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Advanced Driving Assistance System for Cars Using Raspberry Pi

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Abstract

Objectives : Hardware implementation of advanced driving assistance system which can be able to identify i). Lane detection and assist system. ii). Blind spot detection and warning system (BSDW). iii). Forward collision and warning system (FCWS). iv). Pedestrian detection system. The primary goal of the developed system is to identify the above features in order to prevent accidents on the road and ensure pedestrian safety. **Methods**: The suggested method uses a canny edges detection algorithm is used to detect road edges. The input to this system is images captured by the camera with the help of the Open CV library a python image processing algorithm is created that tracks the lane. Histogram of Orientation (HOG) using the sliding window method is used for pedestrian detection. The control unit for the proposed system is Raspberry Pi module 3B, JSN-SR04T ultrasonic sensor and HC-SR04 ultrasonic sensor has been used for (BSDW) system and (FCWS) respectively. **Findings:** Results demonstrate that the suggested technique can accurately recognize both straight and curved lanes using edge detection algorithm, and also able to identify vehicles in Blind spot area. **Novelty:** This technology has a high demand in the automotive industry and the system can be implemented in all the future cars which can able to reduce the accident rates.

Keywords: Adaptive Cruse Control; Blind Spot Detection; Autonomous Driving Assistance system; Lane Detection System; Forward Collision; Pedestrian detection; OpenCV

1 Introduction

In the latest survey the fatal road accident has been increased drastically[1]. These accidents are mainly caused due to the carelessness of the driver and the chance of the driver errors while driving like missing the signals, unable to spot the vehicles on the bling spot region etc. [2]. A quick lane change on a busy road is one of the main causes of accidents. It is crucial to grow technology that can help a motorist navigate while they are on the road. This makes the automotive industries to develop a vehicle with advance driving assistance system (ADAS). The vehicle with ADAS feature can able to prevent the accident or minimize the effect of consequences caused during the accident. The cars are undergoing revolution that they are evolving more sophisticated beings that can drive themselves autonomously and learn for their surroundings [3]. The vision for these autonomous cars is to reduce the accident rates, therefore completely or partially autonomous cars present a very promising approach to reduce traffic congestion and increases the road safety a lane designation system can be of great assistance.

This Research study will give a brief idea about the need of active safety in the automotive industries with some of the ADAS features. Even though some of the research have been going on in this field, in ref[4] the author uses HC-SR04 ultrasonic sensor for BSD which has short range and less field of view to overcome this paper suggests longer range ultrasonic sensor (JSN SR04T) and has field of view of 75degree.Considering edge detection where canny edge detection which involves several steps of image processing but along with lane detection the vehicle should be able to actuate when it is crossing the lane thus the developed prototype uses the threshold value to keep the vehicle in lane [5].

Although the majority of the high-end automakers, like Mercedes Benz, Audi, and Bentley, installed cutting-edge driver aid systems in upscale vehicles that are only affordable to a select group of the population. Due to the high cost of the sophisticated sensors (such stereoscopic cameras, LIDAR, and RADAR) and the exact calibration required to create such systems. Therefore, it's important to make technology available to everyone in society and to create embedded products that can be easily integrated into already-existing vehicles. The Raspberry Pi version 3 is used as a central processing unit in this implementation to test the viability of using it as a controller for an autonomous vehicle that is connected to cameras and ultrasonic sensors. Ultrasonic sensors are less expensive, need less energy, and properly estimate the distance to an obstruction before relaying that information to the system [6]. Obstacles that are present in the front, back, and sides of the car are identified thanks to the Raspberry Pi and the ultrasonic sensor connection. The industry grade ultrasonic sensors also pick up on obstructions in the blind zone. This track the detection of obstacles on a road.

2 Methodology

The system is implemented in four steps (1) Lane detection and assist system (2) Blind spot detection and alerting system (3) Forward collision avoidance system (4) Pedestrian detection system. The proposed system is built on a Raspberry Pi 3 module B board and interfaced with a number of sensors, including camera, display, buzzer, and ultrasonic sensors such the HC-SR04 and JSN-SR04T.The system overview is as shown in the Figure 1.

