduce traffic accident due to drowsy condition, a system must be made that can detect drowsiness of the driver. For that system, we have to process the driver face images which will capture using camera. In that, it is going to analyze the changes that happen in the face and then will be processed through a program in order to detect drowsiness to send few alerts to the driver. The system has also got a provision to reduce the probability of accident and provide alert to relatives of the driver in case of any accident along with sending the heart rate information.

Keywords: Face recognition; finger print authentication; Drowsiness; (EAR) Eye Aspect Ratio; Facial Landmark; Open CV (Computer Vision); Raspberry Pi 3B+; HTTP protocol; pulse sensor

1. Introduction

Security is a defense against threats which provides an assurance of safety. Now and before security is one of the major concern in various places. Security of vehicle is also very important. Hence Proper authentication of Driver is at top priority. As we know that theft of vehicle is a big problem as in 2018 over 40,000 vehicles were stolen, but less than 20 percent cases were solved. And if a car is recovered then its chance to use is less than 20% of the recovered cars.[1]. When it comes to safety of car from wrong hands an authentication system is must which identifies an authentic owner.

Similarly, When it comes working on overall safety system of a car, safety of Driver is also a very important aspect. Here we need to deal with one major issue related to driving that is Drowsiness. The driver who are exhausted took drugs at the driving and are responsible for about 40% of accident. An study has been taken place on the 300-km Agra-Lucknow Expressway by the Central Road Research Institute (CRRI). This will create a major issue in which people who drive would not take a proper rest and put their and other life's in danger.[2].Earlier various other methods have been implemented to detect the drowsiness of a person using the parameters of a car where sensors were placed at accelerometer and steering wheel. But these methods were more inclined towards environment of the car.Along with that a consequence of drowsiness is accident which sometimes leads to death. Even we know that delay of even single minute can take the person from life to death that the injuries care is totally depend on time. Recovering rate from the severe injury on time is lower in low-income and middle income countries like India than high income countries because they have well developed emergency care systems. The modelling

studies suggested that if low and middle-income countries approached to those high-income countries then the third global injury deaths could be prevented. If emergency care is accessible on time then many lives can be saved. It is calculated that up to 500000 road accident could be averted every year if death rate from severe injury due to accident were the same in low- and middle-income countries as they are in high-income countries[3]. The "golden hour" is the first hour after trauma. If proper and timely first aid is given during that time, road accident victims have a higher chance of survival, according to the "The Golden Hour handbook" [4].From the study done by World Health Organization (WHO) in 2015 that 45 million deaths are taken place in both low and middle-income countries every year and among this

54% deaths are due to emergency care and potentially addressable by pre-hospital.[5]

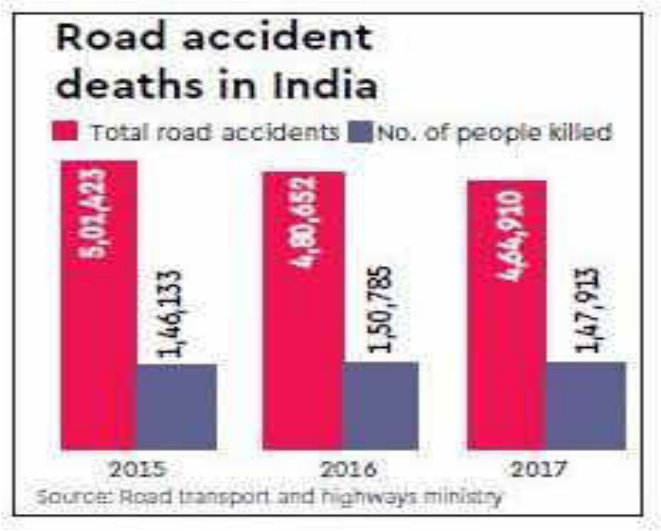

Fig 1: Data regarding Road Accident deaths in India

These deaths can be avoided if information of accident with location can be sent to respective hospital on time. Thus such issue can be solved by implementation of accident alert system which gives information to owner's relative so that proper action can be taken on time. The ministry's report on road accidents cites the case of Tamil Nadu in this context. Between 2017 and 2018, the state saw a 24% decline in road-accident deaths, data show. This decline is attributable to "multi-pronged initiatives" such as better road-traffic enforcement and an improvement in emergency care, the report said.

