Self Driving Car using Raspberry Pi

MINI PROJECT REPORT
SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
BACHELOR OF TECHNOLOGY
ELECTRONICS AND COMMUNICATION ENGINEERING
BY

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CERTIFICATE

Date: 21 February 2021

This is to certify that the Mini project work entitled "**Autonomous Cars Using Arduino UNO and Raspberry Pi**" is a bonafide work carried out by

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in partial fulfillment of the requirements for the degree of **BACHELOR OF TECHNOLOGY in ELECTRONICS & COMMUNICATION ENGINEERING** by the Jawaharlal Nehru Technological University, Hyderabad during the academic year 2020-21.

The results embodied in this report have not been submitted to any other
University or Institution for the award of any degree or diploma.

Internal Examiner External Examiner

ACKNOWLEDGEMENT

We express our deep sense of gratitude to our Guide Dr.D.Venkat Reddy, Professor,Electronics and Communication Department , MGIT, Hyderabad, for his valuable guidance and encouragement in carrying out our Project.

We are highly indebted to our Faculty Liaison Mr. D.V.S.Nagendra Kumar, Sr. Assistant Professor, Electronics and Communication Engineering Department, who has given us all the necessary technical guidance in carrying out this Project.

We wish to express our sincere thanks to Dr. S.P.Singh, Head of the Department of Electronics and Communication Engineering, M.G.I.T., for permitting us to pursue our Project in Cranes Varsity and encouraging us throughout the Project.

Finally, we thank all the people who have directly or indirectly helped us through the course of our Project.

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ABSTRACT

Self driving car is a challenging problem. It has attracted the attention of the computer vision community for several decades. Essentially, self driving car is a feature machine that has become a real challenge for computer vision and machine learning techniques. Although many machine learning methods are used for lane detection, they are mainly used for classification rather than feature design. But modern computer vision methods can also be used to identify the features that are rich in recognition and have achieved success in feature detection tests. However, these methods have not been fully implemented in the efficiency and accuracy of lane detection. We introduced a new method of preprocessing and ROI selection. The main goal is to use the HSV colour transformation to extract the white features and add preliminary edge feature detection in the preprocessing stage and then select ROI on the basis of the proposed preprocessing. This new preprocessing method is used to detect the lane. The results obtained are superior to the existing preprocessing and ROI selection techniques.

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Chapter 1. Overview

Self-driving vehicles are cars or trucks in which human drivers are never required to take

control to safely operate the vehicle. Also known as autonomous or “driverless” cars, they

combine sensors and software to control, navigate, and drive the vehicle.

This Project presents an advanced lane detection technology to improve the efficiency and

accuracy of real-time lane detection

The lane detection module is usually divided into two steps:

(1) image pre-processing and

(2) the establishment and matching of line lane detection model.

where lane detection blocks are the main contributions of this project. The first step is to

read the frames in the video stream. The second step is to enter the image pre-processing module. What is different from others is that in the pre-processing stage. we not only process the image itself but also do colour feature extraction and edge feature extraction

[17]. In order to reduce the influence of noise in the process of motion and tracking, after extracting the colour features of the image, we need to use a Gaussian filter to smooth the

image. Then, the image is obtained by binary threshold processing and morphological closure.

we select the adaptive area of interest (ROI) in the preprocessed image. The last step is lane detection. Firstly, the Canny operator is used to detect the edge of the lane line; then

the Hough transform is used to detect the line lane.

Various self-driving technologies have been developed by Google, Uber, Tesla, Nissan, and

other major automakers, researchers, and technology companies.

1.1. Introduction

An autonomous car is a vehicle capable of sensing its environment and operating without human involvement. A human passenger is not required to take control of the vehicle at any time, nor is a human passenger required to be present in the vehicle at all. An autonomous car can go anywhere a traditional car goes and do everything that an experienced human driver does.

The Society of Automotive Engineers (SAE) currently defines 6 levels of driving automation ranging from Level 0 (fully manual) to Level 5 (fully autonomous). These levels have been adopted by the U.S. Department of Transportation.

The Automotive industry is currently experiencing a paradigm shift from conventional human-driven vehicles to autonomous self-driving vehicles. With it, Self-driving cars are constantly making the headlines. What seemed like a sci-fi movie decades back, is right now the reality. We now have vehicles that are designed to carry humans from point A to point B without any human intervention. Right now Self Driving cars are one of the hottest areas of research and there is no doubt that self-driving cars are the future!

These self-driving cars use computer vision and deep learning in solving automotive problems, including detecting lane lines, predicting steering angle, and much more.

1.2. Aim Of The Project

To detect the lane line using computer vision(OpenCV) and drive the car by detecting the lane line .

1.3. Methodology

Autonomous cars use a variety of techniques to detect their surroundings.The automatic control, computer vision and many other technologies are integrated into the self-driving car. From a different viewpoint, the technology of self-driving car represents the level of scientific research and industrial strength of a country.

1. Introduction to the car
2. Requirements and parts needed
3. Assemble the hardware
4. Required software installation
5. Calibrate your Car Camera and the other components.
6. Working in the Python IDE.
7. Lane detection using OpenCV
8. Embedding the hardware and software
9. Testing the model

1.4. Significance and applications

A decrease in the number of accidents could also reduce traffic congestion, which is a further potential advantage posed by autonomous vehicles. Autonomous driving can also achieve this by the removal of human behaviours that cause blockages on the road, specifically stop-and-go traffic.

Highly automated technologies, often called self-driving cars, promise a range of potential benefits.

-Greater Road Safety
Automation can help reduce the number of crashes on our roads.

-Greater Independence
Full automation offers more personal freedom.

-Saving Money
Automated driving systems could impact our pocketbooks in many ways.

-More Productivity
Wide-scale deployment of HAVs could allow drivers to recapture time.

-Reduced Congestion

Several causes of traffic congestion could be addressed by HAVs

- It can be used in Industries like Shipping , Transportation ,and emergency services.

1.5. Organization of Report

- Chapter 1 includes the complete overview of the project.
- Chapter 2 includes the description about the Hardware components used in the project
- Chapter 3 comprises the project description which consists of Block Diagram , Circuit Diagram. It also includes the process of Firmware Implementation of the project.
- Chapter 4 outlines the Results and Analysis of the project.
- Chapter 5 includes the Conclusion and Future Scope of the project

Chapter 2. Fundamentals of Self driving cars , Raspberry Pi, Camera module, Motor Driver and softwares

2.1. Introduction

It's easy to see why car companies are optimistic about autonomy. Over the past ten years, deep learning — a method that uses layered machine-learning algorithms to extract structured information from massive data sets — has driven almost unthinkable progress in AI and the tech industry. It powers Google Search, the Facebook News Feed, conversational speech-to-text algorithms, and champion Go-playing systems. Outside the internet, we use deep learning to detect earthquakes, predict heart disease, and flag suspicious behavior on a camera feed, along with countless other innovations that would have been impossible otherwise.

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python.We're using Raspberry pi 4 in this project.

The Camera Module can be used to take high-definition video, as well as stills photographs. ... It supports 1080p30, 720p60 and VGA90 video modes, as well as still capture. It attaches via a 15cm ribbon cable to the CSI port on the Raspberry Pi.

This L298N Motor Driver Module is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control.

2.2. Self Driving Cars

A self-driving car is a type of vehicle that does not need a person to operate it.Self driving vehicles use combinations of technologies and sensors to sense the roadway and other vehicles.As the name suggests, self-driving vehicles do not require human intervention to take control and operate those safely. Also known as autonomous or “driverless” vehicles, they bank on sensors and software to control, navigate, and drive the vehicle. These vehicles use combinations of technologies and sensors, such as global positioning system (GPS) or light detection and ranging (LiDAR) to sense the roadway, other vehicles, and objects on and along the roadway.

A self-driving car, also known as an autonomous vehicle (AV or auto), driverless car, or robo-car is a vehicle that is capable of sensing its environment and moving safely with little or no human input.

Self-driving cars combine a variety of sensors to perceive their surroundings, such as Radar,LIDAR,SONAR,GPS,Odometry and inertial measurement units . Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage.

