JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Real-Time Road Lane Recognition and Automation Traffic Sign Detection for Autonomous Vehicle

[1]Chaya Swaroop S, [2]Koulik Saha, [3]Rohit S, [4]Bhuvan S M, [5] Kristamsetty Akhil, [6]Archana Sasi*

[1,2,3,4,5] Final Year Students, Dept. of CSE, Presidency University, Karnataka, India
[6] Assistant Professor, Dept. of CSE, Presidency University, Karnataka, India
*archana.sasi2k8@gmail.com

Abstract : Increasing safety and reducing road accidents are goals of Advanced Driver Assistance Systems (ADAS), hence saving lives which are of major concern. Road lane recognition and traffic sign detection are likely to be among the more significant challenges that future road vehicles will confront. According to research, the majority of accidents are caused by driver negligence, such as refusal to maintain road lanes, failing to obey traffic signs and regulations, and exceeding the speed limit. This research provides an accurate and efficient approach that can automatically recognize road lanes and traffic signs and respond accordingly. In our study, a real-time lane detection method based on Infrared (IR) technology and a sign detection method employing image processing and a machine learning algorithm are proposed. Since there would be no need for a driver or fuel because it runs on electricity, implementing these would be economical. Evaluation of the proposed framework is done by K-Means clustering algorithm using OpenCV. The proposed method was tested, and the outcomes demonstrated that it is reliable and efficient enough for real-time requirements.

***KEYWORDS* - Autonomous Vehicle, Machine Learning, OpenCV, Raspberry Pi, Road Lane, Sensors, Sign Detection;**

I. INTRODUCTION

A driver uses his or her optical sight to steer their vehicle while driving. A lane marking serves as a permanent reference for vehicle navigation. Algorithms must be developed for automatic lane detection to achieve driverless vehicles. The technology of computer vision allows cars to understand their surroundings. It is one of the finest works of Artificial intelligence (AI) that allows the software to recognize lanes in images and videos. With advances in deep learning, much progress has been made in the field of computer vision. By improving the visual patterns that define each object, we can review and compare millions of images and recognize different objects in an image. Deep learning is particularly effective for classifier problems, but it has serious limitations and can lead to unpredictable results. Therefore, self-driving cars may collide with trunks in daylight or even worse, when they collide with pedestrians.

In our daily lives, vehicles are our primary means of transportation. As the number of vehicles increases, motorists are exposed to more risk while driving, which may result in accidents. Thousands of driving assistants are used across the globe every year because drivers are incapable of processing all the visual information they view while driving. Scientists are currently researching to alert drivers of road conditions. By automating vehicle controls present in current automobiles such as the BMW 7 Series, BMW 5 Series, Ford Focus, Ford Edge, and others, the Advanced Driver Assistance System (ADAS) aids in boosting safety and improving driving. Images of traffic signs are recorded by an image sensor in the Ford Focus. The speed limit sign is identified and displayed on the dashboard using a character recognition technique. Due to traffic, weather conditions, or a failure to pay attention, drivers may overlook signage. As a result, it is critical to identify and detect these traffic signals instantly to inform motorists.

Mandatory, cautionary, and informational traffic signs are used in India. Drivers must follow various laws and regulations that are posted on mandated signs. These signs are normally circular, except for the "STOP" and "GIVE WAY" signs. Some signs alert drivers to potentially dangerous road conditions like humpback whales and narrow bridges [21]. Cautionary signs will be triangular in design and have a red top border with a black emblem on a white background. The informational signs show the route's direction, destination, names, and mileage. For an ADAS program to work in real-time, it needs to be able to detect and recognize traffic signs quickly and accurately.

Lane Detection tracks the lane markings on the road with the aid of a camera mounted to your car. It alerts you if your car drifts out of its lane by sending audio or visual signals. It has shown that lane detection systems can reduce the risk of accidents when cars collide with each other in adjoining lanes. Several automakers are investing in self-driving cars, which are expected to revolutionize the automobile industry.

Autonomous vehicles have increased in popularity due to advances in environmental sensing and navigation, as self-driving vehicles must perform well on the roads. Over the past few years, extensive research has been conducted on the identification and classification of traffic signs. Detection of traffic signs is not a new topic, and numerous solutions have been developed recently [2]. Traffic signal detection is still a challenge even with the promise of convolutional neural networks (CNNs). It is common for objects to occupy a large part of an image in object detection datasets. In Spatial Likelihood Voting (SLV), on average, the bounding box of a target item takes up around 20 percent of the image. Traffic signs, on the other hand, typically take up a minor percentage of each image in real-world driving conditions. When it comes to driverless vehicles, traffic signs should be identified even from a considerable distance away, allowing for judgments to be made ahead of time. Under these conditions, traffic signals in detected photographs will be significantly smaller. In computer vision, detecting little things has always been tough. An increase in the feature map and the use of more small detection anchors, for example, result in expensive computational expenses. To be effective in real-world applications, a traffic sign recognition algorithm capable of managing minor traffic signs in real-time must be built.