Thus, keeping these issues at priority a single system needs to be implemented which could handle the safety of car as well as driver at the same time.

2. Proposed System

The proposed system has been made to overcome the disadvantages of the previous transportation system and also to decrease the number of accidents and car robbery. So the objective is to make a smart system that can work automatically for handling the car security problem and drowsiness detection problem.

As I mentioned earlier that we have three objectives to understand this whole project:

1. Security System for Car.
2. Drowsiness Detection System
3. Accident Alert System.

2.1 Security System for Car

In this we check the person who wants to drive a car is an authentic driver or not. Here we use two-way authentication procedure to check the realness of the owner of the car. Two way authentication means to check the person two times that is first by face recognition and second by finger print sensor.

The very first step is driver's face recognition.

For face recognition [6] we have to create a database that already have face samples of car owner and then we have to create a model that will be trained before execution of final code. When driver sit in a car his/her face is captured using raspberry pi camera. The captured face will then compared from the database. Here we recognise the face 10 times for better results. If face is not recognised then assistant would warn the person by speaking through speakers "This is not your car , please get out from the car" and an alert message through HTTP protocol will be sent to the owners Smartphone using Telegram application and also to his/her relatives. But if face is recognised successfully then camera will be off and assistant will assist the driver to give a biometric test to start the car (At this time finger print sensor will be activated). Before using finger print [7] sensor into its real work we have to enroll the car owner finger. The finger print sensor module that we used is R307 which is connected to USB-TTL converter and which is further connected to USB port of Raspberry pi. Now driver place his/her finger on the finger

print sensor to start the car. If finger is recognised successfully then car will start through stepper motor. Here we stick the key of the car to the stepper motor and according to the steps involved to start the car, stepper motor will rotate the key accordingly. But if finger is not recognised then it will ask to try again and this will continue till 5 times after then the driver will again give face recognition test.

2.2 Drowsiness Detection System

When car is started, simultaneously Drowsiness detection system [8] and accident alert system will be activated. EAR expands to Eye Aspect Ratio and also called Eye Closer Ratio, this is defined as the amount of blink with hold of eye [9] takes place for a certain amount of time. For example if eye is open then EAR is higher and if eye is closed then EAR is lower. It is calculated that if a person is not in drowsy condition then EAR should be greater than 0.25 [10] . As EAR decreases[11] then alerts will be activated to wake up the driver. Here we mentioned two alerts and one warning and after that breaking system will be activated. The first alert is a buzzer ,the buzzer will ring to wake up the driver. If he/she again fall asleep then vibrating motors (Second alert) will vibrate which has been placed on the steering, this way driver feel vibration on his/her hand so that he/she will be attentive while driving. Again if he/she fall asleep third time then the assistant[12] (Warning) will give last warning to the driver that "If you will not wake up then automatic breaks will be applied". And at last if driver again fall asleep then finally breaks will be applied slowly. Here we also include YAWN detection algorithm[13] to detect yawning[14] . We only alert the driver with assistant if he/she take yawn. There is no alert for yawn detection.

2.3 Accident Alert System.

If in between the driving , accident happens then according to accelerometer reading, if it crosses threshold then alert message [15] will be transfer with the location of the accident place using GPS[16] module through telegram[17] to the driver's relatives.

As we know that MPU6050[18] will give acceleration as well as gyro readings. So for car accident system we require only gyro readings. Gyro means angular velocity in 3-axis means if car faces a drastic accident then it will definitely a chance that car will be flipped.

In case accident happens and message was sent to the relatives with location then in order to know whether the driver is alive or not we use pulse sensor [19] that will give continuous reading of pulses of the driver at each minute to the relatives through telegram application.

This system can be easily embedded on various portion of the car.

