Autonomous Driving and Stop Sign Detection using AI and IoT

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***Abstract* – Autonomous driving and object detection are two of the most anticipated future technologies, as well as the most important goals of intelligent transportation systems. It is built on techniques from machine learning, image processing, and data analysis. Hence this paper outlines the development of a low-cost prototype of a compact self-driving automotive model that makes use of simple and easily accessible technologies for object detection and autonomous driving. The system comprises of Raspberry Pi 4 and Raspberry Pi camera which automatically gathers the video data which are analyzed in OpenCV to recognize the traffic sign and run the car. The system also comprises of an ultrasonic sensor, which is employed in the object detecting process. Additionally, it has a motor driver and a DC Gear Motor that work together to control the rover's movement in the forward, left and right directions and stops when it encounters a stop sign. A sophisticated model called a Convolutional Neural Network or CNN is used to accomplish road sign detection, object detection in the autonomous vehicle control system. The CNN architecture allows for the construction of creative object identification models.**

***Keywords* – Autonomous driving, Stop Sign Detection, Object Detection, CNN, Raspberry Pi**

I. INTRODUCTION

The era of driverless vehicles is upon all modes of transportation. Relying on artificial intelligence has been a part of the system in various capacities, be it for vehicles, train or aviation auto-pilot mode. Several human errors including talking on the phone, speeding, and intoxicated driving have served as the cause among several transportation issues and accidents. These disorders are statistically prevalent and growing progressively more severe. It is intriguing to confront this human issue with the deployment of technology in the form of a driverless car since researchers have reported that 78% of vehicle incidents are caused by the driver's error or human error in driving. Thus, one of the most frequent contributors to crashes on Indian roadways is driver error. Scientists are employing creative concepts to manufacture self-driving models based on image recognition or sign recognition because of recent improvements in technology. The objective of this paper, "Autonomous Driving & Stop Sign Detection Using AI and IoT", relies mainly on AI libraries. This model incorporates a mechanism for self- driving cars to recognize signs using Raspberry Pi. It is tricky to see traffic signs such as stop signs, turn left, turn right, etc. and objects in the path when there are numerous moving vehicles on the road. The snapshot is captured and examined by the web camera installed on the moving prototype car.

II. LITERATURE REVIEW

[1] **Darsh Parekh "A Review on Autonomous Vehicles: Progress, Methods, and Challenges" | July 2022 Multidisciplinary Digital Publishing Institute**

Utilizing necessary hardware like LiDAR and additional mechanisms like Anti-lock Braking System, Pedestrian Detection, and Region based Convoluted Neural Networks, the authors used YOLOv3 as their architectural design. They identified and reviewed all the upcoming research problems for additional studies in this field while conducting this survey, with the majority of them connected to having put the suggested technology into action. Instead of merely emphasizing on the self-driving model, the author has employed the majority of the various processes and has incorporated an entire system of autonomous vehicles, which it should adhere to be a cutting-edge model.

[2] **Irfan Ahmad, Karunakar Pothuganti "Design & implementation of real time autonomous car by using image processing & IoT" | 2020 Institute of Electrical and Electronics Engineers**

The technologies of traffic sign detection, path identification, and the use of the YOLOv3 model are discussed in this research. The training dataset directory contains all of the photos, which have been labelled by drawing bounding box coordinates around each car that was located. To distinguish between distinct segments and make a crucial decision that will be useful in the field of an autonomous vehicle, a neural network like CNN is used. But even though the YOLO models are quick and appropriate for real-time applications, they are not as accurate as R-CNN models. The YOLO algorithm not only detects the traffic light but also the surrounding objects. In the event that the driver becomes distracted, this algorithm will assist in helping him or her fully comprehend their surroundings. It incorporates CNN similar to other object identification techniques; however, it outperforms other algorithms because to its rapidity and efficacy in real -time situations. This methodology is considered to be the quickest technique for object detection significant algorithm for autonomous vehicles.

