Raspberry Pi Based Real Time Lane, Obstacle and Traffic Signal Detection System

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Abstract - The project proposes a Raspberry Pi-based system for real-time detection of lanes, obstacles, and traffic signals to improve road safety and assist drivers. The system uses computer vision algorithms and sensor data to provide situational awareness for vehicles. The lane detection module uses image processing to identify lane markings and estimate vehicle position, while the obstacle detection module uses visual and distance sensors to identify obstacles in the vehicle's path. The traffic signal detection module uses image processing to identify and interpret traffic signals, helping drivers adhere to traffic regulations. The integration of these modules on a Raspberry Pi platform allows for compact deployment within vehicles, ensuring timely response to dynamic road conditions. This project offers a promising solution for intelligent transportation systems aimed at reducing accidents and improving traffic flow in urban environments.

Key Words: Spotting,hough transform,obstascle detection,rasp cam,traffic signal detection,lane.

1.INTRODUCTION

Sophisticated technology such as a real-time Lane, Obstacle, and Traffic Signal Detection System is used to improve road safety and traffic flow in a variety of settings, such as cities and highways. This technology detects and analyzes the surrounding road conditions in real-time using sophisticated sensors, cameras, and algorithms.

1. **Lane Detection**: This part recognizes solid, dashed, and boundary lines that denote lanes on the road. It supports lane-keeping operations and aids in locating the vehicle within the lane. Image processing techniques are commonly employed by lane identification algorithms to precisely identify and track lane markings.

2. **Obstacle Detection**: This function identifies items or impediments on the road, including cars, people, trash, and animals. By giving the driver early warnings or activating automated braking systems in self-driving cars, it contributes to the prevention of collisions. A variety of sensors, including LiDAR (Light Detection and Ranging), radar, and cameras, are frequently used in conjunction with machine learning algorithms in obstacle detection systems to recognize objects.

3. **Traffic Signal Detection**: This part detects traffic signals at intersections or along the route, such as traffic lights and signage. In order to help drivers modify their speed and behavior, it provides information about impending traffic signals, including their status (red, green, or yellow). Usually, image processing algorithms are used by traffic signal detection systems to identify traffic signals from video feeds.

All things considered, the combination of these three elements into a single system offers drivers, self-driving cars, and traffic management agencies thorough situational awareness. Through precise real-time detection of lanes, obstructions, and traffic signals, this technology contributes to increased road safety, a decrease in traffic accidents, and an improvement in transportation network efficiency. Furthermore, it is an essential component in the creation of advanced driver assistance systems (ADAS) are opening the door to safer and more intelligent transportation networks.

2. Related work

1. **Shoeb, M., Ali, M.A., Shadeel, M. and Bari, D.M.A., Self-Driving Car: Using Opencv2 and Machine Learning. The International journal of analytical and experimental modal analysis (IJAEMA), ISSN, (0886-9367).**

The project aims to create a prototype of a self-driving car model using OpenCV2 and Machine Learning technology. Self-driving cars minimize human intervention, making transportation safer and more comfortable. The car model can detect lane paths, signs, and traffic signals, and respond to real-time traffic. Raspberry Pi is used as the central processing unit, along with peripheral devices like Arduino Uno, L298 H-Bridge, and Raspberry Cam2. Algorithms like Lane Detection, Object Detection, Canny Edge Detection, and Harr Cascade Classifier are combined with Computer Vision for necessary functions.

2. **Mandlik, P.T. and Deshmukh, A.B., 2016. Raspberry-pi based real time lane departure warning system using image processing. International Journal of Engineering Research and Technology, 5(06), pp.755-762.**

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Lane detection is crucial for the Advance Driver Assistance System (ADAS), but detecting road lanes in various environmental conditions remains a challenge. The proposed method uses the canny edges detector to detect road edges, while Hough transform isused for image analysis and digital signal processing. Camera captured images are used to track road boundaries, and the Open CV library function on Raspberry Pi is used for image processing. The system can accurately detect both straight and curve lanes in various challenging situations, ensuring safety for pedestrians and preventing road accidents.

