Smart Wireless Black Box with Intelligent Facial Recognition System for Prevention of Accidents and Theft of Vehicles Using Raspberry Pi Along with Sensors Based on IoT

V. Brijendra Varma[1], Dr. B. V. Kiranmayee[2], L. Ashwik Reddy[1], S. Sravan Kumar[1], P. Sandeep Varma[1]

[1]VNR VJIET, Department of CSE, B Tech Student
brijendra.varma@gmail.com, luckyashwik@hmail.com, shaganti.sravan456@gmail.com, pathapati.sssv@gmail.com
[2]VNR VJIET, Department of CSE, Associate Professor & HOD
kiranmayee_bv@vnrvjiet.in

Abstract. With the increased number of vehicles on road, the number of road accidents are increasing day by day. Every year, approximately 1.35 million people die in those accidents. In most of those accidents, people can be saved if taken to the hospital at the earliest, but due to lack of information regarding the time and place of the accident it may not be possible. This paper aims at building a smart black box system which can help in reducing the road accidents and increasing the chances of saving injured people's lives through accident detection using MEMS accelerometer and thereby alerting the nearest hospital service and the police control room with the exact location of the accident with the help of GPS Sensor and Twilio SMS service. This smart wireless black box comes with an intelligent facial recognition software which prevents vehicle theft by alerting the owner of the vehicle with the image of the unauthorized person captured through camera. There is also a built-in pre-accident detection mechanism in this black box which prevents drunk & drive by detecting abnormal alcohol levels of the driver using an alcohol sensor and thereby stopping the vehicle's motor and alerting the nearest police control room and the driver's relatives. This black box system captures various environmental parameters through sensors from the surroundings such as temperature, humidity, obstacle distance, pulse of the driver, location coordinates of the vehicle and uploads all the data to the cloud and also provides the visualization of the data gathered through the sensors. If any parameter value exceeds the limit then this black box system alerts the corresponding authority via SMS.

Keywords: Vehicle Black Box, Accident Detection, Theft Detection, Open CV, Machine Learning, IoT Technology, Facial Recognition, Haar Cascade Classifier, Raspberry pi, MEMS Accelerometer, Alcohol Sensor, Temperature Sensor, Pulse Sensor, Pressure Sensor, IR Sensor, GPS, Motor, Camera, Cloud.

1 Introduction

1.1 Internet of Things

IoT (Internet of things) is a future that stands between humans and devices. In future, we will use IoT technology to automate our daily usage tasks with the help of devices connected to one-another. The term IoT refers to a situation where networking and computing power extends to devices, sensors and objects, which we use in our daily lives. Devices can communicate to each other with minimum intervention from humans. They generate, transfer and understand the data with other devices by using sensor inputs and react with sensor outputs. By leveraging IoT technology, the world can pretty much become a connected place.

1.2 Motivation

According to the World Health Organization's (WHO) list of top 10 death causes, Road Accidents take the 9th place [1]. Every year almost 1.2 million people die and 20 – 50 million people get injured due to road accidents. Coming to India, it has 1% total vehicles in the world but accounts for 6% of accidents in the globe. Nearly 73% of all the deaths caused from road accidents from the south and south-east Asia region are from India. Road accidents in India stands 12th place for premature-deaths and 10th place for person disability. In 2018 alone, India had 467,044 reported road accidents, an increase of 0.5% from 464,910 in 2017. Among them 1.51 lakh death toll has registered alone in 2018, according to the road ministry's data as shown in Fig 1. [11]