[3] **Dr. Sharmila S. Gaikwad "Model of Autonomous Car" | May 2020 International Journal of Engineering Research & Technology**

Several IoT devices, notably Arduino, Sensors, Raspberry Pi, and software applications like OpenCV, as well as environments like Spyder IDE, are employed in this study. They have adopted neural networks with high-end architecture, such as CNN deep learning models. Also, the RGB image data has been preprocessed into various predetermined formats. This paper describes how to create a self-driving car model. There are detailed descriptions of the various hardware parts, alongside the software and neural network configuration. In this study, a functioning prototype of a self-driving automobile is proposed. This car is capable of travelling through a wide range of environments, including straight tracks, curved tracks, and straight followed by curved tracks.

[4] **Pratibha I Golabhavi , B. P. Harish "Self-Driving Car Model using Raspberry Pi" | Feb 2020 International Research Journal of Engineering and Technology**

Using its General-Purpose Input Output (GPIO) connections, the Raspberry Pi 3 controller is connected to a number of sensors, which included an H-bridge motor driver, IR sensors, and ultrasonic sensors. Python library and a webcam are used for image processing in order to recognize objects in real-time. A Wi-Fi connected Android phone is employed as a desktop to connect to the controller board and function as an input device for commands and program execution. It is discovered that the self-driving automobile can identify traffic lights and react to them as follows: For red, the vehicle stops; for yellow, it moves slightly forward before stopping; and for green, it advances. When a self-driving car is involved in an accident, an alarm message is successfully delivered to the contact person's registered cellphone number through a Twilio account when the X-axis of an accelerometer deviate from a fixed value. This is a low-cost self-driving car prototype that has been constructed and successfully tested for all of its capabilities. With an IR sensor module, the car can effectively follow lanes and identify the colors of oncoming traffic.

[5] **Nandhini N, Rakshana R, Revathi L, Siva Swarnamalya, Nagaraj V "Autonomous cars using Raspberry Pi" | May 2020 International Research Journal of Engineering and Technology**

The suggested system is an autonomous vehicle prototype with many goals, notably pothole identification, traffic light detection, and speed control in school zones. The Raspberry Pi CPU and numerous sensors are used to achieve the aforementioned functions. Gear motors are used to assemble the robot. The humps and potholes are recognized through the use of an ultrasonic sensor. The traffic lights are detected by a color sensor. The speed sensor provides information about the vehicle's speed. The autonomous vehicle system utilizes the algorithm described in this paper with success. An approach to creating a self-driving car is given in this study. The various hardware parts and how they are put together are aptly described.

[6] **Lex Fridman "Large-Scale Naturalistic Driving Study of Driver Behavior and Interaction with Automation" | 2019 Institute of Electrical and Electronics Engineers**

Many Deep Learning models, notably CNN and YOLO, as well as the most recent top datasets, comprising COCO, KITTI, CityScrapes, etc. used SOC (Banana Pi Pro). The dataset for this study comprised 122 volunteers, 15,610 days of involvement, 511,638 miles, and 7.1 billion video frames. The models that were trained using the most recent datasets are very close to becoming state-of-the-art. CV has created intelligent systems like driver heartbeat, facial, and eye surveillance. It has been carefully examined and concluded that the instrumentation platform RIDER has adequate data collecting capabilities towards naturalistic driving research. The phases of research, development, and testing led to several system limitations. A single board computer is sufficient for the bulk of collection related tasks, but due to its little system memory, expansion may be challenging.

[7] **Vaibhav Swaminathan, Shrey Arora, Ravi Bansal, Rajalakshmi R "Autonomous Driving System with Road Sign Recognition using Convolutional Neural Networks" | 2019 International Conference on Computational Intelligence in Data Science**

Existing systems attempts to make it feasible for an autonomous vehicle to sense, identify, and compute the distance to traffic signs in order to make the best decisions regarding when to stop, turn, or continue driving. Road Sign Recognition, Distance Calculation to Road Sign, Lane Following Control, and Autonomous Driving on Assigned Track are the phases that compose up the proposed system. Several experiments were run to examine the algorithm's accuracy. Belgium's traffic sign data set has been taken into account for all experiments. Sorting into one of the five categories—left turn, right turn, men at work, speed limit 20, stop—is the challenge. A total of 385 pictures were taken into account, of which 259 were used for training. 126 photos of "Belgium Traffic Signs - Testing" made the evaluation set, which had an accuracy rate of 83.7%. Belgium traffic signs have good testing accuracy. Yet, 83.7% accuracy is insufficient because the danger in real life is substantially higher. To be useful in real time, this model must be able to execute at a greater level of accuracy, according to our analysis.