3. **Nikam, A., Doddamani, A., Deshpande, D. and Manjramkar, S., 2017. Raspberry Pi Based obstacle avoiding robot. International Research Journal of Engineering and Technology, 4(2), pp.917-919.**

The project aims to create an autonomous robot using Raspberry Pi as a processing chip. An HD camera detects obstacles in real-time, allowing the robot to avoid them using an obstacle detection algorithm. The camera module then uses an image processing algorithm to detect the obstacle and feedback to the Raspberry Pi, enabling it to change the robot's path and redirect it to an obstacle-free path.

4. **Kharkar, V.P., 2018. A road sign detection and recognition robot using raspberry-pi. International Research Journal of Engineering and Technology, 5(9), pp.1001-1005.**

The system designed to prevent road accidents and loss of life and property is based on Raspberry Pi technology. Digital image processing is used for sign capturing and detection, with algorithms resizing captured signs. The Raspberry Pi camera port captures road signs using image enhancement techniques. The embedded system studies speed signs' characteristics and uses daylight vision time for shape analysis and edge detection algorithms. The goal is to implement these techniques to traffic signals using the Raspberry Pi3 board.

5. **Arthi, M.R., Gayathri, M.P., Sree, M.J.K. and HemaPriya, M.K., 2020. Design and \implementation of real time traffic light system using raspberry pi.**

The system uses Raspberry Pis to determine and update traffic light delays based on different vehicle counts. Cameras are placed at intersections to monitor traffic flow and capture picture groups. Message Queuing Telemetry Transport (MQTT) is used to turn red signs into green when an emergency vehicle arrives. This data can be used to investigate traffic conditions at traffic lights connected to the system. The data can be downloaded through communication between Raspberry Pis and computers, which then sends the correct signal to LED lights. This technique is expected to be used to inform people about different places' traffic conditions in the future.

3. Materials and methods

The Raspberry Pi is the central processing unit for autonomous robot operation, coordinating sensors and actuators. It includes a Raspberry Pi board, camera module,ultrasonic sensor, and motor controllers. The software setup includes a Raspberry Pi and a separate computer for intensive processing tasks. Python scripts are developed to capture camera frames and ultrasonic distance data, which are sent to the computer for analysis. Communication between the Raspberry Pi and the computer is established using standard protocols like sockets for seamless data exchange and control command transmission. On the computer side, a robust development environment is set up with libraries for image processing and machine learning. Convolutional Neural Networks (CNNs) are trained for traffic sign detection and Haar Cascade for traffic light detection. The computer script receives data from the Raspberry Pi, processes it using trained models, and combines it with ultrasonic sensor data for obstacle detection. The computer determines the appropriate motor control commands based on factors like sign instructions, traffic light states, and obstacle proximity, sending them back to the Raspberry Pi for execution. This project requires components Raspberry Pi 3B+, Ultrasonic sensor, RaspiCam, L298N Motor driver and DC motors.

Block Diagram

The Raspberry Pi 3B+ is the central processing unit for the system, which uses GPIO pins to interface with sensors and run detection algorithms. It detects obstacles in the vehicle's path and sends distance measurements to the Raspberry Pi for processing. The Raspberry Pi Camera captures real-time video footage of the road, providing input for lane detection and traffic signal recognition algorithms. The laptop is used for monitoring and visualization purposes, receiving processed data wirelessly and displaying the real-time status of lane, obstacle, and traffic signal detection. A Wi-Fi module enables wireless communication between the Raspberry Pi and the laptop, facilitating data transmission. Power supply ensures stable operation of the Raspberry Pi and peripherals. The system workflow involves the ultrasonic sensor detecting obstacles in the vehicle's path, sending distance measurements to the Raspberry Pi, and processing the video feed for lane detection and traffic signal recognition using computer vision algorithms. The results are transmitted wirelessly to the laptop for monitoring and visualization, displaying the real-time status of lane, obstacle, and traffic signal detection.