Possible implementations of the technology include personal self-driving vehicles, shared robot axis , connected vehicle platoons and long-distance trucking. Several projects to develop a fully self-driving commercial car are in various stages of development. Waymo became the first service provider to offer robo taxi rides to the general public in Phoenix,Arizona in 2020, while Tesla has said it will offer subscription-based "full self-driving" to private vehicle owners in 2021.Furthermore, the autonomous delivery company Nuro has been allowed to start commercial operations in California starting in 2021

Autonomous vehicle technology may be able to provide certain advantages compared to human-driven vehicles. One such potential advantage is that they could provide increased safety on the road – vehicle crashes cause many deaths every year, and automated vehicles could potentially decrease the number of casualties as the software used in them is likely to make fewer errors in comparison to humans. A decrease in the number of accidents could also reduce traffic congestion, which is a further potential advantage posed by autonomous vehicles. Autonomous driving can also achieve this by the removal of human behaviours that cause blockages on the road, specifically stop-and-go traffic.

One of the aspects of the vehicle technology used in automated vehicles is ACC, or adaptive cruise control. This system is able to adjust the vehicle’s speed automatically to ensure that it maintains a safe distance from the vehicles in front of it. This function relies on information obtained using sensors on the vehicle and allows the car to perform tasks such as brake when it senses that it is approaching any vehicles ahead. This information is then processed and the appropriate instructions are sent to actuators in the vehicle, which control the responsive actions of the car such as steering, acceleration and braking. Highly automated vehicles with fully automated speed control are able to respond to signals from traffic lights and other such non-vehicular activities.

- Autonomous control: Autonomous control refers to an object's ability to operate solely by itself, using built-in technology to anticipate problems and adjust to prevent them from occurring, without help from an outside force. This term gets used a lot when describing vehicles with self-driving capabilities.
- Automated vehicle: When advertisements describe a car as an automated vehicle, this means that the vehicle can operate by itself for certain periods. However, there are limitations to its autonomy, which means that the driver should be alert and ready to take full control in situations that require manual assistance.
- Fully-Automated vehicle: When a car is said to be fully-automated, this means that it is fully capable of operating by itself, without the help of the driver.

It is essential to understand the different meanings behind these similar but distinctive terms used to describe self-driving cars, so you can fully understand its limitations.

Classification

A classification system with six levels – ranging from fully manual to fully automated systems – was published in 2014 by SAE international , an automotive standardization body, as J3016, *Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems*. This classification is based on the amount of driver intervention and attentiveness required, rather than the vehicle's capabilities, although these are loosely related. In the United States in 2013, the National Highway Traffic Safety Administration (NHTSA) released a formal classification system, but abandoned it in favor of the SAE standard in 2016. Also in 2016, SAE updated its classification, called J3016_201609.

Levels of driving automation

In SAE's automation level definitions, "driving mode" means "a type of driving scenario with characteristic dynamic driving task requirements (e.g., expressway merging, high speed cruising, low speed traffic jam, closed-campus operations, etc.)"

- Level 0: The automated system issues warnings and may momentarily intervene but has no sustained vehicle control.

- Level 1 ("hands on"): The driver and the automated system share control of the vehicle. Examples are systems where the driver controls steering and the automated system controls engine power to maintain a set speed (Cruise Control) or engine and brake power to maintain and vary speed (Adaptive Cruise Control or ACC); and Parking Assistance, where steering is automated while speed is under manual control. The driver must be ready to retake full control at any time. Lane Keeping Assistance (LKA) Type II is a further example of Level 1 self-driving. An automatic emergency braking which alerts the driver to a crash and permits full braking capacity is also a Level 1 feature, according to Autopilot Review magazine.

- Level 2 ("hands off"): The automated system takes full control of the vehicle: accelerating, braking, and steering. The driver must monitor the driving and be prepared to intervene immediately at any time if the automated system fails to respond properly. The shorthand "hands off" is not meant to be taken literally – contact between hand and wheel is often mandatory during SAE 2 driving, to confirm that the driver is ready to intervene. The eyes of the driver might be monitored by cameras to confirm that the driver is keeping their attention to traffic.

- Level 3 ("eyes off"): The driver can safely turn their attention away from the driving tasks, e.g. the driver can text or watch a movie. The vehicle will handle situations that call for an immediate response, like emergency braking. The driver must still be prepared to intervene within some limited time, specified by the manufacturer, when called upon by the vehicle to do so. You can think of the automated system as a co-driver that will alert you in an orderly fashion when it is your turn to drive. An example would be a Traffic Jam Chauffeur, another example would be a car satisfying the international Automated Lane Keeping System (ALKS) regulations.

- Level 4 ("mind off"): As level 3, but no driver attention is ever required for safety, e.g. the driver may safely go to sleep or leave the driver's seat. However, self-driving is supported only in limited spatial areas (geofenced) or under special circumstances. Outside of these areas or circumstances, the vehicle must be able to safely abort the trip, e.g. slow down and park the car, if the driver does not retake control. An example would be a robotic taxi or a robotic delivery service that covers selected locations in an area, at a specific time and quantities.

- Level 5 ("steering wheel optional"): No human intervention is required at all. An example would be a robotic vehicle that works on all kinds of surfaces, all over the world, all year around, in all weather conditions.

In the formal SAE definition below, note in particular the shift from SAE 2 to SAE 3: the human driver no longer has to monitor the environment. This is the final aspect of the "dynamic driving task" that is now passed over from the human to the automated system. At SAE 3, the human driver still has responsibility to intervene when asked to do so by the automated system. At SAE 4 the human driver is always relieved of that responsibility and at SAE 5 the automated system will never need to ask for an intervention.

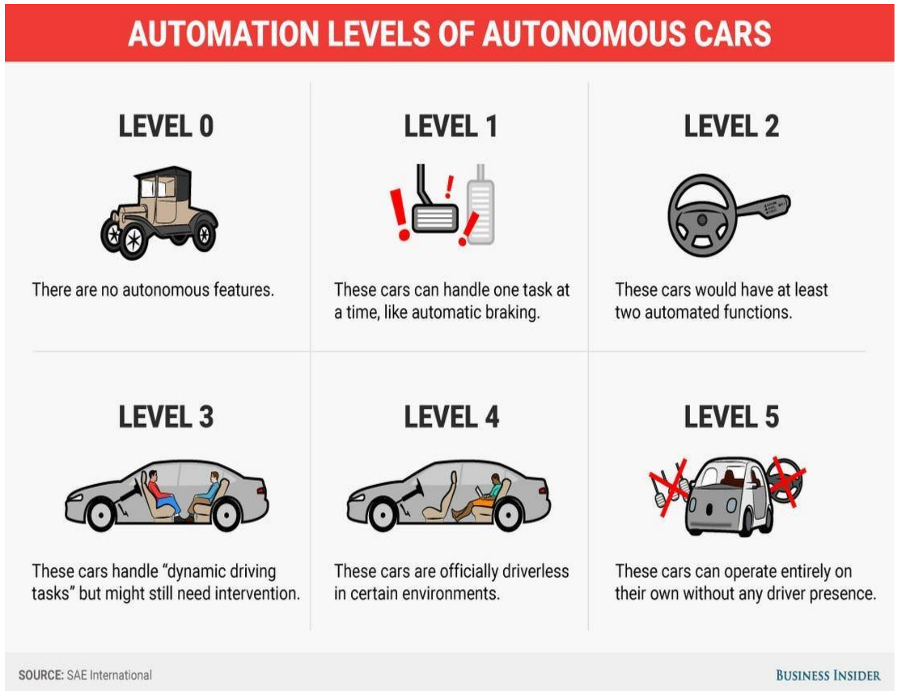

Figure 1 Automation levels of Autonomous cars

Applications

- **Autonomous trucks and vans**

Companies such as Otto and Starsky Robotics have focused on autonomous trucks. Automation of trucks is important, not only due to the improved safety aspects of these very
heavy vehicles, but also due to the ability of fuel savings through platooning . Autonomous vans are being used by online grocers such as Ocado.