[8] **Mr. Nihal A Shetty, Mr. Mohan k, Mr. Kaushik k "Autonomous Self-Driving Car using Raspberry Pi Model" | 2019 International Journal of Engineering Research & Technology**

The Raspberry Pi receives live video broadcasts from the Pi camera. The Arduino then gives the specs for the modelled automobile to enable the function according to its condition using the data that the Raspberry Pi has analyzed. The vehicle notices a pattern on the road and follows it. The model is capable of recognizing the unique pattern that has been supplied and can identify nearby obstacles. As a result, the model is capable of performing all necessary tasks. The suggested mechanism makes running the vehicle less labor-intensive for individuals. Also, we observe that the efficiency of the proposed Autonomous Driving and Stop Sign Detection employing AI and IoT system is dramatically higher than that of an ordinary user by eliminating the most fundamental human mistakes that may well happen.

[9] **K. Vinothini, Dr.S. Jayanthy "Road Sign Recognition System for Autonomous Vehicle using Raspberry Pi" | 2019 International Conference on Advanced Computing & Communication Systems (ICACCS)**

One of the crucial functions of automated transportation systems is the identification of road signs. The project attempts to use the Haar Cascade Classifier technique to provide traffic sign recognition and autonomous vehicle control. In this study, the system automatically recognizes traffic signs, manages the car, and issues commands for certain activities. The system is made up of a Raspberry Pi 3 CPU and web camera that automatically gather video data and transform it into a number of frames which are subsequently examined by an OpenCV algorithm to identify traffic signs and guide the vehicle. Two DC motors connected to a Raspberry Pi are utilized to drive the car in compliance with the observed indication. The data is entered onto Open CV, which is a component of the Raspberry Pi 3 package. Around five datasets of various traffic sign photos are collected and saved on a Raspberry Pi Class 10 SD card for processing in the proposed study. Whenever a traffic sign is detected by a car, the Raspberry Pi results contain image identification with message display.

[10] **Manish Reddy "A Self Drive to Utopia" | 2018 Journal of Legal Studies and Research**
Using the Indian Constitutional Laws which include the Motor Vehicles Act of 1988 and the Information Technology Act of 2000, this case study investigates the legal regulations pertaining to electric vehicles in India. Although the autonomous vehicles aren't entirely ideal, they are indeed a crucial beginning towards the kind of society where critical concerns like parking and accidents that we encounter daily would seem insignificant and unimportant because they would all have been resolved. As stated by the author, there are three primary types of autonomous cars in India, and that each group is governed by different legislation. With existing technology, completely autonomous vehicles really aren't possible, hence there are few laws governing them. Nevertheless, there are various laws and regulations governing semiautomated as well as driver assistance automobiles.

III. OBJECTIVES

The objective is to successfully achieve simple autonomous movement of a rover using AI and deep learning library (OpenCV) from python based on traffic signs.

- We will be using a Raspberry Pi SBC and integrate it with certain moving parts such as servo motors etc. coupled with various components and sensors to form the rover.
- The program running in the SBC consists of strategically competent AI computer vision libraries such as OpenCV and other python libraries.

IV. REQUIREMENTS

Hardware Requirements

- Intel core i5 8th gen and above
- 8 GB RAM (or above)
- Disk space-10 GB minimum
- Raspberry Pi
- Raspberry Pi Camera
- Ultrasonic sensor
- Motor driver
- DC Gear Motor