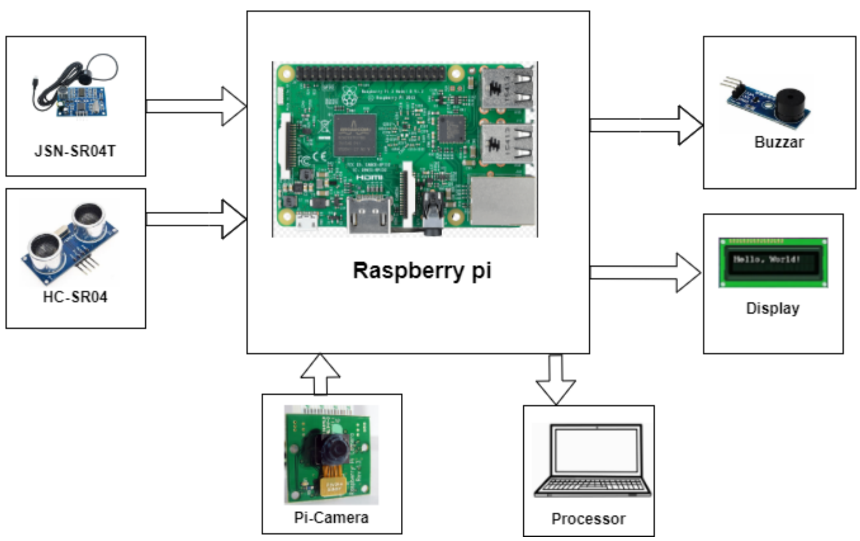

Fig 1. Block Diagram of the System

Figure 2 shows the overall flow diagram of the working process once the sensor giver the output there are two necessary actuation the vehicle supposed to be taken one it should stop to avoid the collision and also indicate the buzzer signal. When the sensors are powered up it gives the continuous signal to the controller in the form of the distance. If the distance is less than threshold distance the controller will take the actuation.

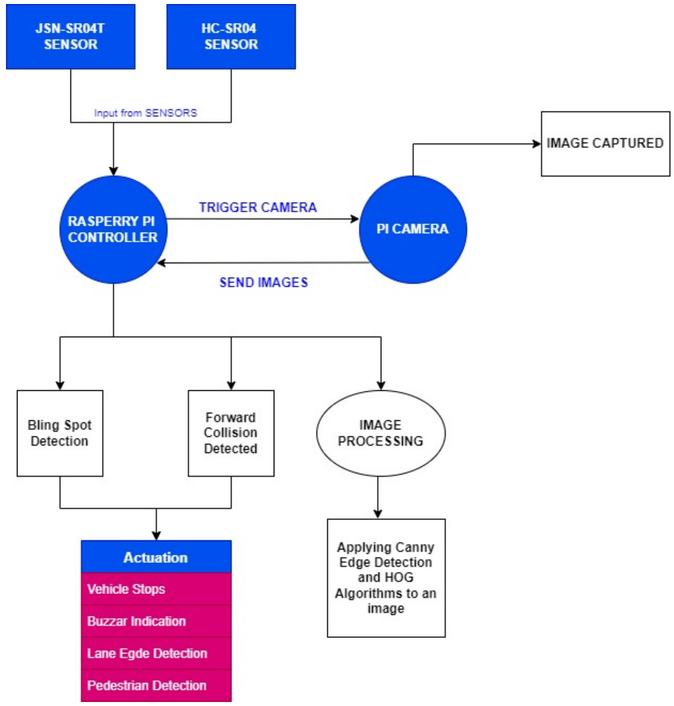

Fig 2. Flow Diagram of developed prototype

2.1 Lane Detection and assist system

Lane detection (LA) is necessary because traffic congestion will be reduced if all vehicles follow one lane. Avert any needless traffic congestion. A control system known as a lane assist system helps a vehicle maintain safe travel within a highway's indicated lane. Without further input from the driver, the LA system recognizes when the vehicle veers off a lane and automatically corrects the steering to resume appropriate lane travel. The ego vehicle will recognize the lane lines and the curves in the lane in front of it for the LA to function properly. Here canny edge detection algorithm is used for detecting the lanes that use a multi-stage algorithm to find different kinds of edges in pictures [7–9]. It works based on the chance in the intensity of the pixels in the edges which makes a lean path. The edge detection operator Canny is particularly well-liked. According to Canny edge detection algorithm, the prerequisites for applying edge detection to various vision systems are largely the same. For this proper edge detection there are few criteria they are