- **Transport systems**

China trialed the first automated public bus in Henan province in 2015, on a highway linking Zhengzhou and Kaifeng.Baidu and King Long produce automated minibus, a vehicle with 14 seats, but without a driving seat. With 100 vehicles produced, 2018 will be the first year with commercial automated service in China.

In Europe, cities in Belgium, France, Italy and the UK are planning to operate transport systems for automated cars, and Germany, the Netherlands, and Spain have allowed public

testing in traffic. In 2015, the UK launched public trials of the LUTZ Pathfinder automated pod in Milton Keynes. Beginning in summer 2015, the French government allowed PSA Peugeot-Citroen to make trials in real conditions in the Paris area. The experiments were planned to be extended to other cities such as Bordeaux and Strasbourg by 2016.The alliance between French companies THALES and Valeo (provider of the first self-parking car system that equips Audi and Mercedes premi) is testing its own system. New Zealand is planning to use automated vehicles for public transport in Tauranga and Christchurch.

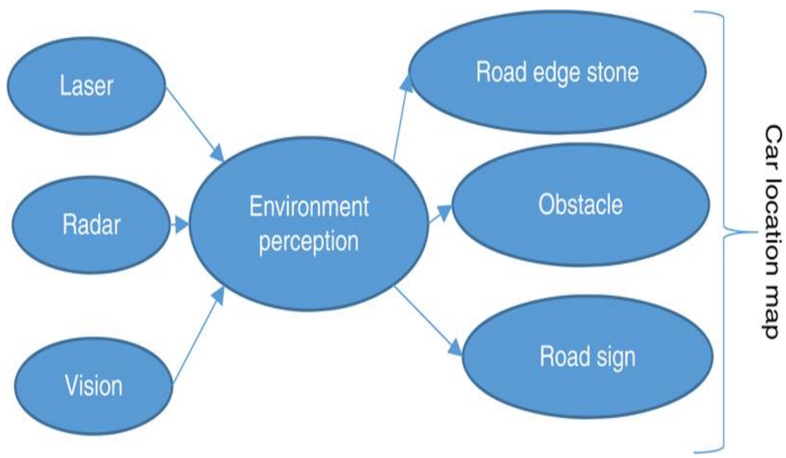

Figure 2 : Typical Perspection Scheme of Self Driving Car

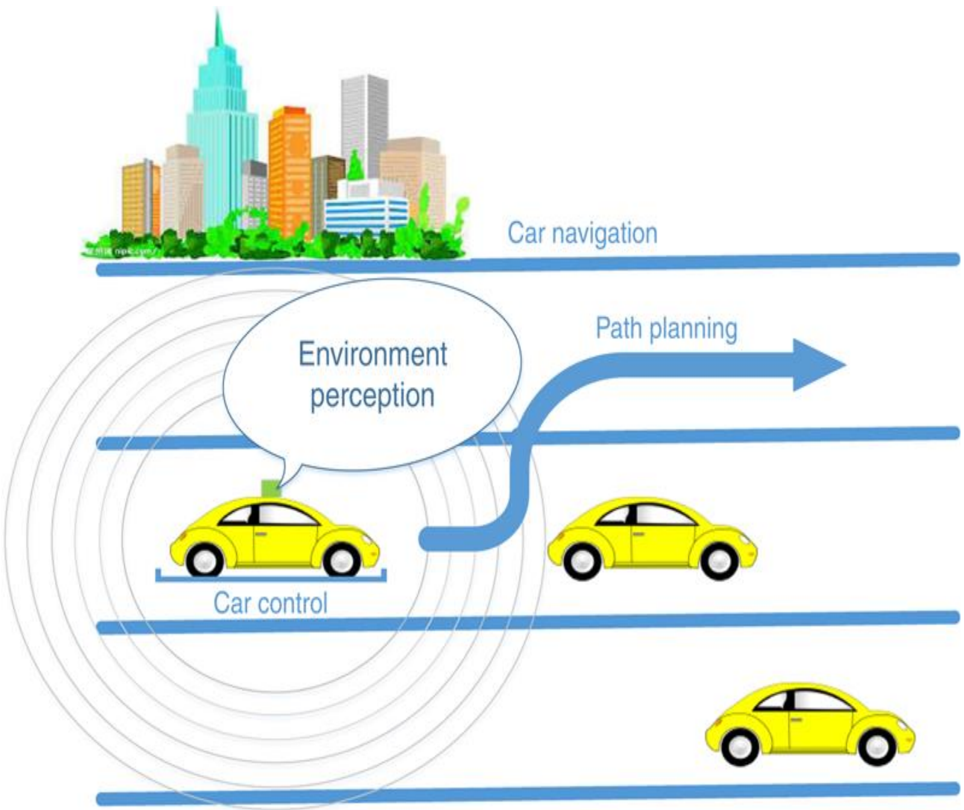

Figure 3 Classification of the key technology

2.3. Camera Module

Autonomous vehicles rely on cameras placed on every side — front, rear, left and right — to stitch together a 360-degree view of their environment. Some have a wide field of view — as much as 120 degrees — and a shorter range. Others focus on a more narrow view to provide long-range visuals.

Some cars even integrate fish-eye cameras, which contain super-wide lenses that provide a panoramic view, to give a full picture of what's behind the vehicle for it to park itself.

Though they provide accurate visuals, cameras have their limitations. They can distinguish details of the surrounding environment, however, the distances of those objects need to be calculated to know exactly where they are. It’s also more difficult for camera-based sensors to detect objects in low visibility conditions, like fog, rain or nighttime

In this project , we’re using Raspberry Pi 5MP Camera Module with Cable.

The 5MP Raspberry Pi Camera Module with Cable equips flexible cable for attaching with Raspberry Pi 3 Model B. The 5MP camera module is perfect for small Raspberry Pi projects which have very little space allowance .

The high-definition 5MP camera delivers outstanding photos but can also shoot video,ideal for drones or a CCTV project. The lightweight camera module allows it to be used in more practical roles, such as a hidden camera or even a camera for a Pi-phone, for example.

This Raspberry Pi Camera Module is a custom designed add-on for Raspberry Pi. It attaches to Raspberry Pi by way of one of the two small sockets on the board upper surface. This interface uses the dedicated CSI interface, which was designed especially for interfacing to cameras. The CSI bus is capable of extremely high data rates, and it exclusively carries pixel data.

The board itself is tiny, at around 25mm x 23mm x 8mm. It also weighs just over 3g, making it perfect for mobile or other applications where size and weight are important. It connects to Raspberry Pi by way of a short flexible ribbon cable. The camera connects to the BCM2835 processor on the Pi via the CSI bus, a higher bandwidth link which carries pixel data from the camera back to the processor. This bus travels along the ribbon cable that attaches the camera board to the Pi.

The sensor itself has a native resolution of 5 megapixels and has a fixed focus lens onboard. In terms of still images, the camera is capable of 2592 x 1944 pixel static images, and also supports 1080p30, 720p60 and 640x480p60/90 video.

No adapters required! This camera will plug directly into the Raspberry Pi 3 Model B camera port!