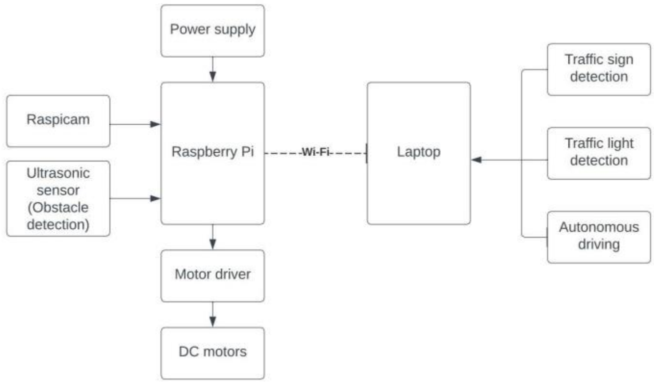

Figure 3.1: Block diagram of the project.

Circuit Diagram

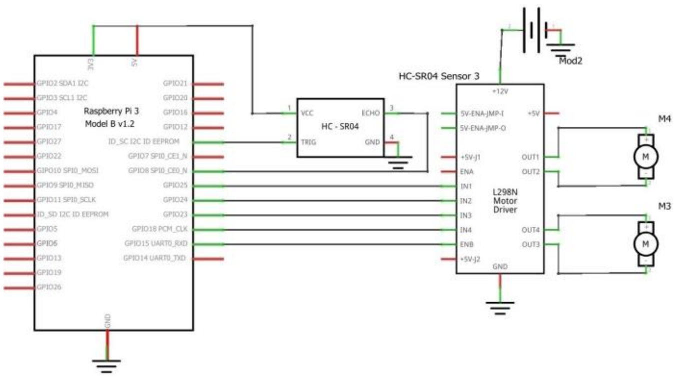

Figure 3.2: Circuit connections of the project

Here the connections are shown as to how Ultrasonic sensor is connected to Raspberry Pi, which in turn is connected with L298N Motor driver which runs the DC motors

Working of the model

A Raspberry Pi-based autonomous robot is being developed to perform sign detection, traffic light detection, and obstacle detection while autonomously driving. The system consists of a Raspberry Pi board, a camera module, an ultrasonic sensor for obstacle detection, and motor controllers for movement control. The software setup includes a Raspberry Pi and a separate computer for intensive processing tasks. Python scripts are developed to capture camera frames and ultrasonic distance data, which are sent to the computer for analysis. Communication between the Raspberry Pi and the computer is established using standard protocols like sockets for seamless data exchange and control command transmission.

On the computer side, a robust development environment is set up with libraries for image processing and machine learning. Convolutional Neural Networks (CNNs) are trained for traffic sign detection, while Haar Cascade is implemented for traffic light detection. The computer script processes data from the Raspberry Pi, processes it using trained models, and combines it with ultrasonic sensor data for obstacle detection. The computer determines the appropriate motor control commands based on factors like sign instructions, traffic light states, and obstacle proximity, sending them back to the RaspberryPi

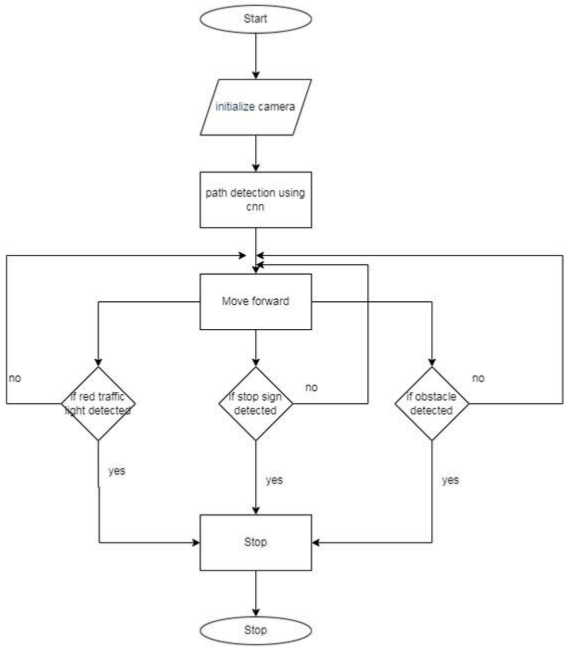

Figure 3.3: Flow of the model

4.Results and discussion

Here the results of Lane, Obstacle and Traffic signal has been presented.