i) Edge detection with low error rate, which means that the detection should precisely capture all of the edges visible in the picture.

ii) The operator's edge point detection should precisely locate on the edge's center.

iii) If at all feasible, picture noise should not produce false edges, and an edge in the image should only be marked once.

The steps involved in canny algorithm is shown in Figure 3.

2.2 Noise Reduction

Since noise in the picture may readily impact all edge detection findings, it is crucial to filter out noise to stop erroneous detection brought on by it. A Gaussian 5x5 filter kernel is convolved with the picture to smooth it out. The Gaussian Filter is a type of low pass filter which is used for noise reduction which are high frequency components. The pixels closest to the kernel's center in a Gaussian blur are given more weight than those furthest from it. This channel-by-channel averaging is followed by the usage of the average channel values as the new value for the pixel in the filtered image.

Mathematically Gaussian blur is the process of applying the convolution to the Gaussian Function. The convolution of two different functions results in the third function which is the product of the first two function and one is reversed and the other

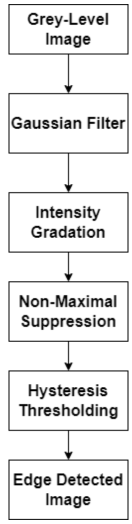

Fig 3. Canny edge detection flowchart

function is time shifted. The expression for gaussian function for the kernel is shown below

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \tag{1}$$

Here 'x' is the distance from the origin in the horizontal axis, 'y' is the distance from the origin in the vertical axis and 'σ' is the standard deviation of the Gaussian distribution.

2.3 Intensity Gradient

A gradient in an image is a shift in hue or intensity that occurs in one direction only. The gradient of the image, one of the fundamental building blocks in image processing, is also utilized to create a progressive color mix that may be thought of as an even gradation from low to high values, as used in the photos to the right from white to black. The smoothed image is filtered using a Sobel kernel in both directions to produce the first derivative in the horizontal direction (Gx) and vertical direction (Gy). Edges are always perpendicular to the gradient direction. It is rounded to one of four angles that stand for the two diagonals, two verticals, and one horizontal.

2.4 Non-Maximum Suppression

Non-Maximum Suppression is a process used to thin out the edges. The principle in this process is that the process looks for the pixels with the highest values in the edge directions among all the points on the gradient intensity matrix. After determining the gradient's size and direction, the entire image is scanned to weed out any extraneous pixels that might not be the edge. For this, it is determined whether each pixel is a local maximum in its vicinity in the gradient's direction.

2.5 Hysteresis Thresholding

Remaining edge pixels after the use of non-maximum suppression offer a more realistic portrayal of actual edges in a picture. However, there are still some edge pixels with noise and color variance. At this stage, it is determined which edges were indeed edges and those which ones are not. For this, we need the threshold values minVal and maxVal. Any edges with gradients of intensity more than maxVal are guaranteed to be edges, and any edges with gradients of intensity lower than minVal are guaranteed to be non-edges, thus they should be ignored. After Hysteresis process a technique known as the Hough Transform can be used to distinguish the characteristics of different shapes within an image. In order to achieve the appropriate picture pixels, the Hough Transform is applied to an image once the canny edges have been detected.