The following section of this paper is organized as follows. Section 2 provides a summary of related works. The Proposed work is explained in section 3. The working technique is outlined in Section 4 along with a detailed description of the model implementation. The findings and discussion of the working model is provided in Section 5. Finally, the paper concludes with a discussion on possible future research.

II. Related work

The primary goal of all road lane detecting systems is safety because the majority of vehicle road accidents arise as a consequence of the driver failing to lead the vehicle's path. As a result, numerous new vision-based road detection algorithms are now being developed to avoid vehicle accidents on the road. A vast spectrum of applications, including geology, healthcare, aerospace engineering, and oceanography, employ digital image processing, or the usage of software systems to examine images. A speed sign scanning and identification system for traffic signs are developed [7] using an embedded system. The primary goal of this research is to show how image processing algorithms can be used on a small computing platform. The necessities and complexities of constructing a real-time framework with an embedded system, including how to cope with data employing the image processing method depending on structure and dimension analysis, are discussed. The methods for selection and recognition are also demonstrated in the paper.

In the twenty-first century, automobiles are perhaps the most efficient means of transportation for everyone. As an outcome, the road traffic scenario is growing more sophisticated, and drivers anticipate an intelligent vision-assisted application to offer traffic sign details, govern driver tasks, and support in-vehicle management to sustain road safety. It entails using vehicle cameras to record real-time road images, which are later processed to identify and detect traffic signs found on the road, offering precise data to the vehicle's driving system [14]. Traffic sign identification and recognition have grown in popularity as one of the most crucial roles, attracting the attention of both domestic and foreign academics.

The objective of the study is to identify and locate traffic signs in a video frame taken by an onboard camera mounted on the vehicle [18]. Traffic Sign Recognition (TSR) is a system that regulates traffic signs, warns drivers, and commands or prohibits certain movements. A quick, accurate, and efficient automatic TSR and identification system can ease the driver and help to increase driving convenience and protection. For Driver Assistance Systems (DAS), automatic recognition of traffic signs is critical. This paper describes a study that used the OpenCV technique to recognize traffic sign patterns. The images are retrieved, identified, and recognized through pre-processing using computer vision and image processing methods like segmentation algorithm, Gaussian filters, Canny edge detection, contour, and Fit Ellipse. The detection and identification of traffic signs is a feature of the ADAS. Drivers can know about traffic regulations, conditions of the road, and route guidance via traffic signs, which can help them drive more safely and effectively. There are two phases for recognizing and identifying traffic signs: The first phase is obtaining traffic signs, while the second stage entails classifying the traffic signs found [20]. The challenges of real-time traffic sign detection are discussed in this article. In the phase of traffic sign recognition, pattern matching and machine learning methods are also explored.

The state of the roads has vastly improved in the modern era. As a result, there may be opportunities for drivers to disregard necessary road rules and signs while driving. The approach suggested in this paper enhances driving comfort and safety by assisting the driver in identifying road signs and preventing accidents on the road [5]. The input image in the detection module segments is in YCbCr colour space, and the cascade classifier is used to detect road signs. Two steps make up the road sign recognition system: The detection phase locates signs within an image, and the classification phase categorises the found sign using one of the database's predefined signs. One of the most important aspects of autonomous driving is traffic sign recognition. High-resolution photos are captured by advanced autonomous vehicles equipped with high-quality sensors for subsequent processing. For localization and decision-making, it is critical to detect traffic signs, moving cars, and lanes. Traditional object identification systems struggle to detect traffic signs, particularly those located far away from the camera. In this study [22] the authors separated the big input photos into small blocks to minimize computing costs and increase detection performance, and then used another detection module to identify traffic signals in the blocks. As a result, this study offers a three-stage traffic sign detector that links a Block Net detection network with an RPN–RCNN detection network. BlockNet is a form of a neural network composed of many CNN layers.

Machine Learning (ML) models developed have a broad range of uses in management and research. For instance, ML-enabled commercial ADAS used in automotive technologies can recognize traffic signs. It is essential to use computer technology to automatically identify and recognize traffic signs because of the rising demand for vehicle intelligence and the development of self-driving cars. In this study, neural networks were employed to evaluate images of traffic signs and produce cognitive choices for autonomous vehicles [13].