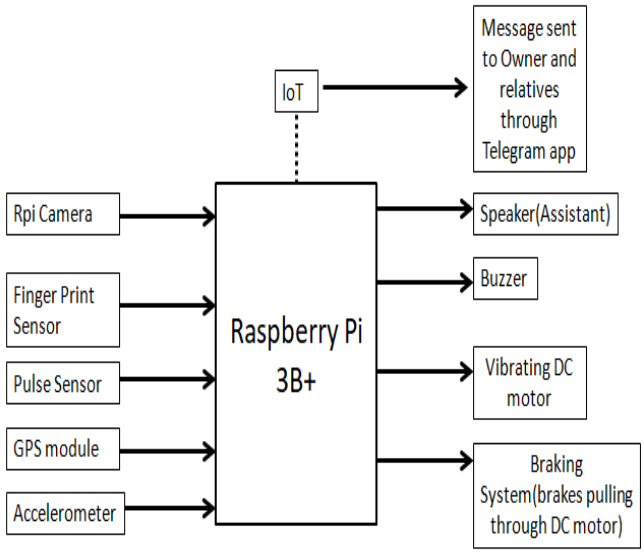

Fig2: Block Diagram of the Project

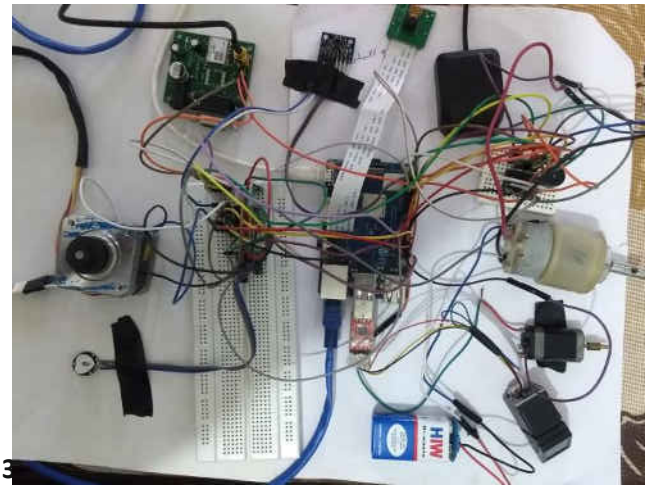

Fig3: Picture of Real Circuitry

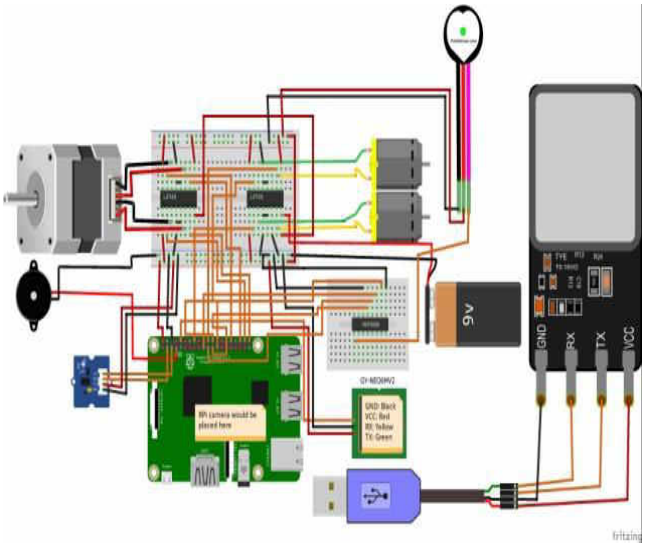

Fig4: Circuit Connections

4. Description of components

Following are the major components that are used in this project :

A. Raspberry Pi 3 model B

The core unit that is being used in this project is Rasspberry Pi 3 B+ is the version that is being used. It has a 64 bi-bit quad core processor which runs at 1.4GHz ,dual band 2.4 GHz and 5 GHz wireless LAN, Bluetooth has the specification of 4.2/BLE .it has faster Ethernet and separate PoE HAT .The dual-band wireless LAN has a modular compliance certification, which allows the board to be designed into end products with reduced wireless LAN compliance testing, improving cost and time to market.[20-21].