2.6 Blind Spot detection and Alerting system

Blind Spot is area behind the car which will not be available either from the front view mirror or from the rear view mirror [10] [11]. The vehicle's BSD autonomy is provided by ultrasonic sensors. The JSN-SR04T sensor was utilized, which could connect via jumper wires to the Raspberry Pi's GPIO pins. The JSN-SR04T operates on the basis that it has four pins: ground, power, trigger, and echo. The trigger serves as a "starting gun" for the sensor by indicating when to emit a high frequency soundwave, and the echo is where the soundwave is received back. Power connection and ground connection were directly to the Raspberry Pi's voltage and ground pins. Despite being binary input/output functions, they may be utilized in python to find the nearest object's distance. The programming logic is shown in flowchart as shown in Figure 4.

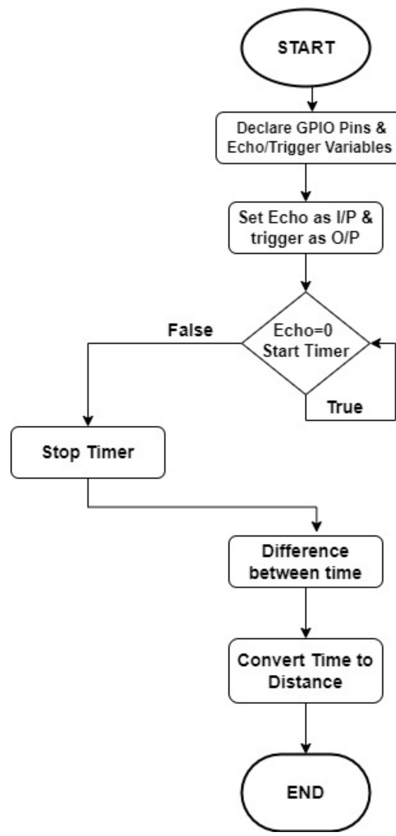

Fig 4. Ultrasonic sensor working flowchart

2.7 Forward Collision Avoidance system

FCAS system monitors the forward motion of the vehicle to identify and warn the approaching conflicts and a type of autonomous emergency braking system [12]. This System tries to prevent the accident by deploying the break until the impact is certain The methodology beyond BSD and FCAS is same expect in the sensor used here is HC-SR04 which has less range compare to JSN-SR04.

2.8 Pedestrian detection system

The implementation of simple Pedestrian detection system is as shown in Figure 5 and is implemented using OpenCV library [13]. OpenCV is a C/C++-based open-source library that can also be used in Python. For computer vision tasks like face recognition, motion detection, object identification, etc., it is one of the most often used libraries. A pre-trained HOG + Linear SVM model is already present and may be used to detect pedestrians. Histogram of Orientation (HOG) using the sliding window method, the algorithm examines each pixel's neighboring pixels. The aim is to determine whether the current pixel is darker than the adjacent pixels, and if it is an arrow is drawn displaying the direction in which the image is going darker for each pixel. For classification and regression issues, the LSVM is a linear model. According to the SVM theory, the algorithm draws a line or a hyperplane that divides the data into classes [14–16]

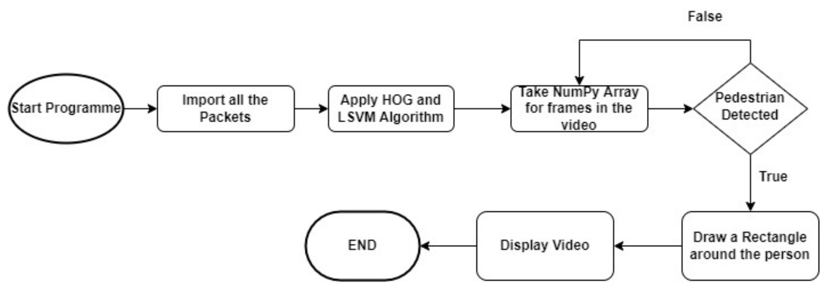

Fig 5. Pedestrian Detection flowchart

2.9 Software Implementation

As Mentioned above the software implementation procedure is as shown in Figure 6 and it is of four features that run in Python (IDE) with the help of OpenCV and NumPy libraries the pedestrian detection and Edge detections are obtained. The following flowchart as shown in Figure 6 describes the overall working of the prototype developed [17].