The ability to recognize traffic signs is essential for automated vehicles and road transport security systems. Still, precise traffic sign detection remains difficult, especially in extreme climates. This paper [15] presents a revolutionary model called Traffic Sign Yola (TS-Yolo) that uses CNN to improve traffic sign detection and recognition precision, mainly in low-visibility and in situations with significantly limited vision. A sample data augmentation strategy was utilized to generate a lot of additional samples from current traffic datasets. Based on You Only Look Once (YoloV5), the mixed depth-wise convolution (MixConv) was employed to merge multiple kernel sizes in one convolution operation. In addition, the Attentional Feature Fusion (AFF) component has been included. The detection and identification of traffic signs are crucial features of ADAS. The detection of a traffic sign will pinpoint the signboard's presence, and its recognition will identify the sign that has been identified. Knowing the substance of a sign is far more significant in the actual world than merely knowing that it exists. This research [9] compares the performance of the Single Shot Multi-Box Detector (SSD) deep learning method with that of traffic sign identification using colour and contour analysis. CNN is also used to categorize traffic signals.

TSR is particularly useful for rookie drivers and self-driving cars. DAS includes automatic TSR. For safe navigation in DAS [19] and driverless cars, effective traffic sign classification is required. CNN is well-known in the field of image categorization. Computer vision is a method for understanding and extracting information from images. A Python module called OpenCV can recognize traffic signs instantly. In this article, the authors have successfully categorized traffic signs in real-time using OpenCV. The model is fully functional and has a low computational cost. The study also includes a task-based experiment in which participants complete many activities. A lot of settings are modified to get the best results.

A wide range of applications has made intelligent transportation systems (ITS) a hot topic in recent years. The detection and recognition of traffic signs is a critical component of ITS. By informing drivers about the traffic signs status and providing practical safety advice, it increases traffic safety. This paper examines the most widely used traffic sign detection methods [3]. Methods based on colour, shape, and machine learning are all accessible. The terms color space, segmentation feature technique, and pattern detection method are discussed in the detection module review. A comparison of these methods is presented in the paper.

To maintain proper traffic flow on busy roads, traffic boards and traffic signals are used. They aid in the recognition of the rules that must be followed when driving a vehicle. These signs serve as a warning to distracted drivers, preventing them from taking actions that could result in an accident. The article [12] proposed a system that can assist in the real-time recognition of these boards and signals, thereby avoiding major mishaps. The driver can gain from real-time automatic sign detection and identification that can significantly enhance his or her safety. As a result of market trend for application domains like autonomous driving, DAS, mobile mapping, Mobil eye, etc. large-scale firms Google, Apple, and Volkswagen, among many others, have recently demonstrated a great interest in TSR. The majority of road accidents are caused by driver mistakes. To assist drivers on the road, improved road infrastructure and facilities such as traffic signage are being constructed. However, several factors influence drivers' awareness of traffic signs, including visual complexity, environmental conditions, and a lack of driver education. As a result, various ADAs such as TSDR have been developed to improve vehicle systems. More complex algorithms are used to improve performance, but this has an impact on real-time systems. This research [16] creates a real-time traffic sign detection and recognition system with voice alert using Python. Its goal is to find the right balance of accuracy and speed in the system's design. In different colour spaces, four pre-processing and object detection methods are evaluated for efficiency and accuracy.

The automatic TSDR system is a critical component of ADAS. The vision-based TSDR has attracted the attention of the scientific community, which is largely inspired by three parameters: detection, monitoring, and categorization. A large number of techniques for TSDR have been reported in the last decade. This paper [19] offers a thorough examination of traffic sign identification, monitoring, and classification. The tables investigate and synthesize the description of algorithms, approaches, and their conditions for detection, tracking, and sorting, as well as the matching essential references. A comparative assessment of every section has also been presented to examine the TSDR data, performance indicators, and their reliability.

Intelligent and autonomous cars, as well as ADA systems, are potential solutions for enhancing safety on the road, traffic concerns, and passenger comfort. Such apps are available with sophisticated computer vision algorithms that are required for powerful computers with the ability to process data at a fast rate by maintaining intelligent cars on the road till they arrive at their destination. In certain circumstances [8], it remains significantly difficult, especially while driving at night. The first and most important responsibility is to ensure that navigation is stable. The acquisition of Red, Green, and Blue (RGB) pictures of the road are frequently dependent on system vision. The vehicle's performance is the second task. Based on its speed, location, and direction, a dynamic controller is used. This work provides a road boundary system that is both precise and efficient. They used an algorithm for detecting painted lines for intelligent and autonomous vehicles. It uses the Hough Transform to start the procedure.