B. Pi Camera Module

The **Pi camera module** is a portable light weight camera that supports Raspberry Pi micro-computer. It communicates with Pi using the MIPI (MIPI CSI-3 is a high-speed, bidirectional protocol primarily intended for image and video transmission between cameras and hosts)camera serial interface protocol. It is normally used in image processing n surveillance projects. It is commonly used in surveillance drones since the payload of camera is very less. Along with this modules Pi can also use normal USB webcams that are used along with computer.[22]

C. Fingerprint Sensor

The fingerprint sensor module used in this project isR307.The module consists of optical fingerprint sensor, high-speed DSP processor, fingerprint alignment algorithm, high-capacity FLASH chips and other hardware and software composition.

D. USB-TTL Converter

Earlier computers had RS232 ports, but now a days the only option for communication between laptop and FPV devices are USB ports. So a USB to TTL convertor converts a USB signal which is a serial signal into a true TTL that is a transistor transistor logic which is known as RS232 protocol in electronics industry. Therefore, TTL is communication protocol that allows FPV devices for programming and connect to laptop.TTL is also known as RS232 communication protocol.

E. L293D motor driver IC

The L293D is a 16-Pin **Motor Driver IC**. It is mainly used to drive motors. A single **L293D IC** is can run two DC motors at the same time; along with that the direction of these two motors can be controlled independently. It works on the principle of Half H-Bridge. In H bridge principle we can run motors both in clock wise and anti clockwise direction. IC is capable of running two motors at the any direction at the same time

F. ADC MCP 3008

The **MCP3008** is an **8-Channel 10-bit ADC IC**, so it can measure 8 different analog voltage with a resolution of 10-bit that is each sample out of 8 different voltage will be represented by 10 bts. It measures the value of analog voltage from 0-1023 and sends the value to a microcontroller or microprocessor using **SPI communication protocol**. It can operate on both 3.3V and 5V and hence it can be used with 5V microcontroller as well as with 3.3V systems like the Raspberry Pi.

G.GY-521 MPU6050 3-Axis Gyroscope and Accelerometer Module

GY-521 MPU6050 6DOF 3-AxisGyroscope and Accelerometer Module is a carrier board based on MPU-6050 sensor which contains an accelerometer and a gyroscope. MPU-6050 sensor contains a MEMS accelerometer and a MEMS gyro in a single chip(MEMS stands for micro electro mechanical system). It is accurate since it contains 16-bits analog to digital conversion hardware for each channel. Therefore it captures the x, y,

and z channel at the same time. The sensor uses the I2C-bus in order to interface with microcontrollers.[23]

H. Pulse Sensor: The other name of this sensor is heartbeat sensor or heart rate sensor. It works which made to come in contact with the fingertip of human, after which it needs to connected to ADC further to process the output using a micro-controller .So that heart rate can be easily calculated.

I.SIM28 GPS RECIVER: This GPS receiver modem is based on SIMCOM's SIM28M/SIM28ML GPS module. SIM28M is a standalone or A- GPS receiver. With built in LNA, SIM28M can relax antenna requirements and don't need an external LNA. SIM28M is capable of tracking a signal as low as -165dBm signal even without network assistance. It has very good low power consumption characteristics (aquisition 17mA, tracking 16mA).