Software requirements

- Python
- OpenCV
- Linux
- PuTTY
- VNC Viewer

V. DESIGN

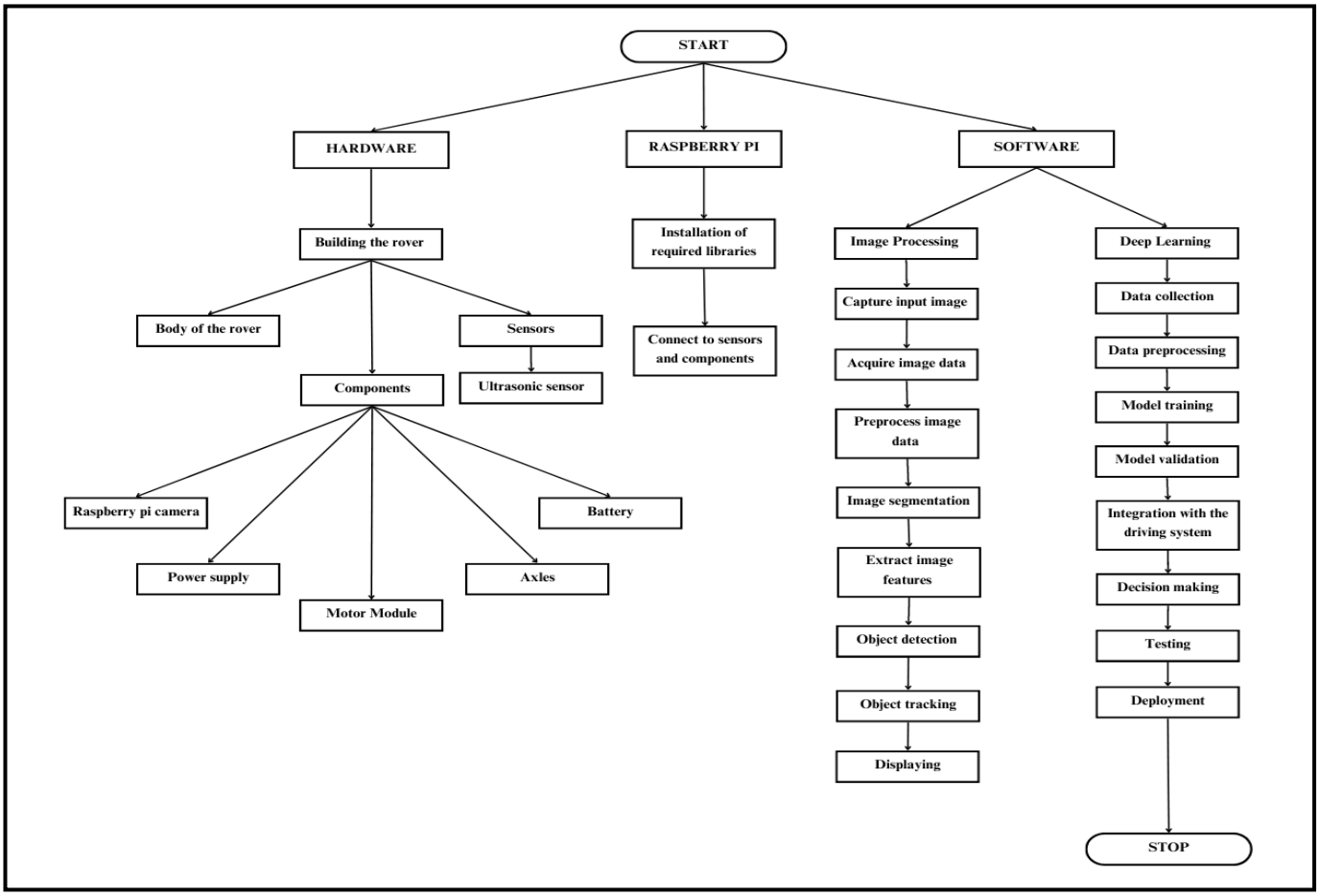


Fig.1 Flowchart

VI. METHODOLOGY

1. Installation of Raspberry Pi and importing libraries.
2. Hardware section - Building the car
3. Software section which includes image processing, deep learning and accessing the Raspberry Pi desktop.

Installation of Raspberry Pi and importing libraries

Setting up the hardware and software required to run a Raspberry Pi single-board computer is part of the Raspberry Pi installation process. A Raspberry Pi board, power supply, SD card, mouse, keyboard and a tv or a monitor are required.