Autonomous Vehicles are another term for self-driving cars. This automobile is capable of sensing its surroundings [6]. These detected characteristics are analysed, and the car's many actuators will operate in accordance with them, without the need for human intervention. A self-driving automobile functions in the same way as a regular vehicle. However, there is no human driver in this scenario. Sensors, actuators, and machine learning algorithms are key components of autonomous vehicles. All automated functions must be performed using the software. For autonomous vehicles, the software component is vital. The architectural pattern connects the hardware and software components. AUTOSAR is a software standard for automobiles. AUTOSAR stands for Autonomous System Architecture Reference Model. All communication is handled through this standardized architecture.

III. Proposed Approach

3.1 Hardware Requirements

3.1.1 Raspberry pi

The Raspberry Pi is a cheap, credit card-sized notebook with a stylish keyboard and mouse that plugs into a laptop monitor or television as depicted in Fig.1. In addition to teaching programming languages like Scratch and python, it provides a way for people of all ages to learn about computing [10]. With it, we can do everything we would anticipate from a normal desktop computer, comprising surfing the web, playing high-definition video, spreadsheet creation, word processing, and gaming

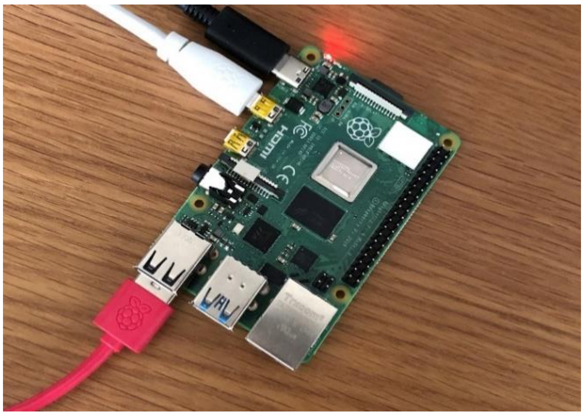

Figure 1 Raspberry pi

3.1.2 Raspberry Pi Camera

A Raspberry Pi camera module is a digital camera that can capture images and record high-definition video. The Raspberry I Board has a SI (digicam Serial Interface) interface to which we shall attach the I camera module at once. Using 15-pin ribbon cable, this I digicam module can be connected to the Raspberry pi's SI port [20]. A Raspberry Pi camera module is shown in Fig.2. Due to the very low payload of camera, it is commonly used in surveillance drones.

Figure 2 Pi Camera

3.1.3 IR Sensor

Motion detectors are used today for detecting unwanted visitors or turning on lights in building using IR sensors [4]. Human motion and specified attitude varieties cause heat radiation (infrared radiation) to change with time and space. It is an optoelectronic component with a spectral sensitivity of 780nm – 50m associated with radiation-sensitive optoelectronics. Fig.3 shows an IR Sensor with an integrated light sensor and a mounting hole. The device measures the intensity of infrared radiation within a given spectral range.

Figure 3 IR Sensor

3.2 Software Requirements

3.2.1 Open CV

The Open CV acronym stands for Open-Source Computer Vision. Machine learning tasks that require computer vision and image processing are handled by this open-source library. MATLAB – like Numpy is used to perform the numerical operation on all Open CV array structures in Open CV – python. The vector space and mathematical operation used to identify image patterns are used to identify various features of the image.

3.2.2 VNC Viewer

VNC stands for Virtual Network Computing. The machine enables us to remotely operate another system with cross-platform screen sharing. A distant user can use secondary devices to view the computer's screen, keyboard, and mouse as if they were sitting right next to it. VNC is available in several variants, each offering different functions; for example, some are optimized for Microsoft Windows, and some allow file transfers.

IV. Methodology

4.1 Road Lane Detection

In this paper, pair of IR sensors are being used to detect road lanes. IR sensors are basically of two types: Active IR sensors and Passive IR sensors. Active IR sensors are the ones with two parts i.e Light-Emitting Diode (LED) and receiver when an entity or object approaches the sensor, the infrared light from the LED reflects back striking the object, and the object is being detected after receiving the signal from the receiver. Passive IR sensors are the ones with no Light Emitting Diode (LED) they are primarily used in motion detection alarms, security alarms, and automatic lighting applications.

In our work, we are using an Active IR sensor. We use a pair of IR sensors one to detect the left road lane and the other one to detect the right road lane since the vehicle has to move within the track detecting the road lane on both sides is important and IR sensitivity is being adjusted as required. Later both the IR sensors' values will be set to high. when the white lane is being detected by IR on the left side the vehicle turns right to get back into the path and vice-versa. If both the IR sensors are turned to low then the vehicle stops. Fig.4 shows the working of the IR Sensor.