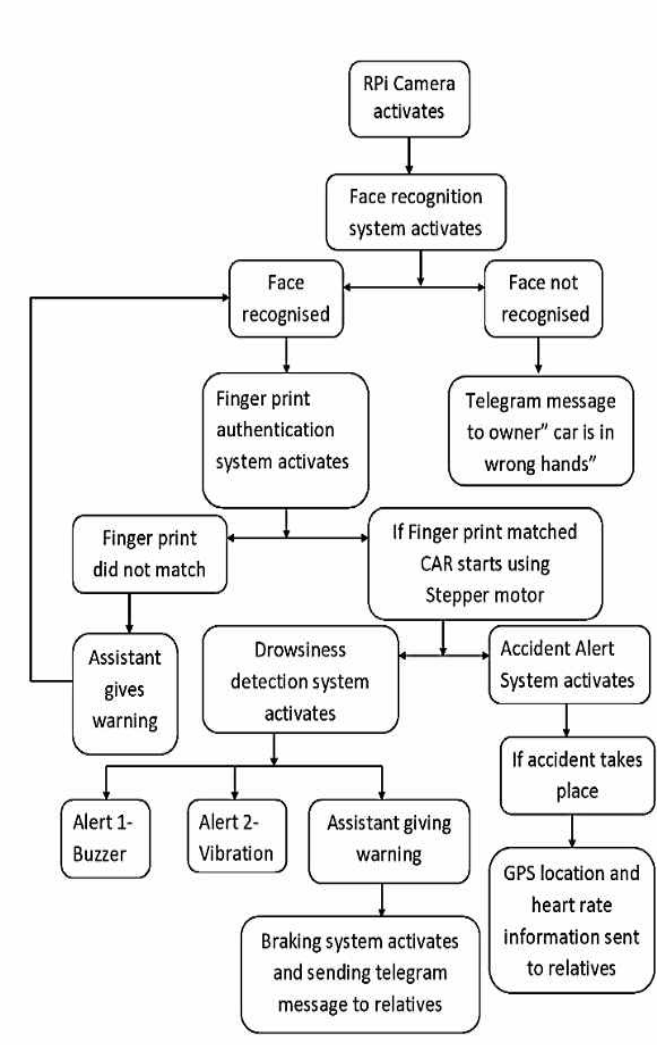

Fig 5: Flow chart of the project.

5. Methodology

5.1 Face Recognition

To develop a Face Recognition system, we must work on 3 very distinct phases:

Phase 1. Face Detection and Data Gathering

Phase 2. Train the Model

Phase 3. Face Recognition

Phase 1 : To detect a face we need some predefined faces using the "Haar Cascade Clasifier". In this a cascade function is trained using machine learning from a lot of negative and positive images. It is then used to detect objects in other images like face, eye, nose etc. For facial features we use "haarcascade_frontalface_default.xml". Here we are using very important library Open CV (Computer vision) that will convert the images into Numpy array. Using Rpi camera we capture the image, then it will convert numpy array using open CV library and store into database.

Phase 2: After storing data into database, we have make a trainer.yml file in which we train the model which will compare the picture that is already captured and stored in the database with the live picture which will be captured during live video streaming.

Phase 3: In this phase we will capture a live face from RPi camera that will compare the pre-existing face from the database which is already trained and ready to do prediction.

5.2 Finger Print Authentication

To create a Finger print (Biometric) authentication program, we must work on 2 very distinct phases:

Phase 1. Enroll the finger

Phase 2. Search or check the enrolled finger

Phase 1: First we enroll the fingerprint in the fingerprint sensor (R307). The sensor have capacity to enroll 1000 distinct fingers print.

Phase 2: In this phase it will check the fingerprint weather it is actually present or not or we can say it is authenticate user or not.

5.3 Drowsiness Detection System

To create a Drowsiness Detection Program, we must work on 3 very distinct phases:

Phase 1. Face Detection and Data Collection

Phase 2. Train the Model

Phase 3. EAR and YAWN Detection

The first two phases are similar to face recognition that we discussed above.

Phase 3 : To detect drowsiness in a driver the EAR should be calculated and with that we can determine that driver is in drowsy condition or not.

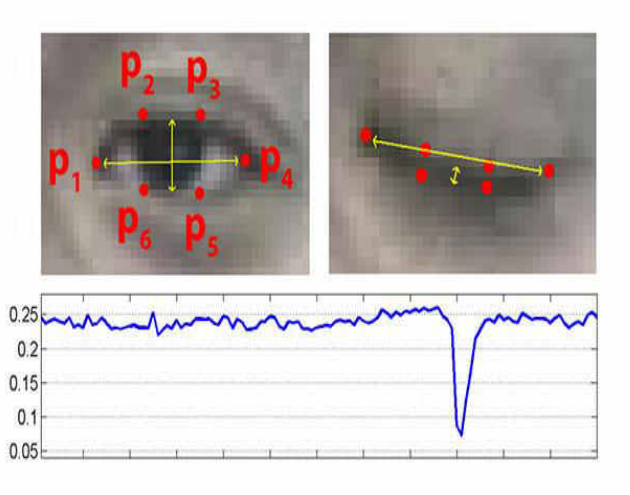

Fig 6: Six landmarks of the eye before and after closing eyelids

Every portion in the face have some facial landmarks. As shown in fig 6 the facial landmarks of eyes, similarly we can also identify facial landmarks of mouth to detect yawning. The images of these faces are converted into grayscale format because the inherent complexity of gray level images is lower than that of colored images.[24,25]. When the facial landmarks of the driver face were detected then the eye coordinates were extracted using the 6 (x,y) coordinates of the eye structure as shown in Fig 6.