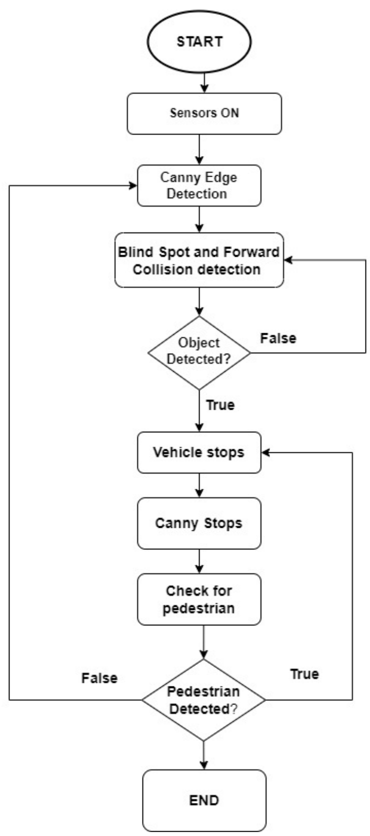

Fig 6. System flowchart

When the device is powered all the sensors turned ON. Using Canny Edge detection technique, the road edges are detected and simultaneously the Blind spot and forward collision detection will be detecting the object in the region. If the object in the region is detected the vehicle applies autonomous breaking and stops at the mean time Canny algorithm is stopped and checks for the pedestrian or the object if not in the region the vehicle continues to move.

2.10 Hardware Implementation

The hardware components used for implementation of prototype are as follows

1. Raspberry pi B+ model: Raspberry Pi 3B is the third generation of raspberry pi which has some added features to the previous module b+ and raspberry Pi 2. Coming to the overview of this module the size of this board is as credit card which has 64-bit quad core processor and this processor is running at 1.4 GHz frequency and the dual-band 2.4GHz frequency.
2. Motor Driver (L298N): The L298N driver module is utilized in the project to operate DC and stepper Motors. It is a driver module with high power.
3. Power Bank (for source)
4. LCD (liquid crystal display) (16x2)
5. Pi CAM (for video feed): Official Raspberry Pi merchandise includes the Camera Modules. The 5-megapixel model Camera Module v2 is utilized in our project.
6. Ultrasonic sensor (HC-SR04, JSN-SR04T)
7. Motors

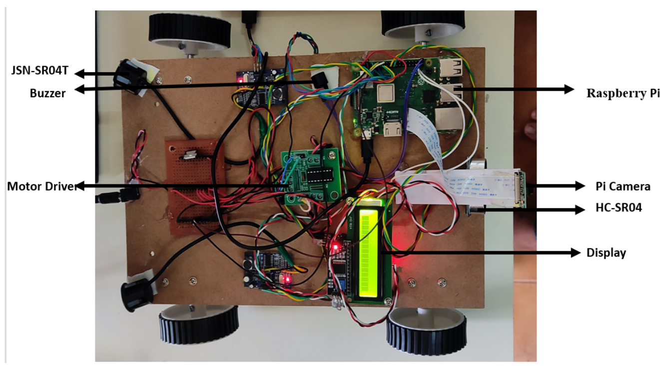

Fig 7. Autonomous Vehicle

The above Figure 7 shows the developed prototype. The raspberry pi is wired to each and every component of the system. The raspberry pi received input stream from the pi camera. All these sensors sends the data to the controller and Raspberry Pi makes the decision and sends it to the motor which controls the vehicle.

3 Results and Discussion

The test was conducted in the laboratory where the prototype is developed, for Edge detection the various types of straight lane and Curved lane video were played, and pi camera captures that Image in RGB form and Grey scale is applied to reduce the Noise components in an image, then Intensity Gradation is applied using Sobel kernel along X and Y direction to find the edges, Non Maximum Suppression is done to thin out those edges.