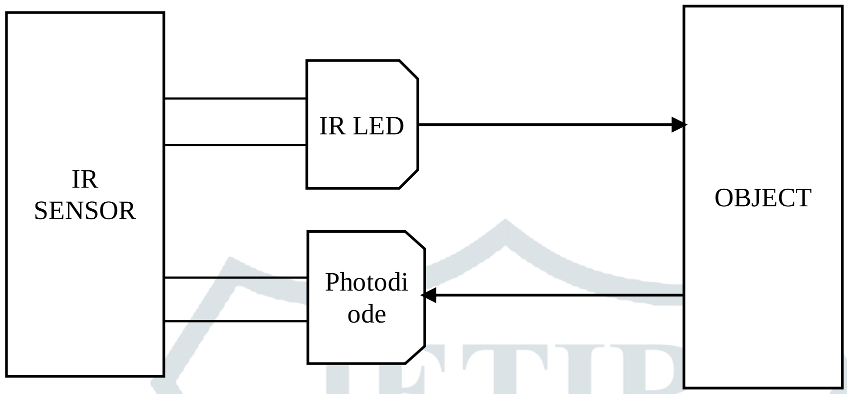

Figure 4 IR Sensor Working

4.2 Traffic Sign Detection

Automatic driving systems and traffic assistance driving systems, rely on traffic sign detection and recognition. It facilitates the detection and recognition of traffic signs.

4.2.1 K-means Clustering

In this project, K-means clustering assigns every data point to the nearest centroid for the minimization of performance indexes by summing the squared distances of all points within a cluster domain of the image. Every point is assigned to the centroid, which is the average. The procedure is then repeated. Each spot is allocated to the centroid closest to it, and centroids are relocated to the mean of the points allocated to it. The centroids indicate the mean of the points given to these. Then the new cluster centre is recalculated to create a cluster based on its smallest distance, then the resulted image will go through the following process as mentioned below in Fig.5.

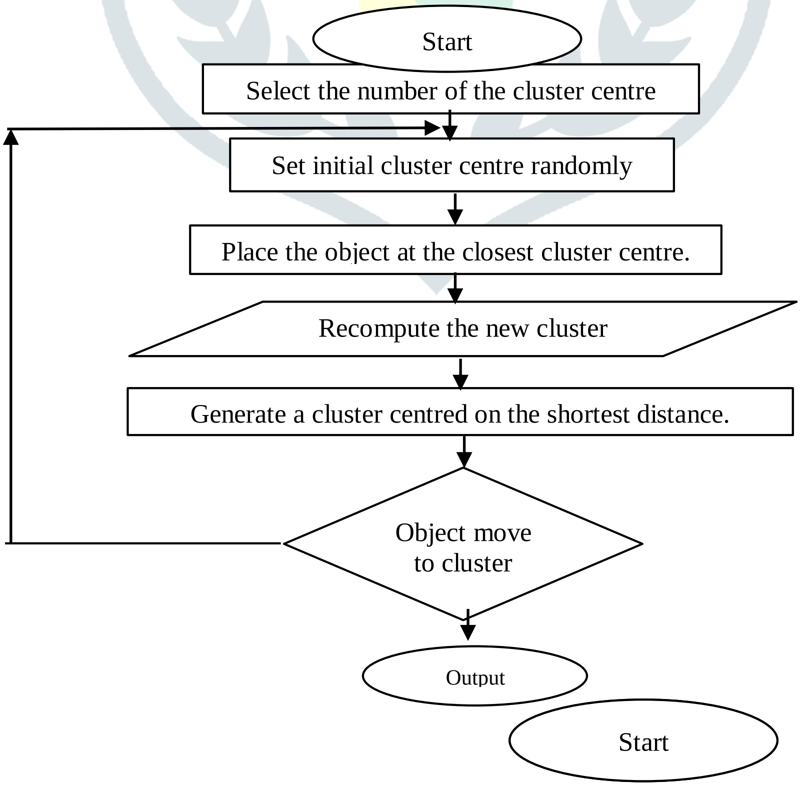

Figure 5 K-Means Clustering Flowchart

4.2.2 Image Pre-Processing

The main goal of image pre-processing is to make all of the photographs seem better. Images may contain noise, which will be minimized and image quality will be increased. Then reshape the image in order not to have two different pixel values for length and width.

4.2.3 Image Segmantation

In this project, Image segmentation identifies the differences between two photos by extracting the characteristics of the image. In image segmentation, segments, or groups of pixels are taken out of a digital image to simplify processing or analysis of it. Digital images are broken down into subgroups called segments to help further simplify image processing and analysis.