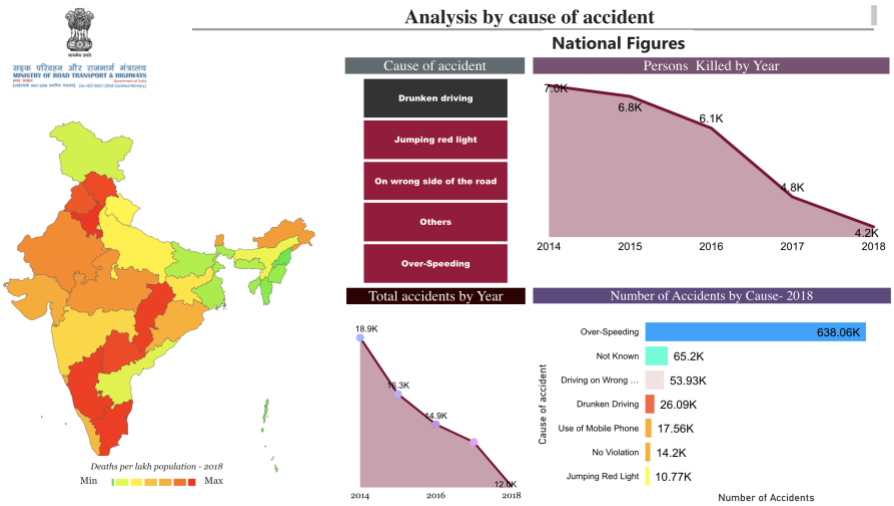

Fig. 1. road ministry's data for accident from 2014 to 2018 (Source: https://morth.nic.in)

Based on the analysis of the accident records, major causes for road accidents in India are over-speeding and rash driving by drivers consuming excess alcohol. In spite of many campaigns against over-speeding, this problem continues to exist in several counties. With the advancement of IoT technology we can leverage data collecting devices called sensors and then build a system which can monitor several parameters that are related to the cause of accidents and thereby prevent them. Collectively that monitoring system is called a Black Box which generally exists in Air Planes for post-crash analysis.

In this paper, we propose a black box system to detect collisions with the help of a MEMS Sensor installed and then immediately alert the nearest ambulance system with the exact location of the vehicle with GPS sensor and also capture the incident using a camera installed for detailed analysis of the accident that has occurred. We would like to reduce the accidents caused by drunken drivers by installing an alcohol sensor which detects the excess alcohol consumption of the driver and then the motor of the vehicle gets turned off thereby not permitting the drunk driver to drive the vehicle. Simultaneously, an SMS alert will be sent to the Police by indicating the location of the vehicle. Not only accidents, but also vehicle theft is a major concern for the public. Theft of vehicles is an opportunistic crime committed in almost every country in the world and causes major financial loss to people. Since vehicle has become an affordable resource to the people for comfortable transportation, it is very essential to build a system which can alert the owner of the vehicle while a thief is trying to steal the vehicle. We propose a facial recognition system to recognize the owner of the vehicle with the help of a camera and permit only the authorized people to enter into the car. If the person is not authorized, then the captured image will be sent to the owner indicating the theft of the vehicle and also alerts the owner with a buzzer sound.

2 Literature Review

In order to know the existing techniques and their significance in building a black box for the main purpose of accident detection, a literature survey is conducted.

Kassem, A., et al. [4] described a black box system with sensors and a Microcontroller which acts as the brain of this black box. Here mainly two approaches are depicted. One is with the detection and storing of data gathered using sensors attached to the to the microcontroller. And the second one deals with the visualization of the recorded data. For detection of environment parameters there are various sensors attached like Speed Sensor which detects the speed of the vehicle, Water Sensor for detection of water level in the vehicle's surroundings, Accident Sensor to detect the collision, Belt Sensor for ensuring the seat-belt safety of the driver, Light Sensor for analyzing the direction of the vehicle and finally the Brake Sensor for detecting whether the driver pushes brake or not during the collision. Now all this recorded data is transferred to the microcontroller's EEPROM. And then this recorded data is transmitted to a computer interface where a VB.Net program can utilize this data for analysis. Main advantage of this paper is that only authorized people can see the data analysis.

Watthanawisuth, N., et al. [5] described an alert system which is implemented through black box that can accurately send the location of the vehicle where the accident has occurred. This black box system is implemented using Accelerometer, GPS device, Microcontroller unit (MCU) and GSM Module. Here Accelerometer is used for detection of fall of the vehicle i.e., collision of the vehicle with another vehicle by monitoring the 3 axis of the vehicle that it is attached to Microcontroller (MCU) is used to store and process the data signal generated from the accelerometer in real time. GPS device is used to detect the location coordinates of the vehicle where an accident has occurred and GSM Module enables that location of the vehicle to be sent as SMS alert. This black box system has a specialty of non-linear fall of the vehicle. In case of non-linear fall, the speed of the vehicle is calculated using a GPS module to detect the ground speed of the vehicle in order to prevent from sending false SMS alerts which take place when the driver hits the brake suddenly.