The vertical eye landmark and horizontal eye landmark are responsible to calculate eye aspect ratio function. The EAR function is defined as ratio of distance between vertical eye landmarks and distance between horizontal eye landmark. Here, we use Euclidean Distance of the eye region is used.

$$d(\mathbf{p},\mathbf{q}) = d(\mathbf{q},\mathbf{p}) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2 + \cdots + (q_n - p_n)^2}$$

$$= \sqrt{\sum_{i=1}^{n} (q_i - p_i)^2}.$$

In the above equation d(p,q) is the Euclidean distance between points p and q. pi and qi are two points in Euclidean n-space.

As we know that each eye in human face is corresponds to 6(x,y)-coordinates as shown in fig 6. The eye aspect ratio will be determined on how far the eyelids are apart from each other i.e. the major part to calculate EAR is by calculating distance between vertical eye landmarks. When a person blinks then EAR significantly goes to zero and it was detected as drowsy so to overcome this problem we find that the time between eye blink and eye opens is approximately 100 to 400ms[27]. From this paper we deduced that the duration of eye closure must be greater than 400ms so that we can detect the person blink eye or not. If closure of eye is more than 400ms then it will detect that person blinks his or her eye. As we know that one frame is equal to 100ms so we consider four frames to represent 400ms that means if eye is closed in four successive frames with EAR is less than 0.25 that means one blinks is takes place. Thus it is easy to identify that eye closure pattern between the drowsy and eye blink.

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

To calculate EAR , the distance between vertical eye landmarks and distance between horizontal eye landmark should be calculated for every video frame. Then we calculate EAR between width and height of the eye from the formula given below.

In the above formula p1, p2, p3, p4, p5 and p6 are the two-dimensional landmarks location of the eyes. The EAR for both the eyes are averages because blinking of eyes takes place together.

In the same way we can detect YAWN according to the opening and closing of the mouth and similarly find coordinates ofYAWN.

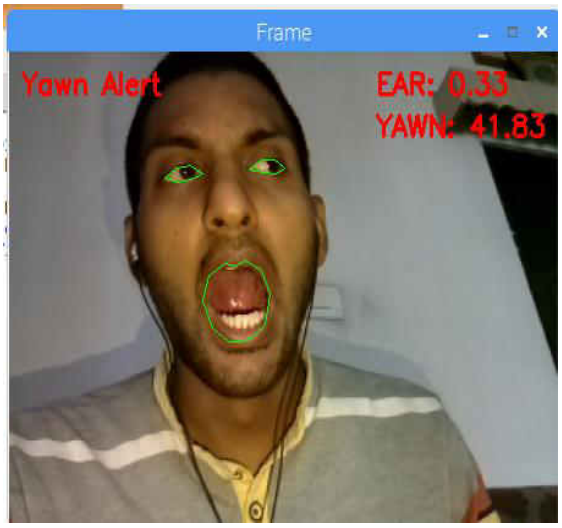

Fig 7: Yawn detection with alert

6. Results and outputs

Here we are showing step wise execution of the program.