4.2.4 Edge Detection Segmentation

Edge detection is a technique for extracting features from edges and outlines by multiplying the input picture matrix with a weight matrix. It aids in determining the image's borders and comparing the form of the items. By multiplying the input picture matrix with a weight matrix, edge detection is used to extract features from edges and outlines. It aids in determining the image's borders and comparing item shapes. The following is a step-by-step explanation of how it works:

i) Consider the weight matrix.
ii) Place at the top of the image.
iii) Get the result of element-wise multiplication.
iv) Adjust the weight matrix to match the stride.
v) Convolve the input till all the pixels are utilized.

Sign detection helps to immediately detect and recognize traffic signs and it assists drivers and automatic driving systems to follow the sign. Fig.6 shows the flow chart of Sign detection.

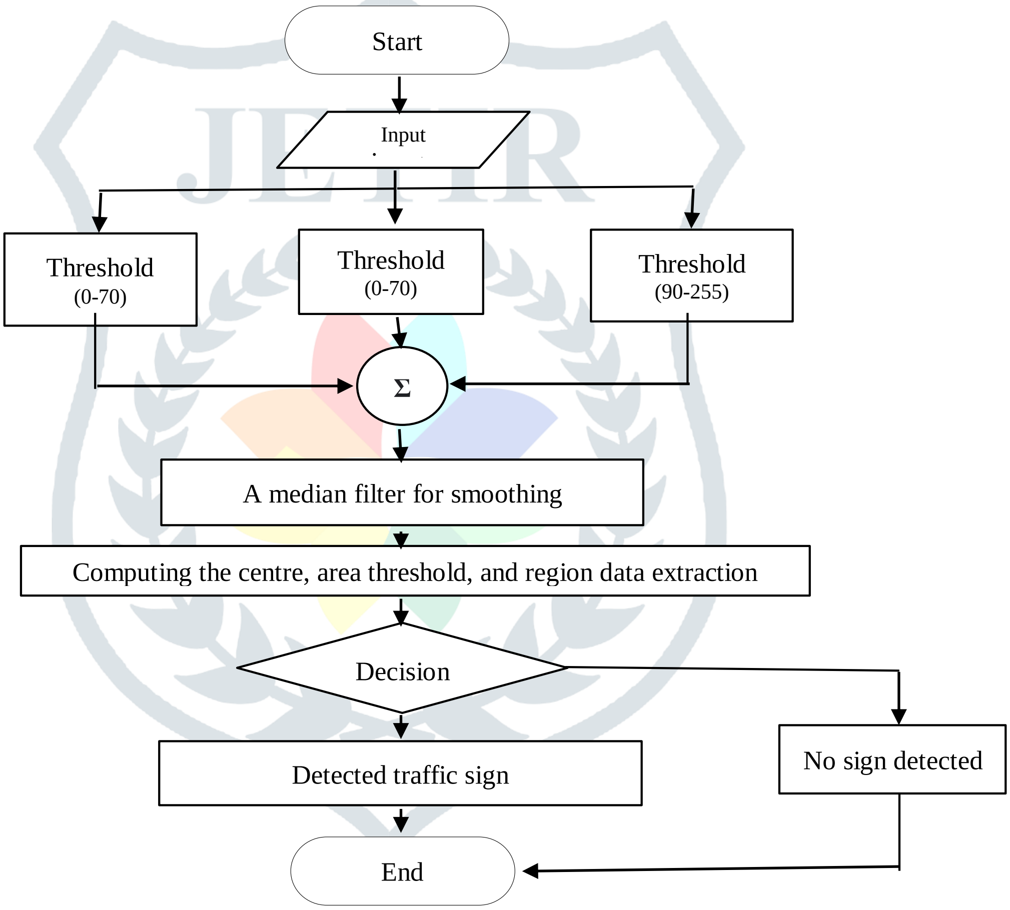

Figure 6 Sign Detection

Video is captured through the Pi-camera and then it is broken into image frames. For this project, we are using the camera and at the same time, we just need the traffic sign to focus on it and don't neglect other things that could result in false decisions. As soon as the traffic sign is detected, we will detect the sign's states by dividing it into three zones. If no sign is detected then the car keeps following the previous result and goes accordingly. Once a traffic sign is detected then the next step is to detect what is the traffic sign states, for that we have divided the traffic sign into 3 zones as shown in Fig.7. Applying the above condition we check what a traffic sign states (eg:- if the traffic sign shown is straight, then zone1 will be greater than zone 0 and zone 1 we also be greater than zone 2 since there is no arrow or marking in zone 0 and zone 2), based on which a decision on how the vehicle should move is being taken.