Das, A., et al. [6] described a robust & sophisticated black box system. This black box system comes with Eye blink Monitoring, Alcohol detection, Automatic speed control mechanism and Accident alert system. Microcontroller (MCU) acts as the brain of this entire black box system as all the sensors are attached to it. This system requires Eye blink sensor for detecting the abnormal eye blinking rate of the driver, alcohol sensor for detection of excess alcohol level of the driver and an Ultrasonic proximity sensor which calculates the distance between the vehicle and the obstacle. This black box system also comes with a GSM module for locating the vehicle and thereby can send SMS alerts if any of the sensors attached to it detect any abnormalities. The main advantage of this black box is in monitoring the driver fatigue, which prevents the accidents when the driver is tired. This black box also stops drunk people from driving using an alcohol sensor.

Anil Kumar, M., et al. [7] described an Intelligent black box system along with its implementation. The main advantage of this black box comes with the inclusion of Cloud storage. This system comes with a microcontroller and multiple sensors attached to it. Sensors include Alcohol Sensor for detecting excessive alcohol level of the driver, Accelerometer Sensor for monitoring the 3 axes of the vehicle, Ultrasonic sensor for calculating the distance between the vehicle and the obstacle, Panic buttons for the driver emergency and obviously a GPS and GSM modules for locating the vehicle and sending SMS alert to the programmed entity respectively whenever accident occurs. Here the GPS coordinates of the vehicle are continuously transferred to Cloud thereby the owner of the vehicle can trace the vehicle's location.

Motivation for Proposed System:

The proposed system in this paper is the advancement of the above 4 papers with the actual implementation process of a smart black box system. In this paper, we provide special features of the black box that are not present in any of the above 4 papers such as facial recognition system using a camera in the black box which is very much essential for preventing vehicle theft. Also, this proposed black box system comes with various other sensors like pulse sensors, temperature sensors, etc., which collect data

and it can be uploaded to cloud for post-accident analysis. This black box monitors the heart-beat of the driver using pulse sensor and send SMS alert if the driver gets a cardiac arrest. Instead of GSM module for sending SMS, we are using Twilio SMS API Service, which is much more sophisticated with many built-in libraries and debugging tools that come in handy for developers.

3 Proposed System

In this paper, we provide a smart wireless black box implemented with the help of Raspberry-pi which acts as the brain of this black box system by storing and processing the data that is gathered through various sensors like temperature sensor, pulse sensor, MEMS accelerometer, Alcohol sensor, Ultrasonic sensor, IR sensor, GPS, Camera and Motor as shown in Fig. 2.

The proposed black box system consists of 2 main modules as follows:

1. Face Detection & Recognition system for **theft prevention** using Haar Cascade Classifier.
2. Smart Wireless Black Box system for **Accident prevention** using various sensors.

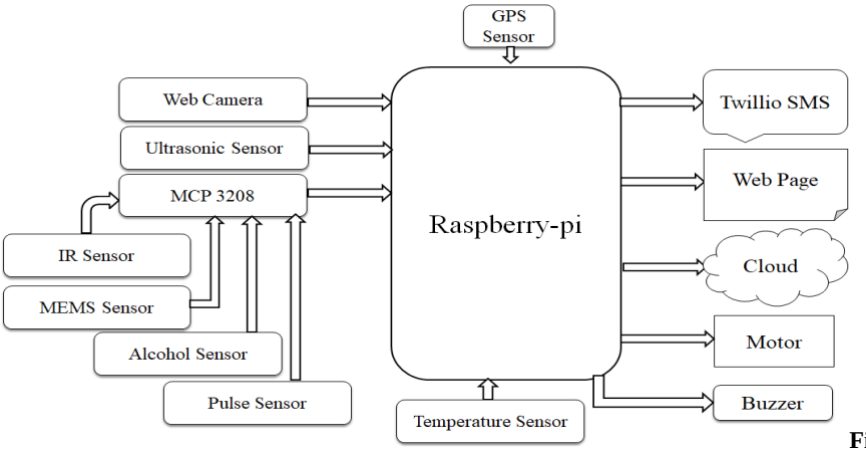

Fig. 2. Hardware Architecture of the Proposed Black Box System

4 Implementation

4.1 Face Detection and Recognition System to prevent theft of Vehicle

In order to prevent the theft of the vehicle, we have come up with a Face Authentication application which we authorize the driver, when trying to start the vehicle. We are using Haar Cascade machine learning algorithm for Face detection which is quick and robust. It was proposed by Paul Viola and Michael Jones in their paper [10]. In order to authorize the driver, first we need to create a face detection system. After detecting the

face and highlighting it with a rectangle, we need to recognize the face. For performing the recognition, there are 3 algorithms available – Eigenface, Fisherface and Local Binary Pattern Histogram. Here in our project, we are using Fisherface recognition algorithm, since it is fast in recognition and also occupies less space in the memory.