Figure 4.1: Lane view through the camera

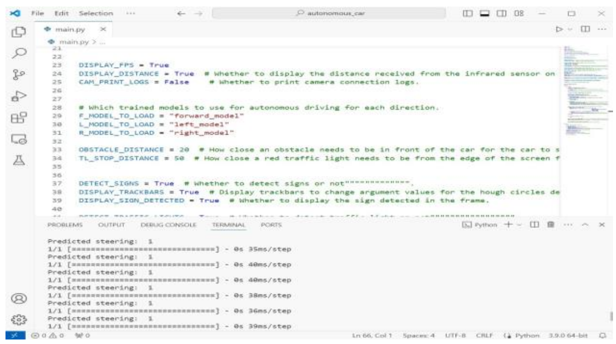

Figure 4.2: Window showing Lane specifications

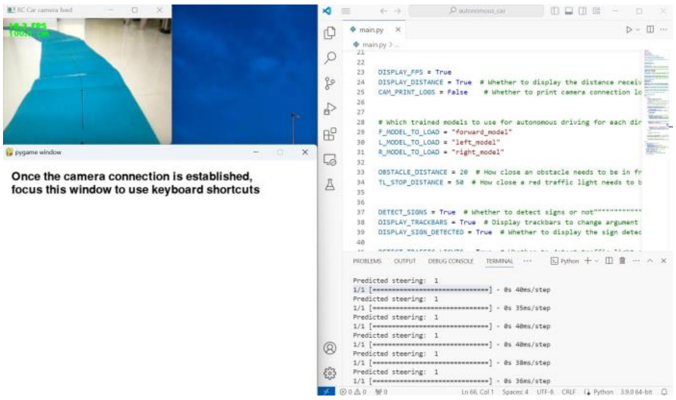

Figure 4.3: Window showing overall Lane detection

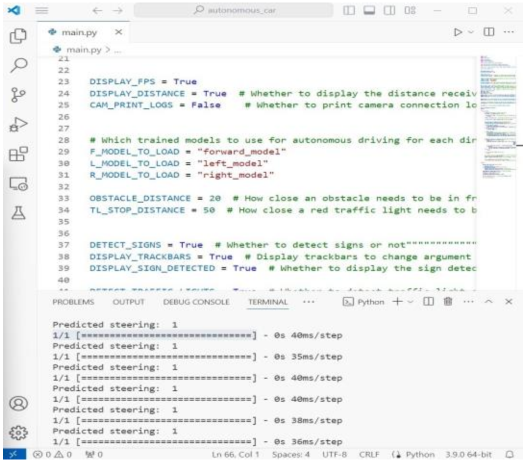

Figure 4.5: Window showing Obstacle specifications

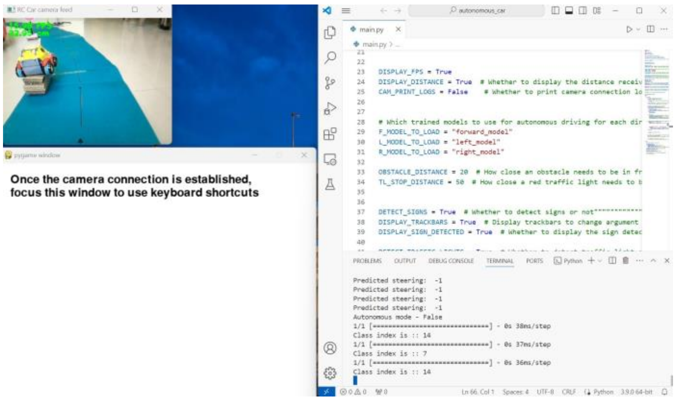

Figure 4.6: Window showing overall Obstacle detection