Features of Raspberry Pi 5MP Camera Module with Cable:-

- Fully Compatible with Both the Model A, Model B and Model B+ Raspberry Pi
- 5MP Omnivision 5647 Camera Module
- Still Picture Resolution: 2592 x 1944
- Video: Supports 1080p @ 30fps, 720p @ 60fps and 640x480p 60/90 Recording
- 15-pin MIPI Camera Serial Interface - Plugs Directly into the Raspberry Pi Board
- Size: 20 x 25 x 9mm
- `Weight 3g

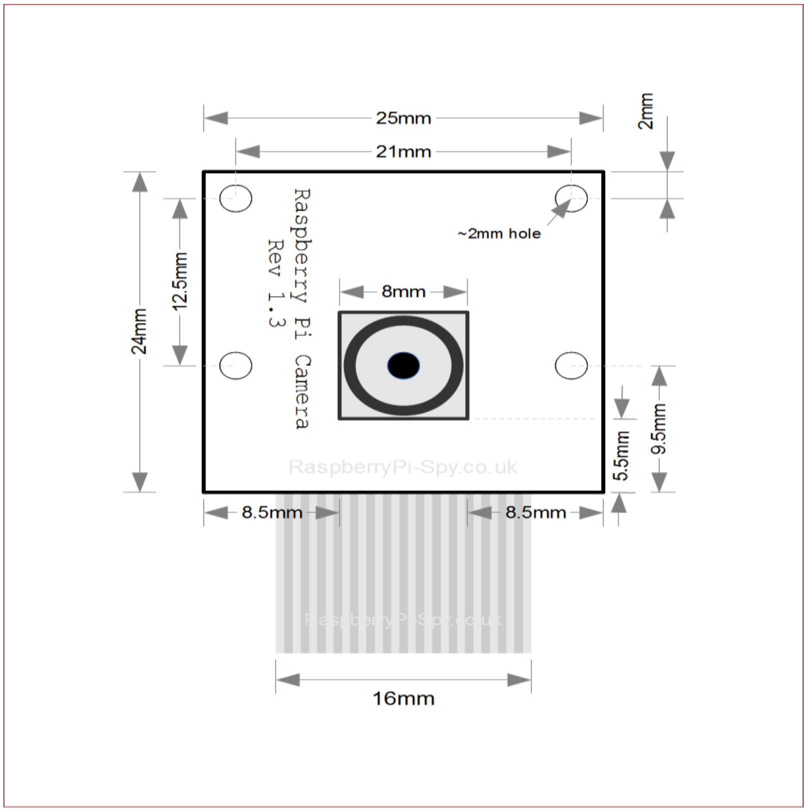

Figure 4 Mechanical Dimensions of Pi camera

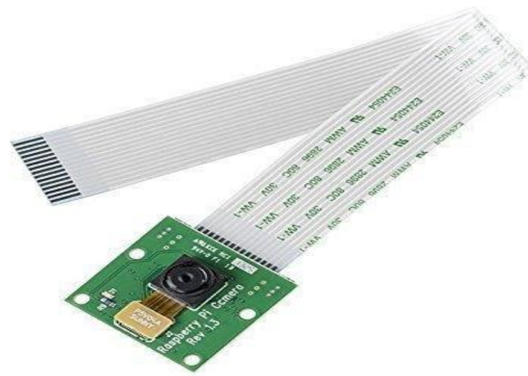

Figure 5 PiCamera Module

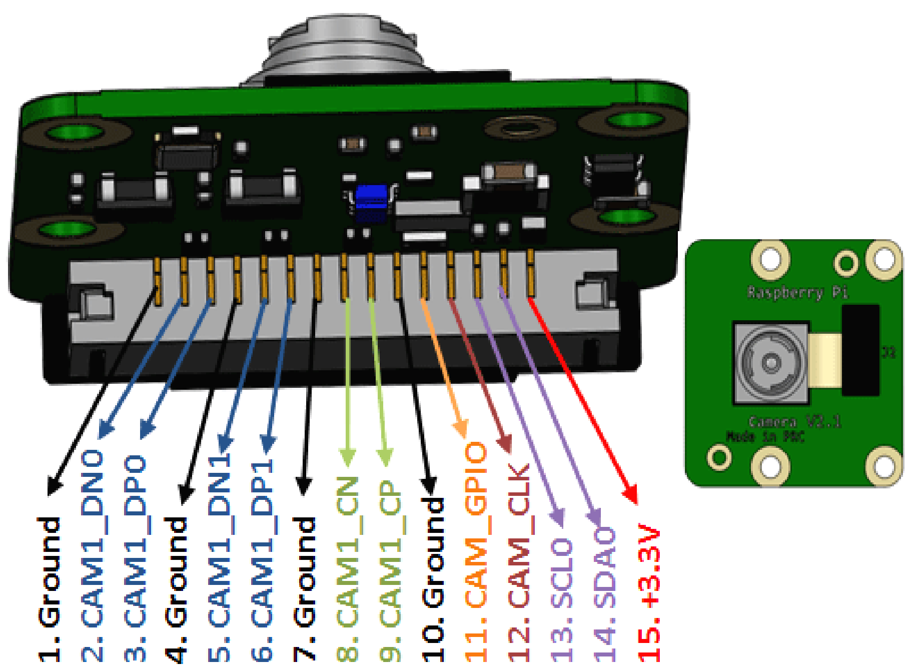

Figure 6. Pi Camera pinout

Pin Description

Pin Number	Pin Name	Description
1	Ground	System Ground
2,3	CAM1_DN0, CAM1_DP0	MIPI Data Positive and MIPI Data Negative for data lane 0
4	Ground	System Ground
5,6	CAM1_DN1, CAM1_DP1	MIPI Data Positive and MIPI Data Negative for data lane 1
7	Ground	System Ground
8,9	CAM1_CN, CAM1_CP	These pins provide the clock pulses for MIPI data lanes
10	Ground	System Ground
11	CAM_GPIO	GPIO pin used optionally
12	CAM_CLK	Optional clock pin
13,14	SCL0, SDA0	Used for I2C communication
15	+3.3V	Power pin

Table 1 Pinout description of Pi Camera Module

2.4. Raspberry Pi

Raspberry Pi is a series of small single board computers developed by the United States in the Raspberry Pi Foundation in association with Broadcom . Early on, the Raspberry Pi project leaned towards the promotion of teaching basic computer science in schools and in developing countries . Later, the original model became far more popular than anticipated, selling outside its target market for uses such as Robotics. It is now widely used in many areas, such as for weather monitoring,because of its low cost, modularity, and open design.

The Raspberry Pi is a very cheap computer that runs Linux, but it also provides a set of GPIO (general purpose input/output) pins that allow you to control electronic components for physical computing and explore the Internet of Things (IoT).