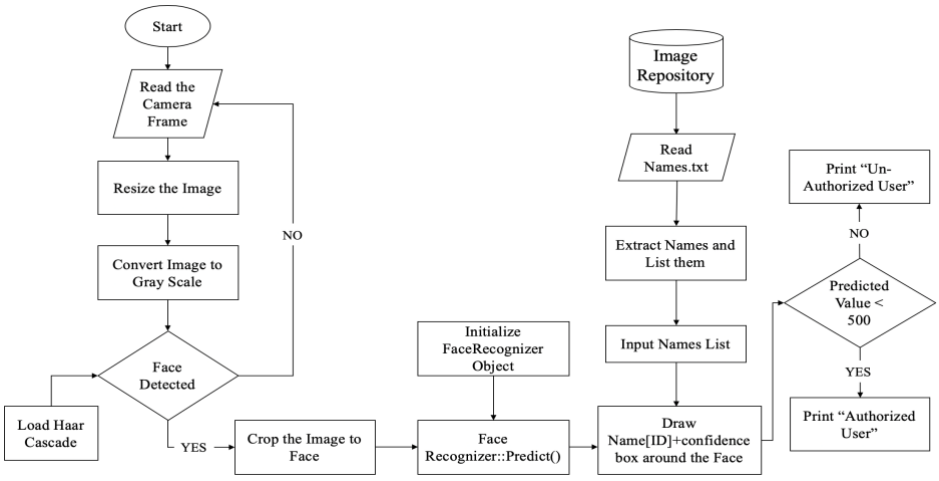

Fig. 3. Flowchart of the Facial Recognition module for Theft Prevention

Steps involved in the Facial detection & recognition process:

Step 1: Import necessary modules

The modules include cv2, numpy, os, sys and image module. The module OS is used for the extraction of names of the image from the directory and a number that is extracted from the image is used as a label for the face present in that image.

Step 2: Create a Facial Detection System

In order to create a face detection system, we need to create a camera object **cv2.VideoCapture()** to capture the face of the driver and load the cascade classifier using **cv2.CascadeClassifier()** which is present in the file **haarcascade_frontalface_default.xml.** Now for identification of the face, we need to convert the captured face image to **grayscale** using **cv2.cvtColor()** and detect the features of the face using **CascadeClassifier.detectMultiScale().** After gathering the features of the face image, we can draw the rectangle around the face using **cv2.rectangle()** and label the face within the rectangle using **cv2.putText().**

Step 3: Create Face Recognizer Object

After detecting the face, we need to recognize that face by indicating the name of the person as a label in the rectangle formed. For that, we need to create a Face Recognizer object. We have used **FisherFace Recognizer** which consumes less

memory and is very fast. Using this FaceRecognizer object, we can leverage functions like **FaceRecognizer.train(), FaceRecognizer.predict(),** etc.,

Step 4: Prepare a training dataset and train the images

We can create a dataset of images with their corresponding labels using a function that takes in the absolute path of the image directory and takes two input parameters – image, label. After that we can use a predefined function called **FaceRecognizer.train**() for training the images.

Step 5: Testing

We can perform testing of the FaceRecognizer by comparing the predicted label with the actual label. We can get the actual label from the OS module.