The installation process typically involves the following steps:

- First step is to flash the SD Card with Raspberry Pi OS which is also known as Raspbian.
- Insert the SD card in the microSD card slot on the Raspberry Pi's underside after configuring it with Raspberry Pi OS.
- Connect the mouse and keyboard to the Raspberry Pi.
- The monitor is also plugged and switched on. Then the Raspberry Pi is connected to the monitor.
- Ethernet is connected for Internet. Power supply is given to the Raspberry Pi through the power port.
- Finally, the Raspberry Pi OS setup is done.
- All required libraries like OpenCV, NumPy, SciPy are installed onto the Raspberry Pi.

Hardware Section – Building the car

The various hardware components used are

1. Raspberry Pi 4
2. Ultrasonic Sensor
3. Raspberry Pi Camera
4. DC gear motor
5. Battery
6. Driver motor
7. Power supply

All of the aforementioned components are connected to build the rover. The wheels and axels are coupled to DC gear motors, which propel the rover along its path. The rover's front end is where the ultrasonic sensor is located which is used to detect objects in the

path and to determine the distance. The raspberry Pi camera, which is mounted on the rover's top, is in charge of seeing traffic signs i.e., forward, left, right, and stop signals. An external power source is provided for the Raspberry Pi. The battery is attached to run the rover.

Software Section

This section deals with the sign detection and object detection. The three components of the software portion are

1. Image Processing
2. Deep Learning
3. Remotely accessing the desktop of the Raspberry Pi

Image Processing

Image processing is a technique for analyzing digital photographs with the use of computer programs and algorithms. Image processing is done to an image in order to extract relevant information from it, enhance its quality, or change it into a more acceptable format for additional analysis or visualization. This deals with the reaction to visual stimuli.

The image processing steps involve:

a. Capture input image
b. Collect image data
c. Preprocess image data
d. Prepare and feed image to CNN model
e. Extract image features
f. Object classification
g. Postprocessing
h. Displaying

Therefore, image processing in CNNs entails performing a series of operations on input pictures in order to extract valuable features that may subsequently be utilized for a wide range of image processing tasks, including object detection.

Deep Learning

Deep learning in CNN educates the network to recognize characteristics in pictures at various levels. Convolutional, pooling, and fully linked layers are among the layers that make up the network. The task of removing features from the input picture is carried out using convolutional layers. These feature maps record several facets of the source picture, including edges, corners, and other patterns. Pooling layers reduce the spatial size of the feature maps by down-sampling them. As a result, the network becomes more effective and the amount of computing needed in later levels is reduced. The input picture is classified using fully linked layers. They use the characteristics that were retrieved by the convolutional and pooling layers to anticipate what the image's content would be.

Deep learning process involves the following steps:

a. Data collection: For CNN models to be trained for autonomous driving, a vast amount of training data which include pictures must be gathered.
b. Data pre-processing: In this phase, the data is pre-processed to make sure it is in a format that can be used for training.
c. Model training: The pre-processed training data is used to train the CNN model. The model is trained to recognize several different types of road sign by becoming familiar with their distinctive patterns and characteristics.
d. Model validation: After the model has been trained, its accuracy and performance are assessed using the validation set.
e. Integration: Once the CNN model is trained, it is integrated with the autonomous driving system.
f. Decision making: This involves using the model to analyse real-time data from sensors and cameras, to make decisions and control the vehicle.
g. Testing: To guarantee that the system is reliable and safe, various scenarios and settings are used to test and verify it.
h. Deployment: Once it is determined that the system is performing as intended, it may be employed in autonomous vehicles, the rover in our scenario.

Remotely accessing the desktop of the Raspberry Pi

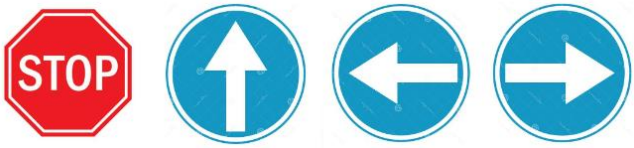
With the help of PuTTY and VNC Viewer, we can remotely view the Raspberry Pi's desktop via the internet.