Step 1. Face Recognition

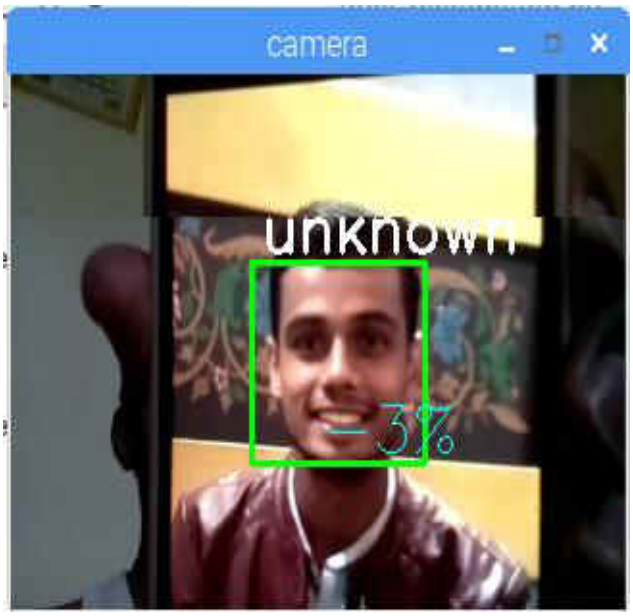

Fig 7: Unknown face detected

If face is not recognised then an alert message will send to the owner of the car and also assistant will alert the unknown person to get out from the car.

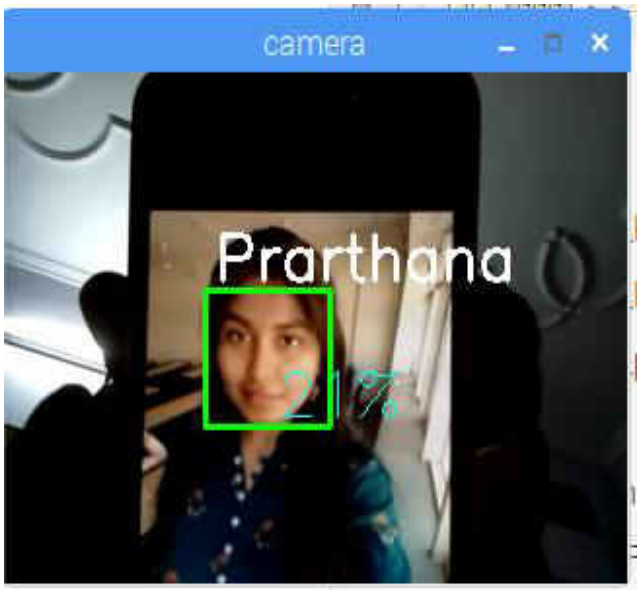

Fig 8: Known face detected

If person is recognised with his/her name according to the index value given in the program then finger print authentication will get activated.

Step 2: Finger print authentication

Fig 9: Finger print test

After successful face recognition the driver of the car would give finger print test to start the car. This test will again verify the owner of the car. Here if finger print is not recognised at first attempt then assistant will assist the driver to try again and it will repeat 5 times till correct finger print is not recognised. If driver fails in all 5 attempts then he/she will again give face recognition test. If finger print is recognised successfully then car will start through stepper motor.

Step 3: Drowsiness Detection System and accident alert system.

After car starts Drowsiness Detection System and

Accident alert system will get activated.If driver feels drowsy then alerts will get activated.

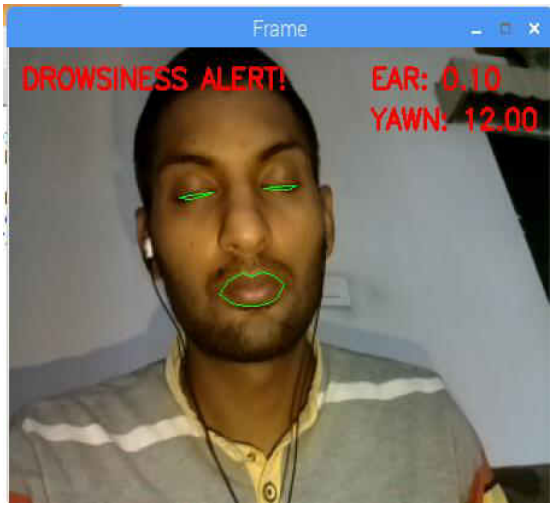

Fig 10: Drowsiness Test

Step 4: Notify the driver and driver's relativesThere are three situations in which an alert message will transfer to the driver (Owner) and his/her relatives.

Situation 1: When face is not recognized.