4.2 Smart Wireless Black Box system for accident detection of vehicles

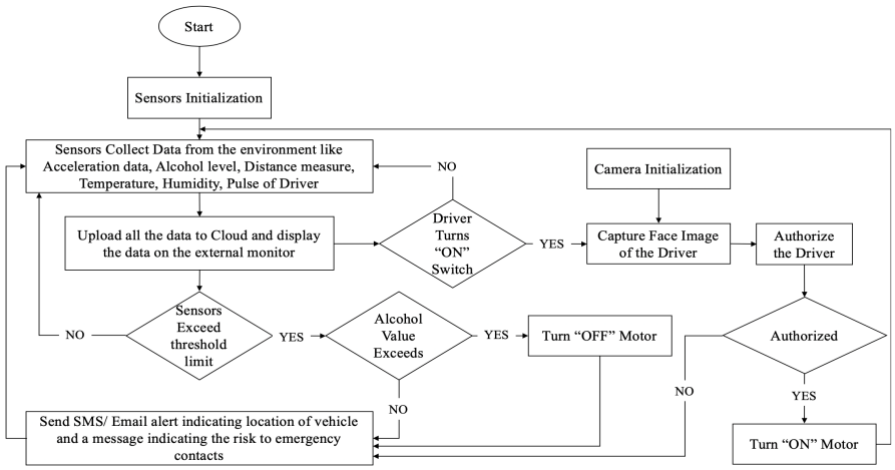

Fig. 4. Operational Flow chart of Smart Wireless Black Box System

Steps involved in the Working of our Smart Wireless Black Box System

Step 1: Firstly, the legitimate owners of the vehicle must register their face in the system. If already registered, then goto *Step 2.*

Step 2: After the system (Raspberry pi) is turned 'ON', the sensors – MEMS accelerometer, Ultrasonic sensor, pulse sensor, temperature sensor, alcohol sensor, GPS get initialized.

Step 3: All the sensors collect the data continuously for every 5 seconds and is displayed on the monitor. This data includes position of vehicle (MEMS), alcohol level of driver

(alcohol sensor), temperature & humidity level inside the vehicle (temperature sensor), pulse of driver (pulse sensor) and vehicle to obstacle distance (ultrasonic sensor).

Step 4: The sensors data including location coordinates of the vehicle are uploaded to cloud in the respective channels created, where the data is visualized in graphs.

Step 5: If driver turn 'ON' Ignition Switch of the vehicle, then his face is captured and authorized.

- If Driver is Authorized then Motor is turned 'ON'.
- Else Alert the Owner of the vehicle via Email with the captured face image.

Goto *Step 3.*

Step 6: If any abnormal value of sensor data is detected i.e., if any sensor data exceeds the threshold limit, then immediately SMS alert is sent to the concerned authority with the risk associated to the vehicle/driver along with the location coordinates of the vehicle using Twilio SMS API service. If NOT, go back to *Step 3.*

Step 7: If collision is detected through MEMS sensor, then Capture the incident using camera and Email the incident image to concerned authority for future analysis and go to *Step 6.*

Step 8: If the alcohol level exceeds the threshold limit, then Immediately stop the vehicle Motor and go to *Step 6.*

5 Results

The hardware setup and experimental results of our Black Box system are depicted below in figures: Fig. 5, Fig. 6, Fig. 7, Fig. 8, Fig. 9, Fig. 10 and Fig. 11