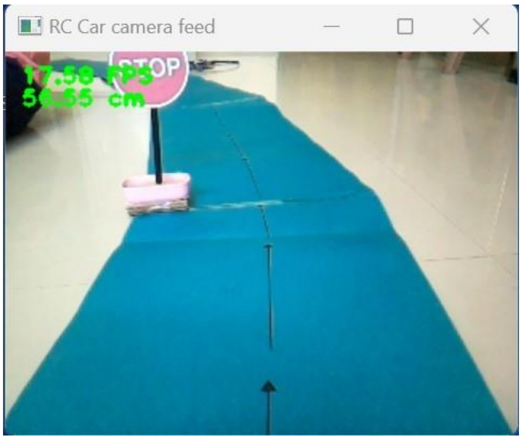

Figure 4.7: Stop sign view through the camera

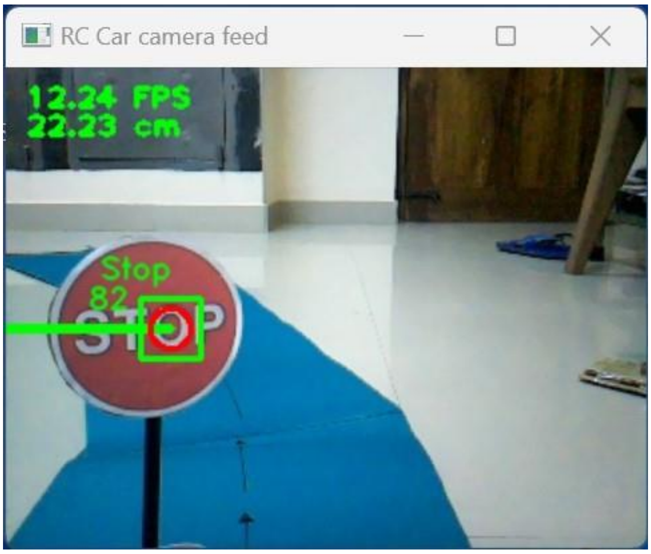

Figure 4.8: Window showing overall stop sign detection

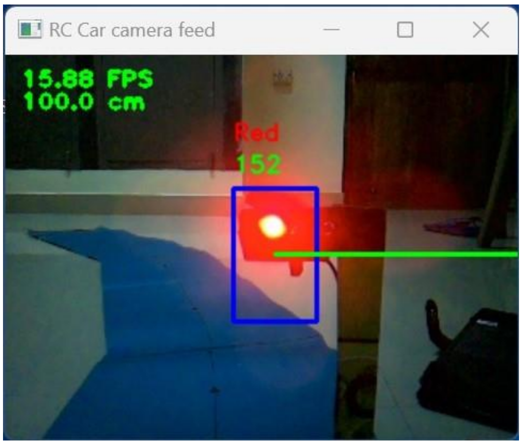

Figure 4.9: Window showing red traffic light detection

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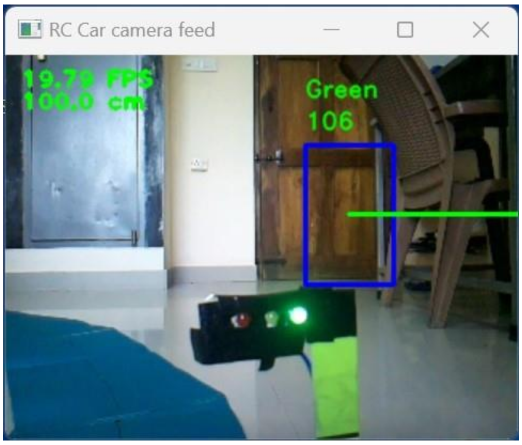