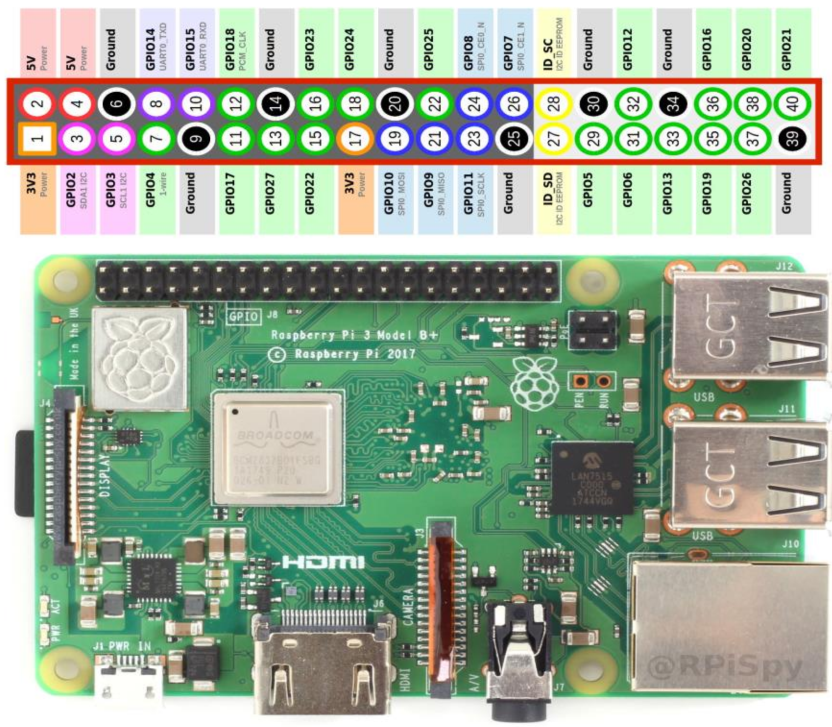

Figure 7 Raspberry Pi Pin out diagram

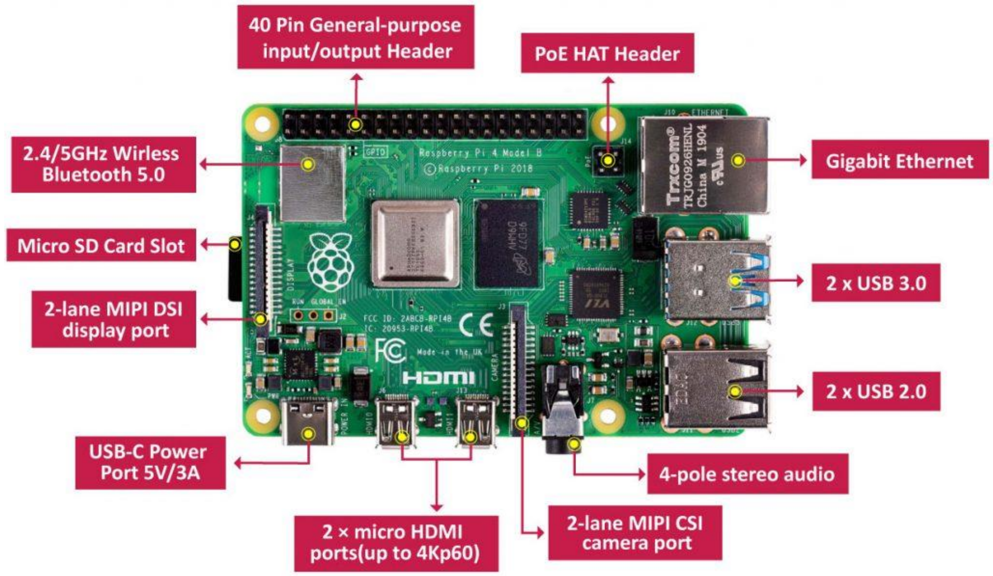

Figure 8 Raspberry Pi Architecture

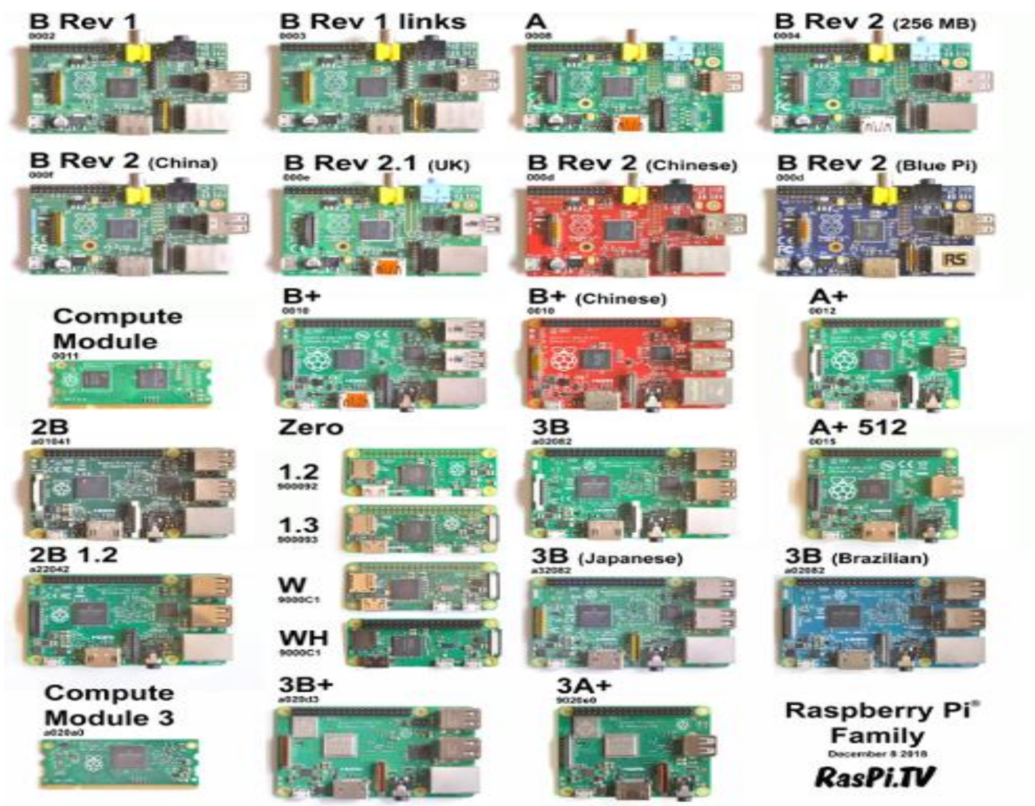

Figure 9 Raspberry Pi Generations

Raspberry Pi Platform	RAM	Processor	USB	Ethernet	Wi-Fi	Bluetooth	HDMI	Other Video	MicroSD
Raspberry Pi A+	512MB	700 MHz ARM11	1 Port	-	-	-	Yes	DSI, Composite	Yes
Raspberry Pi B+	512MB	700 MHz ARM11	4 Ports	10/100Mbps	-	-	Yes	DSI, Composite	Yes
Raspberry Pi 2 B	1GB	900 MHz Quad-Core ARM Cortex-A7	4 Ports	10/100Mbps	-	-	Yes	DSI, Composite	Yes
Raspberry Pi 3 B	1GB	1.2 GHz, Quad-Core 64-bit ARM Cortex A53	4 Ports	10/100Mbps	802.11n	4.1	Yes	DSI, Composite	Yes
Raspberry Pi 3 B+	1GB	1.4 GHz 64-bit ARM Cortex A53	4 Ports	300/Mbps/PoE	802.11ac	4.2	Yes	DSI, Composite	Yes
Raspberry Pi Zero	512MB	1 GHz single-core ARM11	1 Micro USB	-	-	-	Mini-HDMI	-	Yes
Raspberry Pi Zero Wireless	512MB	1 GHz single-core ARM11	1 Micro USB	-	802.11n	4.1	Mini-HDMI	-	Yes

Raspberry Compute Modules*	RAM	Processor	USB	Ethernet	Wi-Fi	Bluetooth	HDMI	Other Video	MicroSD
Raspberry Pi Compute Module	512MB	700 MHz ARM11	1 Port	-	-	-	Yes	DSI, Composite	No
Raspberry Pi Compute Module 3	1GB	1.2 GHz, Quad-Core 64-bit ARM Cortex A53	1 Port	-	-	-	Yes	DSI, Composite	Yes
Raspberry Pi Compute Module 3 Lite	1GB	1.2 GHz, Quad-Core 64-bit ARM Cortex A53	1 Port	-	-	-	Yes	DSI, Composite	Yes

Family	Model	Form Factor	Ethernet	Wireless	GPIO	Released	Discontinued
Raspberry Pi	B	Standard[a]	Yes	No	26-pin	2012	Yes
	A		No			2013	No
	B+		Yes		40-pin	2014	
	A+	Compact[b]	No			2014	
Raspberry Pi 2	B	Standard[a]	Yes	No		2015	
Raspberry Pi Zero	Zero	Zero[c]	No	No		2015	
	W/WH			Yes		2017	
Raspberry Pi 3	B	Standard[a]	Yes	Yes		2016	
	A+	Compact[b]	No			2018	
	B+	Standard[a]	Yes			2018	
Raspberry Pi 4	B (1 GiB)	Standard[a]	Yes (Gigabit Ethernet)	Yes		2019[39]	March 2020[1]
	B (2 GiB)						
	B (4 GiB)						
	B (8 GiB)					2020	
	400 (4 GiB)	Keyboard					
Raspberry Pi Pico	N/A	Pico (21 mm x 51 mm)	No	No	26-pin	2021	

Table 2 Raspberry Pi Specifications

In our project we’re using the Raspberry pi 4 model. The speed and performance of the new Raspberry Pi 4 is a step up from earlier models. Whether we’re editing documents, browsing the web with a bunch of tabs open, juggling spreadsheets or drafting a presentation, we’ll find the experience smooth and very recognisable — but on a smaller, more energy-efficient and much more cost-effective machine.

Features of Raspberry Pi:

- **Silent, energy-efficient**

The fanless, energy-efficient Raspberry Pi runs silently and uses far less power than other computers.

- **Fast networking**

Raspberry Pi 4 comes with Gigabit Ethernet, along with onboard wireless networking and Bluetooth

- **USB 3**

The new Raspberry Pi 4 has upgraded USB capacity: along with two USB 2 ports you'll find two USB 3 ports, which can transfer data up to ten times faster.