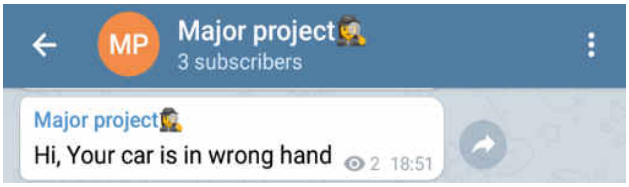

Fig 11: Alert message when car is in wrong hand

Situation 2: When driver feel drowsy more than three time and then automatic breaks are applied through DC motor and car will stop safely.

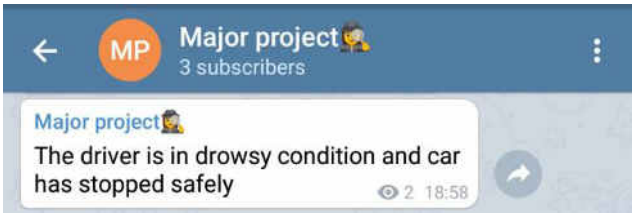

Fig12: Alert message when driver is drowsy

References

Situation 3: When Accident takes place.

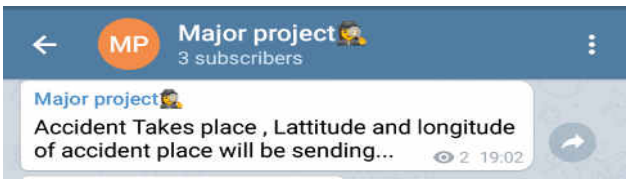

Fig13: Alert message when accident happens

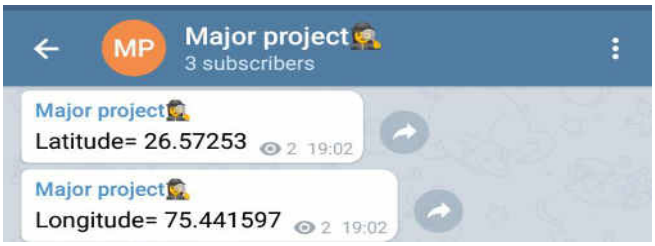

Fig 14: Message of latitude and longitude

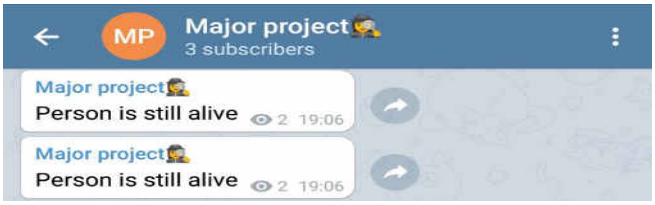

Fig 15: Message of pulse sensor that indicating person is alive

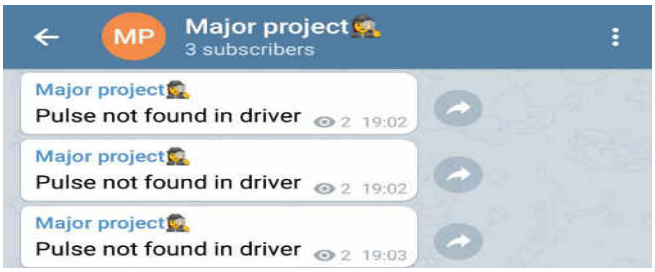

Fig 16: Message of pulse sensor that indicating person is dead

The alert message will transfer through HTTP protocol using Telegram bot service. For this we must have telegram bot id and telegram channel name. The HTTP protocol is request/response service in which first it will trigger the web request and then response accordingly.

7. Future Work

In future, we would like to make the system which is comparatively more compact so that the system can be made space friendly. Along with that we have the vision to work on the detection of drowsiness especially at the night by including a night vision camera. In addition to this, we are also determined to work towards a better network so that information can be sent faster by inclusion of 5G.

8. Conclusion

In this paper ,we have reviews various methods to deal with the safety of car as well as the driver. For car safety we have worked over two level authentications and for Driver safety Drowsiness parameter along with yawning is being integrated. In addition to that Accident alert system is an another level safety measure taken for the safety of

driver. This paper deals with accuracy of using physiologicalparameters (physical parameter like eye landmarks) to detect drowsiness are really high. This approach will helps in preventing most of the road accidents and deaths. There is always a scope of improvement. Here work can be done at the detection of drowsiness at night.

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