Figure 4.10: Window showing Green traffic light detection

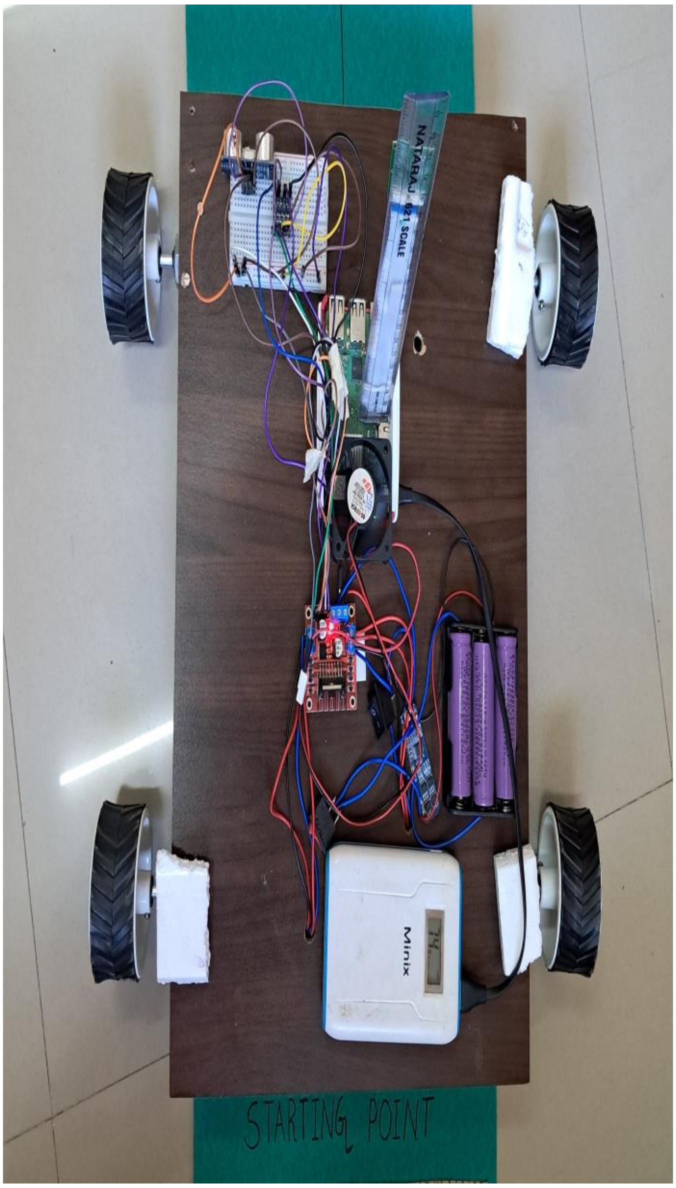

Figure 4.11: Model view

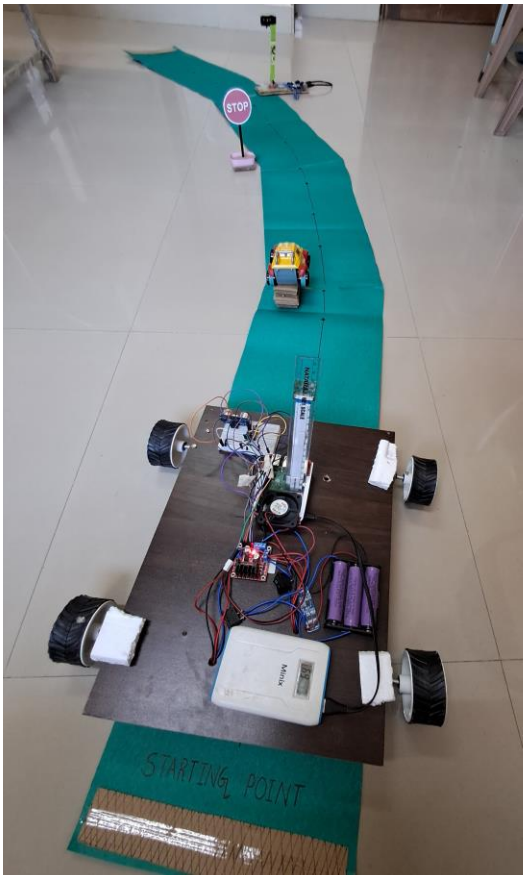

Figure 4.12: Overall model

4.CONCLUSION

The project successfully demonstrated the use of a Raspberry Pi-based system for realtime lane obstacle and traffic signal detection. The system, which can process video streams from a Raspberry Pi camera module, achieved high detection accuracy and minimal latency. Its modular architecture allows for easy integration of additional features like vehicle detection and advanced driver assistance systems. The project represents a significant step towards developing intelligent transportation systems using affordable hardware platforms like Raspberry Pi. Future work includes multi-camera support, optimization of algorithms, and integration with V2I communication systems.

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