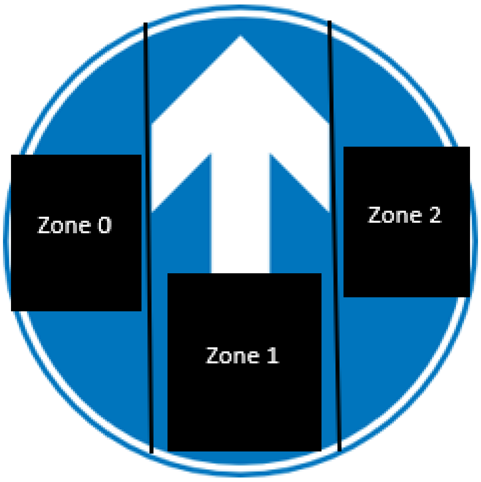

Figure 7 Zone Division

V. RESULTS AND DISCUSSIONS

This project was built on a system running with a 64-bit Windows 10 operating system with Intel(R) Core(TM) i3-6100U CPU @ 2.30GHz and 12 GB RAM. Python 3.10 is used as the development language. This model was being built using the K-means clustering algorithm and a colour dominant function, basically a user-defined function to look at the dominant colour (i.e obtained when one colour serves as the focal point in a frame) in the field.

In this paper, a Raspberry Pi 3 is used which is a cost-efficient yet powerful pocket-sized computer. First, we are connecting Raspberry pi to WI-FI, the same network is being connected to the system as well. Later connection is being established with the help of an IP address in the VNC viewer. VCC of the left IR sensor is connected to the VCC of the right IR sensor, and the GND of the left IR is connected to the GND of the right IR sensor. VCC, GND, OUT of left IR is connected to pin 2, pin 34, pin 3 of Raspberry pi, OUT of right IR is connected to pin 5 of the Raspberry pi. IN1 of the motor driver is connected to pin 11 and pin 12 of Raspberry pi, and IN 2 of the motor driver is connected to pin 7 and pin 8 of the raspberry pi. Motor 1 positive and negative and Motor 2 positive and negative of the motor driver is being connected to the respective motor. The Pi camera is connected to raspberry pi's camera module port. The lane detection by IR Sensor and movement of vehicle-based on right and left IR Sensor value is depicted in Table 1.

Table 1: Vehicle Movement Direction Based on IR Sensor Value

Lane Present	IR(Left)	IR(Right)	Vehicle Moment
NO	HIGH	HIGH	STRAIGHT
YES	LOW	HIGH	LEFT
YES	HIGH	LOW	RIGHT
YES	HIGH	HIGH	STOP

Initially, both the IR sensors before detecting the white lane (road lane) will be high which makes the vehicle move straight according to the program written. Once a white lane is being detected by the left IR sensor it will be turned to low which stops the right motor movement, but the left motor continues to move due to which the vehicle moves away from the vehicle and vice-versa. When both IR detects road lanes, the motor will be stopped which stops the movement of the car automatically.

Table 2: Zone Identification for Sign Detection

Sign	**Colour Zone**	**L-Motor**	**R-Motor**	**Vehicle Movement**
Forward	zone_1_colour > zone_0_colour and zone_1_colour>zone_2_colour	Rotates	Rotates	Straight
Left	zone_0_color>zone_2_color	Stops	Rotates	Left
Right	zone_2_ccolor>zone_1_color	Rotates	Stops	Right

Table 2 states how the traffic signs are detected and how the vehicle follows traffic signs with the help of a colour dominant function. The video is broken into frames when a traffic sign is kept in front of the Pi camera, many things would be visible to the camera but we just need a traffic sign for having the focus on the traffic sign and to neglect other disturbances which would result in false prediction. We are using k-means clustering which would help us find traffic signs.

VI. CONCLUSION AND FUTURE WORK

In terms of transportation technology, driverless automobile seems to be challenging and critical. The percent of accidents, according to studies, are the result of driver irresponsibility, including failure to keep traffic lanes maintained, disobeying traffic signals and laws, and going over the posted speed limit. The goal of this paper is to detect traffic signals automatically and to resolve the various limitations that could overcome road lane recognition in real-time. This will help to reduce the number of road accidents and thereby enhance public safety. In the course of our research, a real-time sign detection approach employing image processing and a machine learning algorithm as well as lane detection based on Infrared (IR) technology is proposed. K-Means clustering technique using OpenCV is used to analyse the proposed framework. The proposed approach was tested, and the results showed that it is reliable and effective enough for real-time needs.

The suggested framework is demonstrated to be more effective than other existing works. The overall detection time satisfies the needs of real-time applications. However, there are still restrictions and flaws in the suggested plan. If the vehicle speed exceeds a certain limit, the fitting algorithm does not operate efficiently. To address this shortcoming, the proposal has to be improved still more. Deep Learning techniques like RCNN, LSTM, and GAN can also be successfully utilized; this can be taken up as a subsequent extension of the paper.