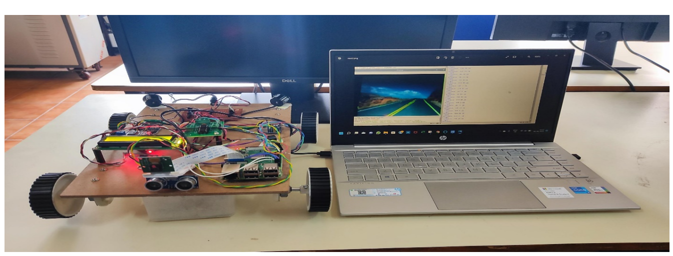

Fig 8. Experimental Setup

The Figure 8 shows the experimental setup. Firstly, highway roads and curve roads provides the best edge detection output with least False edges rate and in the night view some of the false edges were observed but able to detect the roads with edges detection. It is demonstrated in the following figures. Figure 9 shows the edge detection output for the straight lane as the video of straight line is feed into controller through pi camera and the edges are detected successfully. In Figure 10, the curve edge video is feed to the pi camera for edges detected. Figure 11 shows the canny edge detection output for straight roads during night view. Similarly under various road conditions such has snow road, mud road, roads without lanes and also highway road during night has been verified and listed in table I. The Ultrasonic sensors are also verified which were used for blind spot and forward collision and the readings are as shown in Figure 12. The minimum range for which JSN-SR04T which is used for BSD can detect is 22cm, so the detection starts if the obstacle is in the range between 22cm -600cm. The buzzer signal with low frequency will be sent to the driver if the vehicle is in the range of 400 cm and as the vehicle starts approaching near the range mentioned above, the frequency of buzzer will be increased to avoid collision. Here for experimental purpose, we have kept the safe distance as 50cm below which the buzzer signal is given and also the designed system capable enough to detect the pedestrian as shown in the Figure 13.

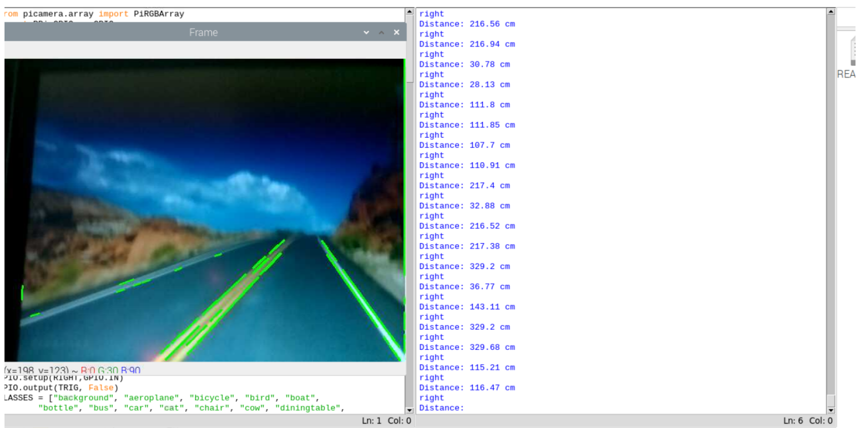

Fig 9. Canny edge detection output for straight roads and forward ultrasonic reading