For computers running Microsoft Windows, PuTTY is an entirely free program that implements SSH and telnet which additionally comes with an xterm terminal emulator. PuTTY enables users to establish network connections to distant servers and gadgets using a number of protocols. In order to access an account on a Unix or other multi-user system from a PC, in our case Linux, PuTTY will be helpful.

VNC is a method for remotely viewing the graphical desktop of your Raspberry Pi. VNC Viewer is quite simple to set up, but it often only allows access from a different computer that is connected to the same network as the Raspberry Pi. Therefore, the computer and the Raspberry Pi is connected to the same network to access the desktop of the Raspberry Pi on a computer.

VII. RESULT

The four-wheeled self-driving rover analyses the signs given and drives accordingly.



It also detects obstacles on its way using Ultrasonic sensor. The four-wheeler reads traffic signals and drives safely using CNN. Innovative object identification models are built using the CNN architecture and the rover is controlled by the Raspberry Pi on the model based on these models. The visual inputs are taken using the Raspberry Pi camera.

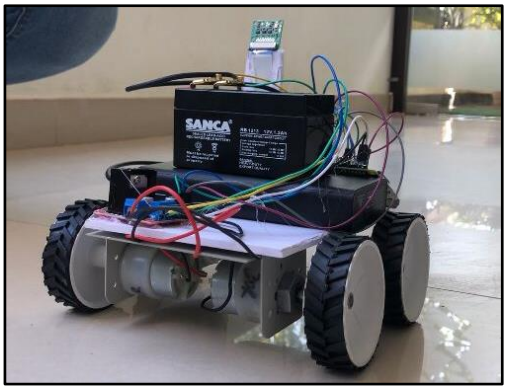


Fig.2 Four-wheeled Rover

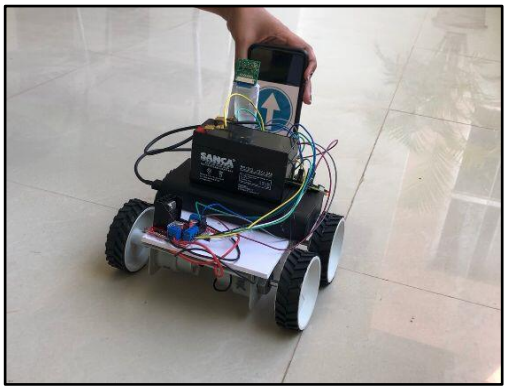


Fig.3 Forward Sign

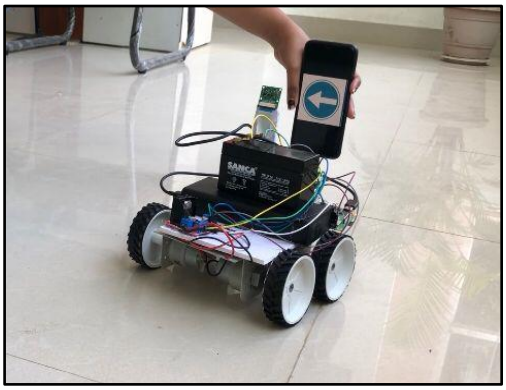


Fig.4 Left Sign

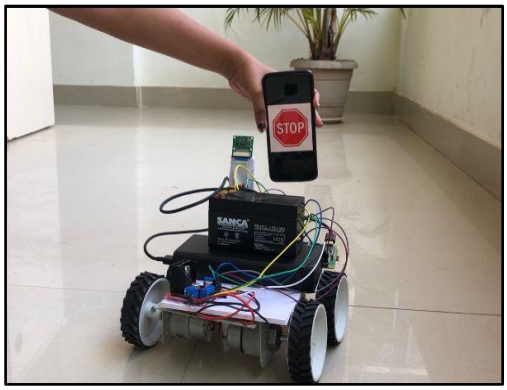


Fig.5 Stop Sign

VIII. CONCLUSION

We have detailed, highlighted, and examined the technical advancements in autonomous driving throughout the world. In this paper, the design and construction of a self-driving rover are described. The different hardware parts and their integration are described in great depth. The four-wheeler reads traffic signals and drives safely using CNN. The goal of our effort is to make independent mobility realistic and practicable.

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