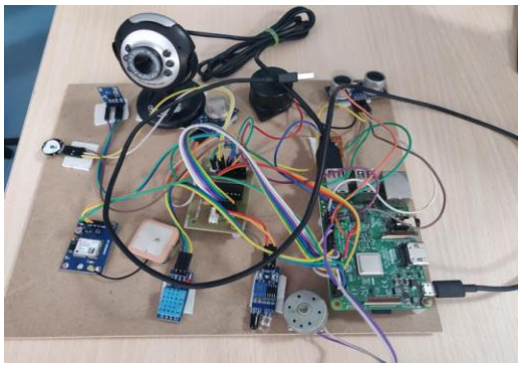

Fig. 5. Hardware Setup of Black Box System

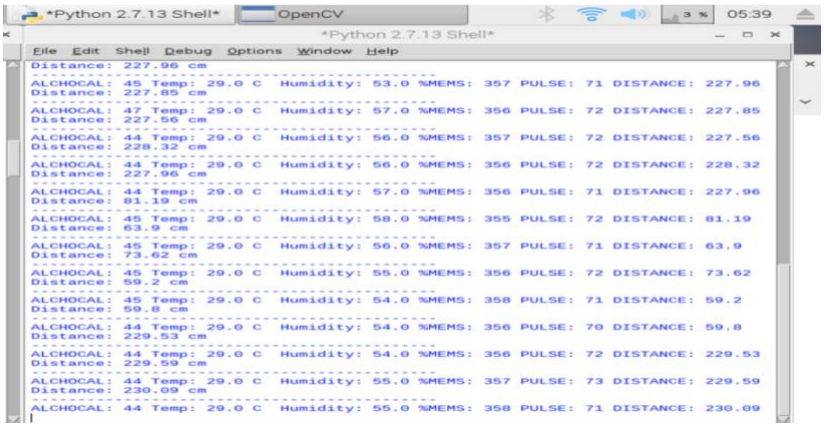

Fig. 6. Output of the Black Box System

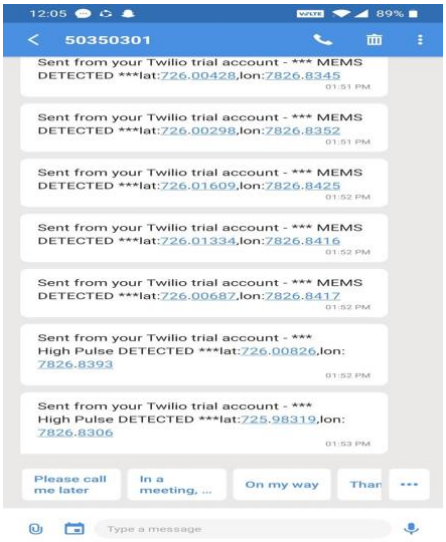

Fig. 7. SMS Alert indicating the vehicle location and risk associated

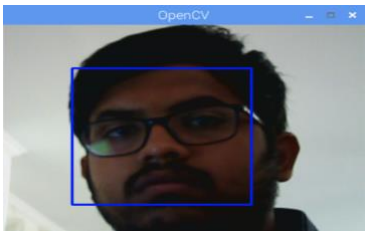

Fig. 8. Training of the Face for Face Recognition

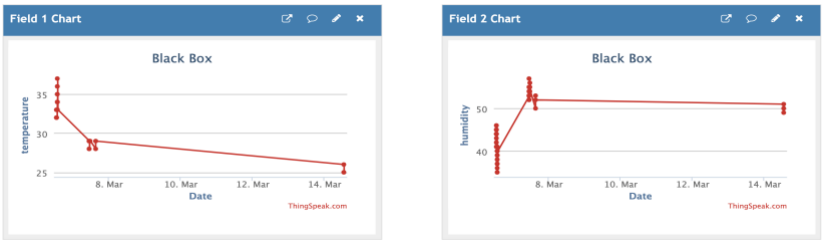

Fig. 9. Temperature & Humidity Data sent to Cloud for further analysis

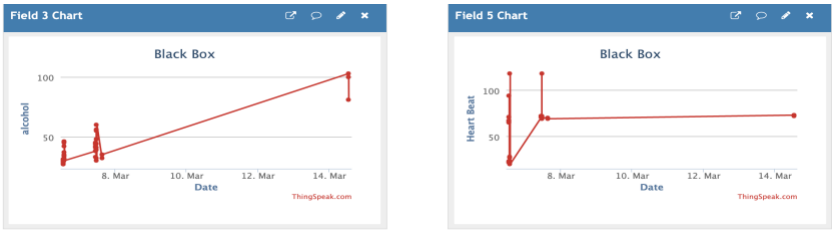

Fig. 10. Alcohol & Pulse Data sent to Cloud for further analysis

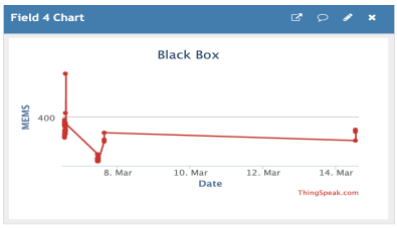

Fig. 11. MEMS Accelerometer Data sent to Cloud for further analysis

6 Conclusion

This paper has proposed and demonstrated a smart and efficient wireless black box system by overcoming the limitations of existing black boxes as presented in our detailed survey. Our Black Box system can prevent accidents and save the lives of the injured people in the vehicle who met with an accident using IoT technology. This black box not only applies for accident prevention, but also extends to theft prevention application. Our Black Box works as pre-accident detection system by preventing the drunk driver from driving the vehicle with the help of Alcohol sensor. We have also made an effort to monitor the health of the driver by monitoring his/her pulse with Pulse sensor by which we can save the driver and others lives by informing the hospital services at an early stage. We also provided with the detailed analysis of vehicle surroundings with sensors data by visualizing them in separate channels. Using our black box system, there can be significant reduction in the occurrences of accidents.

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