- **Our choice of RAM**

Different variants of the Raspberry Pi 4 available, depending on how much RAM you need — 2GB, 4GB, or 8GB.

With the all new Raspberry Pi 4 released recently, with impressive speeds and performance power compared to previous models, the Raspberry Pi 4 have now been a must-buy for all makers and tech enthusiasts.

The Raspberry Pi 4 seems to be perfect, however, how does it fare compared to its predecessor: The Raspberry Pi 3 Model B+

2.5. L298M Motor Driver

The L298 Driver is a high voltage, high current dual full bridge driver designed to accept standard TTL logic levels and drive inductive loads such relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together the corresponding external terminal can be used for the connection of an external sensing resistor.

This L298N Motor Driver Module is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driverIC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control

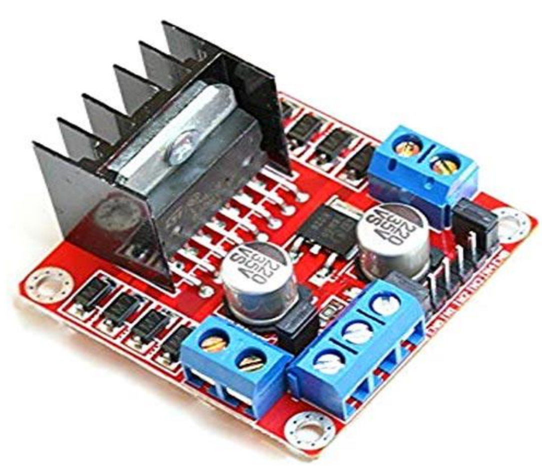

Figure 10 L298N Motor Driver IC

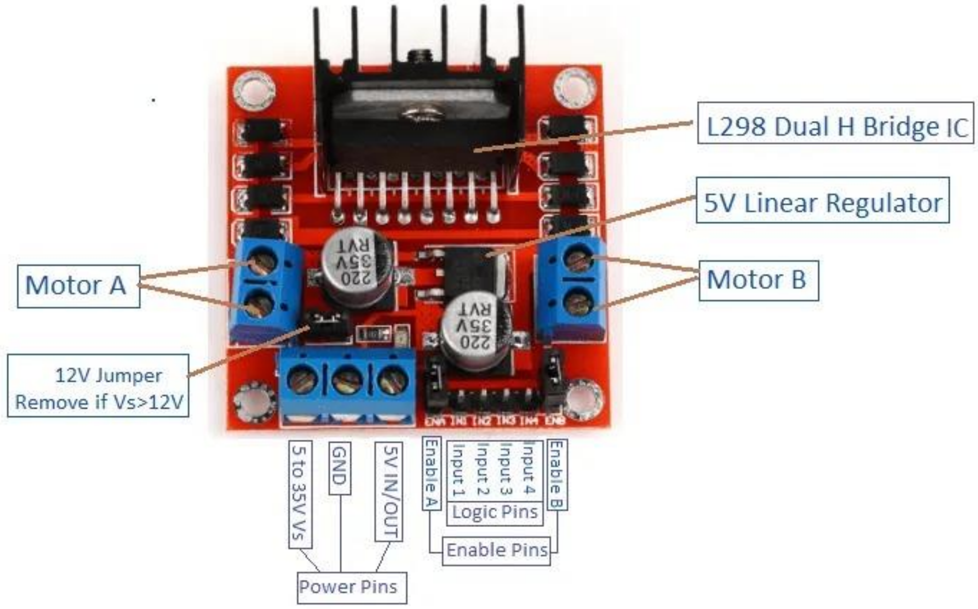

Figure 11 L298N Motor Driver IC pinout

2.6. Computer Vision for Autonomous Driving

We, humans, are heavily dependent on our five senses to interpret what is going on around us. Every sense is equally important to us. Eyes are what we use to see and perceive a lot of things around us. It helps us to see the road around us, see the obstacle around us, identify the lanes and much more. In applications like autonomous vehicles, Robotics, this still is one of the most challenging tasks to teach machines to see and understand like humans.

Computer vision is one of the hottest topics in Artificial Intelligence. It is being used extensively in Robotics, Autonomous Vehicles, Image Classification, Object Detection & tracking, Semantic Segmentation as well as in various photo correction apps. In Autonomous vehicles, vision remains the main source of information to detect lanes, traffic lights, and other visual features.

Despite the challenges, we have already done so many advancements in the field of Computer Vision.

Figure 12 Self driving car vision

2.6.1. Open CV

OpenCV (*Open Source Computer Vision Library*) is a library of programming functions mainly aimed at real-time computer vision .Originally developed by Intel , it was later supported by Willow Garage then Itseez (which was later acquired by Intel. The library is cross. Starting with 2011, OpenCV features GPU acceleration for real-time operations

Applications :

OpenCV's application areas include:

- 2D and 3D feature toolkits
- Egomotion estimation
- Facial recognition system
- Gesture recognition

- Humane computer interaction(HCI)
- Mobile robotics
- Motion understanding
- Object detection
- Segmentation and recognition
- Stereopsis stereo vision : depth perception from 2 cameras
- Structure from motion(SFM)
- Motion tracking
- Augmented reality

To support some of the above areas, OpenCV includes a statistical machine learning library that contains:

- Boosting Boos
- Decision tree learning
- Gradient boosting trees
- Expectation-maximisation algorithm
- K-nearest neighbour algorithm
- Naive bayes classifier
- Artificial neural networks
- Random forest
- Support vector machines (SVM)
- Deep neural networks (DNN)

Programming language :

OpenCV is written in C++ and its primary interface is in C++, but it still retains a less comprehensive though extensive older C interface . All of the new developments and algorithms appear in the C++ interface. There are bindings in Python , JAVA and MATLAB/OCTAVE and Wrappers in several programming languages have been developed to encourage adoption by a wider audience. In version 3.4, JavaScript bindings for a selected subset of OpenCV functions was released as OpenCV.js, to be used for web platforms.

Hardware acceleration :

If the library finds Intel's Integrated Performance Primitives on the system, it will use these proprietary optimized routines to accelerate itself.

A CUDA -based GPU interface has been in progress since September 2010.

OS support :

OpenCV runs on the following desktop operating systems: Windows , Linux , macOS, FreeBSD , NetBSD , OpenBSD . OpenCV runs on the following mobile operating systems: Android , iOS , Maemo , Blackberry 10 .The user can get official releases from SourceForge or take the latest sources from GitHub.OpenCV uses CMake.

Chapter 3. Principle and Working

3.1 Hardware

3.1.1. Firmware Installation

- Flash Raspbian OS to memory card using Raspberry Pi Imager.
- Create a configuration file(wpa supplicant.conf) for accessing through Wi-Fi , which consists of credentials i.e username and password of WiFi
- Create an empty SSH file .
- Insert the memory card into the Raspberry Pi and connect it to the power supply
- Find the IP address of Raspberry Pi and enter it in VNC viewer
- Enter the username - pi and password as Raspberry pi , by default.
- Installation of libraries

To install PIP:

- **PIP for python2 - sudo apt-get install python-pip**
- **PIP for python3 - sudo apt-get install python3-pip**

To update packages:

The below commands are for updating every applications or package which is already installed.

sudo apt-get update

sudo apt-get upgrade

To install python3 in Raspberry Pi:

sudo apt-get install python3

To install OpenCV in Raspberry Pi for python3 in single command:

sudo apt install libqtgui4

sudo apt install libqt4-test

sudo pip3 install opencv-python

3.1.2. Circuit description

- Connect motors to motor drivers.
- Connect the motor driver's Enable pins to the Raspberry Pi's GPIO pins.
- Connect the camera module to the Raspberry Pi
- Connect the Raspberry Pi and the motor driver to the power supply.