VII. Acknowledgment

Primarily, we owe a debt of gratitude to GOD ALMIGHTY for enabling us to succeed in our efforts to finish this project on schedule. We sincerely thank Presidency University's esteemed dean of engineering, Dr. Abdul Sharief, for granting us permission to carry out the project. We express our sincere gratitude to Dr. C. Kalaiarasan, our beloved professor and the project's lead administrator for University Project II at Presidency University, for his prompt assistance in making this project a success. We owe a huge debt of gratitude to our mentor, Mrs. Archana Sasi, Assistant Professor in the Department of Computer Science and Engineering at Presidency University, for her motivational advice, insightful suggestions, and for giving us the chance to demonstrate our technical prowess in every way for the project work. We are grateful to our friends for their strong encouragement and motivation in helping us launch this project.

References

[1] Adonis Santos, Patricia Angela Abu , Carlos Oppus ," Rosula Reyes1 ,Real-Time Traffic Sign Detection and Recognition System for Assistive Driving", 25 August, 2020.
[2] Albert Keerimolel, Sharifa Galsulkar, Brandon Gowray." A SURVEY ON TRAFFIC SIGN RECOGNITION AND DETECTION", April 2021.
[3] Ayoub Ellahyani, Ilyas El Jaafari and Said Charfi,Traffic Sign Detection for Intelligent Transportation Systems,2021.
[4] B. Varshini, H. Yogesh, S. D. Pasha, M. Suhail, V. Madhumitha, and A. Sasi, "IoT-Enabled Smart Doors for Monitoring Body Temperature and Face Mask Detection," Glob. Transitions Proc., pp. 0–17, 2021, doi: 10.1016/j.gltp.2021.08.071.
[5] Dr. D.K. Shedge, Blessy Mathai, Prasad Barude, Shivam Katkamwar, Anjali Ranjan ,"Road Sign Detection Using Cascade Classifier",April 2017.
[6] Dr.P. Sivakuma, S Swetha,"SSLA Based Traffic Sign and Lane Detection for Autonomous cars".
[7] Enis Bilgin,"Road Sign Recognition System on Raspberry Pi", April 2016.
[8] Farid Bounini, Denis Gingras, Vincent Lapointe,Herve Pollart", Autonomous Vehicle And Real Time Road Lanes Detection And Tracking", October 2015.
[9] Haifeng Wan , Lei Gao , Manman Su,Qinglong You,3 Hui Qu and Qirun Sun ,"A Novel Neural Network Model for Traffic Sign Detection and Recognition under Extreme Conditions", 10 July 2021.
[10] https://www.instructables.com/Raspberry-Pi-4-Traffic-Sign-Recognition-Robot/.
[11] https://www.raspberrypi.com/documentation/accessories/camera.html.
[12]https://endtimesdarknessdescending.wordpress.com/2022/01/01/rapture-watch-2022-signs-the-3-30-and-90-balaamic-fig-tree-prophecy-codes/.
[13] Karan Singh1 , Nikita Malik ,"CNN Based Approach for Traffic Sign Recognition System", 26 September 2021.
[14] Maithili Lakshadeep Dessai, Dr. Luis C Mesquita, Cassandra Fernandes,"TRAFFIC SIGN RECOGNITION USING IMAGE PROCESSING",2018.
[15] Mr.Mustafa Surti ,"Real time traffic sign detection and classification system on Jetson TX1 Embedded Development Board", August 2019.
[16] Nikhil S. Rajguru , Gopal D. Upadhye,"Implementation paper of Traffic Signal Detection and Recognition using deep learning", 05 April 2021.
[17] Pramod Sai Kondamari Anudeep Itha ,"A Deep Learning Application for Traffic Sign Classification. traffic signs are typically pictorial",2021.
[18] Pritha Gawande,"Traffic Sign Detection and Recognition Using Open CV ",April 2017.
[19] Safat B. Wali , Majid A. Abdullah , Mahammad A. Hannan , Aini Hussain , Salina A. Samad , Pin J. Ker and Muhamad Bin Mansor ," Vision-Based Traffic Sign Detection and Recognition Systems, 6 May 2019.
[20] SwathiM,K.V.Suresh,''Automatic Traffic Sign Detection and Recognition'',2018.
[21] Vidyagouri B. Hemadri,P. Umakant Kulkarni, "Detection and recognition of mandatory and cautionary road signals using unique identifiable features",11 International Conference & Workshop on Emerging Trends in Technology, DOI:10.1145/1980022.1980406.
[22] Yizhi Song, Ruochen Fan, Sharon Huang, Zhe Zhu, and Ruofeng Tong, "A three-stage real-time detector for traffic signs in large panoramas" ,2019.