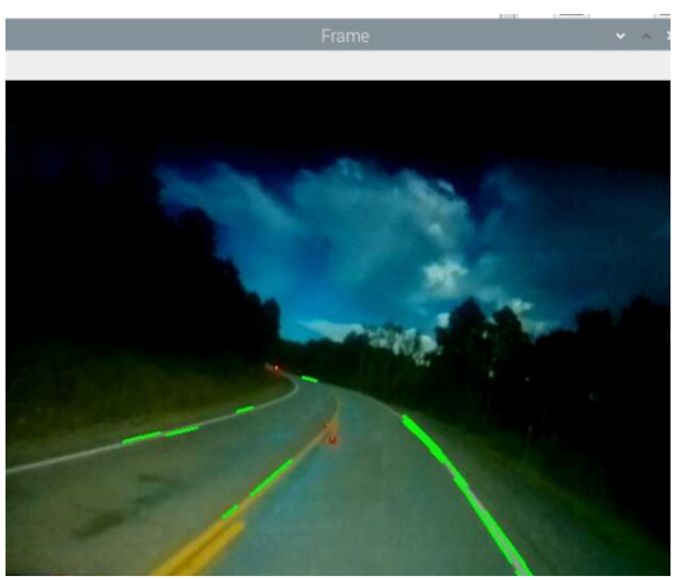

Fig 10. Canny edge detection output for curved roads

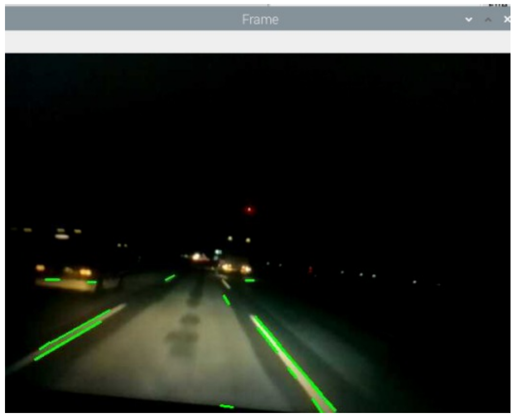

Fig 11. Canny edge detection output for straight roads duringnight view

```
[INFO] loading model...
Distance: 71.62 cm
left: 27.77 cm
right: 269.07 cm
straight
Distance: 71.84 cm
left: 27.78 cm
right: 22.8 cm
straight
Distance: 57.78 cm
left: 22.84 cm
right: 686.65 cm
straight
Distance: 26.05 cm
left: 30.87 cm
right: 270.06 cm
straight
```

Fig 12. Ultrasonic Readings For BSD and Forward Collision

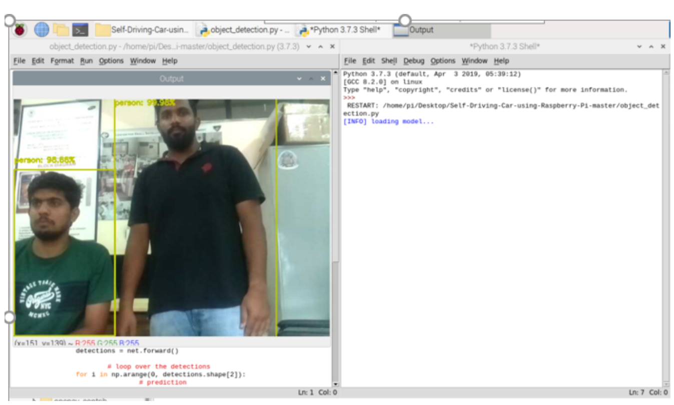

Fig 13. Pedestrian detection using OpenCV

4 Conclusion

This study mainly presents the prototype for autonomous vehicle with all the four features which we have discussed above section. The algorithms were put into practice on raspberry pi to utilize lane detection in real time. The Canny algorithm is regarded as the approach for edge detection, which is a crucial component of lane detection. The realization approach of lane edge detection is provided utilizing a combination of the aforementioned attributes. The lane edge detection implementation steps are then provided. A linear lane is detected using the Hough Transform. Both the ultrasonic seniors JSN-SR04T (2) and HC-SR04 are able to identify the obstacle in the defined region accurately and able to actuate the vehicle. The Raspberry Pi operates as a potential microcontroller alternative for an autonomous system, as demonstrated through the development and assessment of the driverless car. Since Raspbian, the operating system that the Raspberry Pi runs, is not optimized for performance in real-world settings, speed is the key area of concern. However, the advantages of automating a system have been demonstrated by our results using the Raspberry Pi as a microcontroller. The viability of usage enables access to data that may be extrapolated to identify systemic issues.

Future Scope: ADAS is one of the most emerging technology in the automotive industry. In Future, the driver less car will be common so that it give some flexibility to the driver. Each features in this prototype can be installed in the car with separate advanced controllers and sensors for real time usage. All this ECU's should communicate through the CAN module and gives the information to the driver.

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