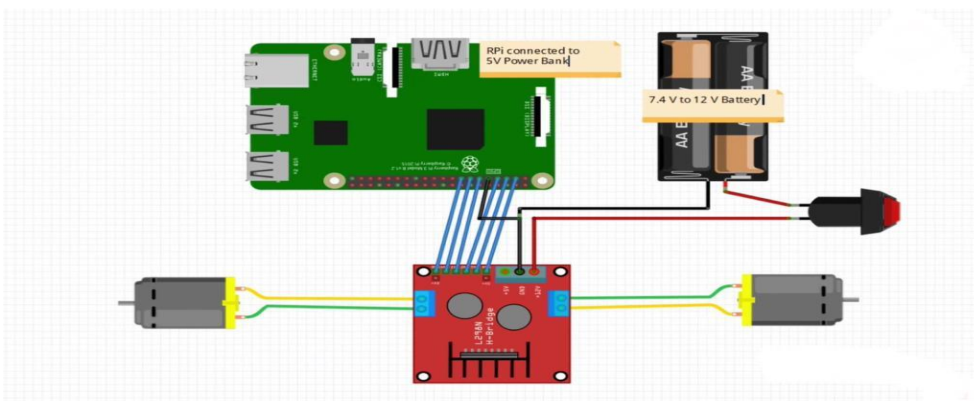

Figure 13 Circuit Diagram

3.2. Software

3.2.1. Motor Driver Module

- Enable and initialize the GPIO pins.
- Run the motor based on certain conditions

3.2.2 Initializing the Camera Module :

- Open the terminal in Raspberry Pi
- Enter sudo raspi-config
- Select the interface options and enable the camera
- Test it by running commands raspistill -o img.jpg

3.2.3 Lane Line Detection

Lane line detection using OpenCV

Loading the Image Frame and defining the Region of Interest

The purpose of this section is to build a program that can identify lane lines in a picture or a video frame. When we humans drive, we use eyes and common sense to drive. We can easily identify the lanes on the road, and we do the steering based on that. But to do this with machines, it's a difficult task and that's when computer vision comes in. We build complex computer vision algorithms in order to teach machines to identify the lane lines.

Our main approach here is to build a sequence of functions in order to detect lane lines. We will use an image frame as a sample image, once we are able to detect lane lines in this image frame then we will club everything together which can accept dash cam video footage and detect lane lines on it.

Pre-Processing:

Pre-processing is an important part of image processing and an important part of lane detection. Pre-processing can help reduce the complexity of the algorithm, thereby reducing subsequent program processing time. The video input is a BGR-based colour image sequence obtained from the camera. In order to improve the accuracy of lane detection, many researchers employ different image pre-processing techniques.

Figure 14 Sample Image for Lane Line

Color Transformation:

Colour model transform is an important part of machine vision, and it is also an indispensable part of lane detection in this paper. The actual road traffic environment and light intensity all produce noise that interferes with the identification of colour. We cannot detect the separation of white lines, yellow lines, and vehicles from the background. The BGR colour space used in the video stream is extremely sensitive to light intensity, and the effect of processing light at different times is not ideal. In this paper, the BGR sequence frames in the video stream are colour-converted into HSV colour space images. HSV represents hue, saturation, and value. Experiments show that the colour processing performed in the HSV space is more robust to detecting specific targets.

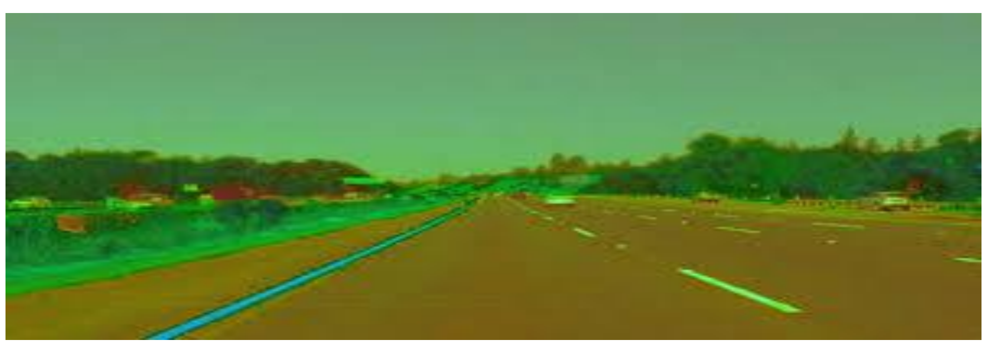

Figure 15 Color Transformation(BGR to HSV)

Pre-processing Images:

A Large number of frames in the video will be pre-processed. The images are individually gray scaled, blurred, X-gradient calculated, Y-gradient calculated, global gradient calculated, thresh of frame, and morphological closure. In order to cater for different lighting conditions, an adaptive threshold is implemented during the pre-processing phase. Then, we remove the spots in the image obtained from the binary conversion and perform the morphological closing operation. Basic pre-processed frames cannot be very good at removing noise. It can be seen from the results after the morphological closure that although preliminary lane information can be obtained, there is still a large amount of noise.

Color extraction:

In order to improve the accuracy of lane detection, we add a feature extraction module in the pre-processing stage. The purpose of feature extraction is to keep any features that may be lane and remove features that may be non-lane. This project mainly carries on the feature extraction to the colour. After the graying of the image and colour model conversion, we add the white feature extraction and then carry out the conventional pre-processing operation in turn.

Edge detection :

The first time is to perform a wide range of edge detection extraction in the entire frame image. In the second, the edge detection is performed again after the lane detection after ROI selection. This detection further improves the accuracy of lane detection . This section mainly performs the overall edge detection on the frame image, using the improved Canny edge detection algorithm. The concrete steps of Canny operator edge detection are as follows: First, we use a Gaussian filter to smooth the image (preprocessed image), and then we use the Sobel operator to calculate the gradient magnitude and direction. Next step is to suppress the non maximal value of the gradient amplitude. Finally, we need to use a double-threshold algorithm to detect and connect edges.

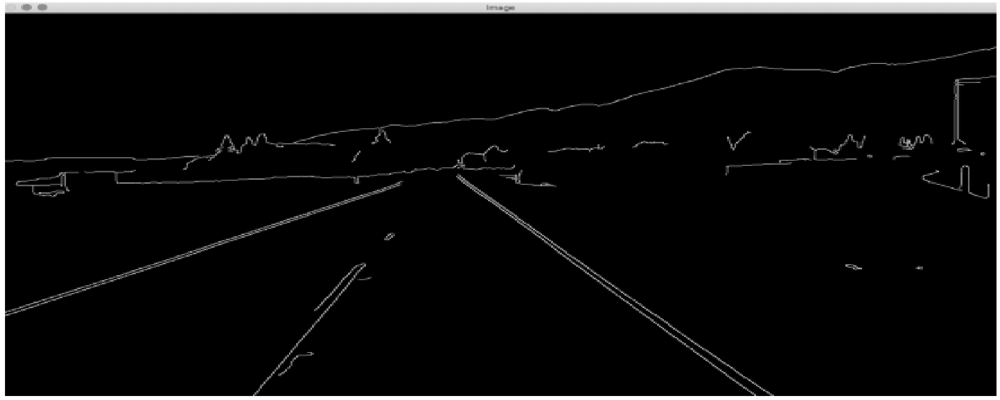

Figure 16 Edge Detection

ROI Selection:

After edge detection by Canny edge detection, we can see that the obtained edge not only includes the required lane line edges, but also includes other unnecessary lanes and the edges of the surrounding fences. The way to remove these extra edges is to determine the visual area of a polygon and only leave the edge information of the visible area. The basis is that the camera is fixed relative to the car, and the relative position of the car with respect to the lane is also fixed, so that the lane is basically kept in a fixed area in the camera.

In order to lower image redundancy and reduce algorithm complexity, we can set an adaptive area of interest (ROI) on the image. We only set the input image on the ROI area and this method can increase the speed and accuracy of the system. We divide the image of each frame in the running video of the vehicle into two parts, and one-half of the lower part of the image frame serves as the ROI area, But, here not only the lane information but also a lot of non-lane noise is present in the upper half of the image. So we cut out the lower half of the image (one-half) as the ROI area.

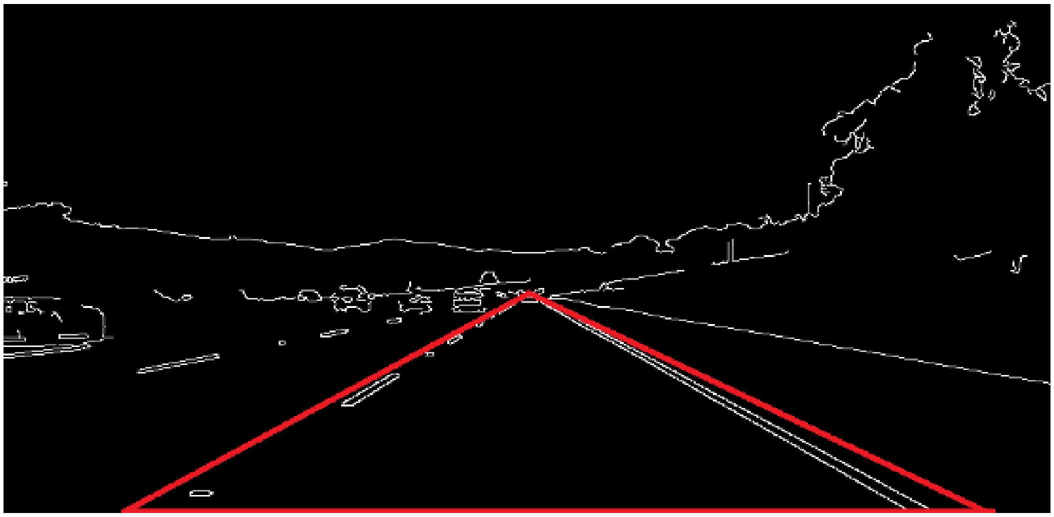

Figure 17 Region Of Interest

Perspective Transformation:

This stage takes a road image and maps it to the birds eye view using the perspective transform to determine the position and orientation of candidate lines. This make it easier and accurate to fit a lane curve/line in subsequent stages. The stage provides a set of lambda functions for warping (from perspective to birds eye) and unwarping (bird's eye to perspective) transformation; the warping function uses the perspective transform which was provided a set of 4 points on a trapezoidal arrangement and then mapped to a rectangular arrangement for 'rectifying' the image. The points on the trapezoid were tagged manually in the Matplotlib interactive mode. The perspectives return the M and M_INV transform matrices which are conditioned into the warp and unwarp closures.

Figure 18 Perspective Transformation (Bird-Eye View)

Lane Curve Detection:

This First step uses a histogram analysis of the bottom half of the frame to detect 'hot' Area for the lanes. Then detect non-zero pixels from the binary image within the sliding window boundary and append it to the list of left and right lane pixel arrays. The step is mirrored across the right and left halves of the images to detect the left and right lane pixels. The aggregate lane pixels from the sliding window search is then curve fitted to a second degree polynomial which is then used in the second step to speed up the search process in subsequent frames.

This uses the lane curves from the histogram search to search for lane pixels in the vicinity of the curves. The Process is the same as the histogram search except that no histogram analysis is required because we already know the area in which we are likely to find lanes. In subsequent frames the local search may return poor results because of changing road topologies and therefore we may have to fall back to the histogram search to re-prime the search.

The lane is then estimated from the candidate pixels from the search using Numpy poly-fit algorithm approximated to a second order polynomial fit.

Lane detection stages from undistorted image to binary to curve fit on bird's eye view

Then Radius of the Curvature is calculated.

If it is negative the path is to the left and if positive the lane is towards the right side

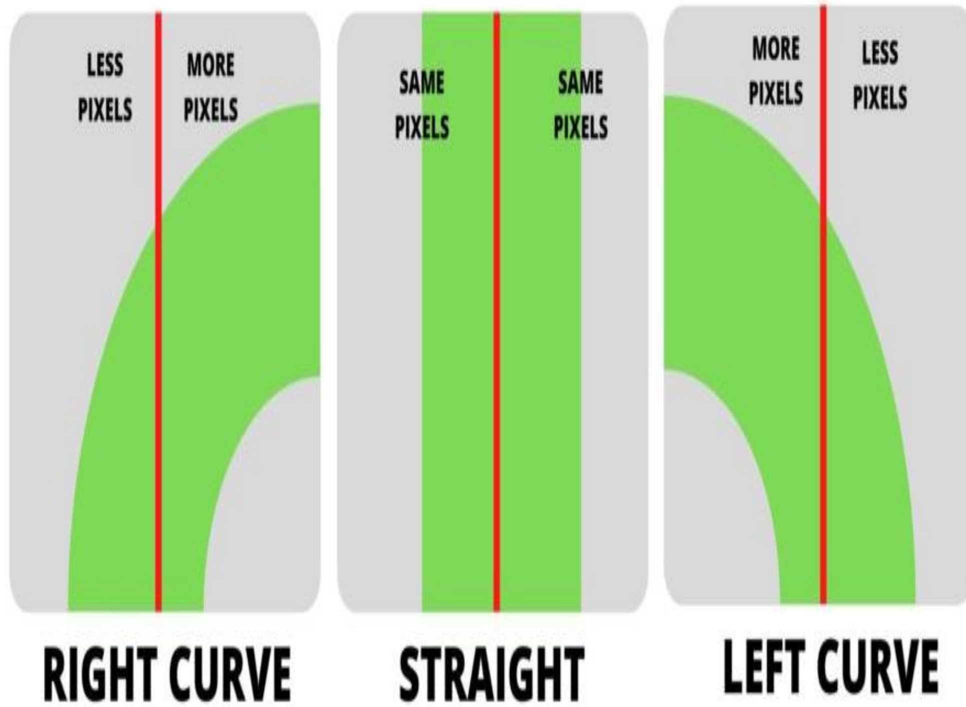

Figure 19 Lane Curve Detection

3.3. Final testing :

Based on the lane detection , the car can drive itself
Merging all the codes and executing it on the hardware.

Chapter 4. Result and Analysis

4.1. Result

We proposed a new lane detection preprocessing and ROI selection methods to design a lane detection system. The main idea is to add white extraction before the conventional basic preprocessing. Edge extraction has also been added during the preprocessing stage to improve lane detection accuracy. We also placed the ROI selection after the proposed preprocessing. Compared with selecting the ROI in the original image, it reduced the non lane parameters and improved the accuracy of lane detection.

In the future, we will exploit a more advanced lane detection approach to improve the performance

As a result, those who currently drive should be able to work, rest or play while getting from A to B. It was evident by the end of the project that both manufacturers had made major progress in terms of their respective autonomous vehicle capabilities.

4.2. Advantages

- Drop in harmful emissions.
- Traffic reduction
- Increase in lane capacity.
- Reduction in travel time.
- It runs on electricity or solar power hence reducing the fuel emission

Chapter 5. Conclusion

5.1. Conclusion

The big question around self-driving cars, for many people, is: When will the technology be ready? In other words, when will autonomous vehicles be safe enough to operate on their own? But there has been far less attention paid to two equally important questions: When will the driving environment be ready to accommodate self-driving cars? And where will this technology work best?

Self-driving cars are the most challenging automation project ever undertaken. Driving requires a great deal of processing and decision making, which must be automated. On top of that, there are many unpredictable external factors that must be accounted for, and therefore many ways in which the driving environment must change.

Cars are heavy,fast-moving objects, operating in public places. Safety is largely the responsibility of the driver, who must continuously observe, analyze, decide, and act. Not only do drivers have to follow the rules of the road, but they also have to communicate with each other and other road users to navigate ambiguous or contested situations; think about how you wave or nod to someone to signal “You go first.”

Self-driving systems have to execute all of these functions, and do so accurately, reliably, and safely, across a wide variety of situations and conditions. Currently, the technology is more capable in some situations than in others.

5.2. Future Scope

In the future , we can also embed LIDAR , RADAR , GSM and GPS technologies to enhance the accuracy of the model and make it future ready.

By using the solar panel, we can reduce the emission of fuels and make these cars electric, which reduces the pollution.

Self-driving cars will reduce accidents, increase productivity for commuters, lower greenhouse gas emissions, decrease traffic congestion, and provide mobility to those unable to drive.

The dream of cars driving itself is becoming a reality. Before , the question was whether it is possible . Now , we know it is .

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