

# Development and Design of Autonomous Navigation Robot Using Raspberry Pi and Computer Vision

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**Abstract** - Visual perception is the most important ability for any robot, animal or social animal to learn, process and act accordingly. Our paper represents the computer vision-based approach programmed in python language - using various libraries like OpenCV and NumPy on Raspberry Pi 3 model b+ to navigate robot autonomously. The high definition USB camera mounted on a custom-built chassis (.approx. 23 X 20 cm) captures the surrounding at several field rates. An algorithm based on simple geometric shape, area and color detection is developed to control the behavior of wheels. Digital image processing techniques like image thresholding and contours detection are used. The robot will operate autonomously without any manual control, it will act only on the data input from the camera, processed by the mini-computer as per the program written in it. Our experiment illustrates the efficacy of technology to gain results with least error.

**Key Words:** Computer Vision, Digital Image Processing, Algorithm, Raspberry-Pi 3 model b+, Robot.

## 1. INTRODUCTION

Human exposure to an unsafe work environment and recent COVID-19 pandemic has boosted the need to develop a technological solution. Small steps can be taken to reduce this vulnerability. 'Computer Vision' refers to the human visual like the tendency for a computer such as extracting, classifying and creating a model to act effectively. Lawrence Roberts (PhD at MIT, the Year 1963) is known as "Father of Computer Vision". "Machine

Perception of Three-Dimensional Solids" is his most admired work. Robots are multipurpose programmable, versatile manipulators forged to locomote material, parts, tools, or specialized devices through various prearrange motions for the execution of a variety of assignments. The cyber-physical augmentation of computer vision on the robot or machine to perform a task is known as robot vision.

Some work related to autonomous navigation has been done previously. Unlike other computer vision-based autonomous navigation techniques, to ease the process of way-finding use of simple geometric shapes of a specific colour and area calculation has been involved in this paper. This concept will navigate the robot more effectively. It will transform and advance more research based on driverless vehicle technology.

The prototype involves a USB camera mounted on the front portion of a custom-built Acrylic robot chassis, Raspberry-pi 4 as robot brain, jumper wire as nerves to carry electric impulse, 12V DC geared motor as Actuator, Li-po battery. The USB camera will transmit the robot's view to Raspberry-Pi 3 model b+. The brain of the robot Raspberry-Pi processes raw input video using computer vision technique. OpenCV is a computer vision library used to perform digital image processing to control the vehicle in a smarter and intelligent way. The output generated during the various processes in raspberry-pi controls the behaviour of the robot by generating signals in the form of pulses to the motor driver circuit for wheel movement. Thus a complete system is established. Such types of an autonomous robot come to aid in a hazardous/non-hazardous environment to explore, deliver material or to carry operations by adding more functionality to it.

## 2. SOFTWARE IMPLEMENTATION

### A. Modus Operandi

The environment which is captured using HD usb camera acts as input for raspberry pi. It is further processed by the algorithm based on the computer vision tool. The algorithm enhances geometric shapes that produce commands to perform the operation by the robot using a motor driver such as moving forward, stopping; turning left and right of the wheels. Computer vision techniques help us to understand more of image information, mainly the area of contour and counting edges of geometric shapes.

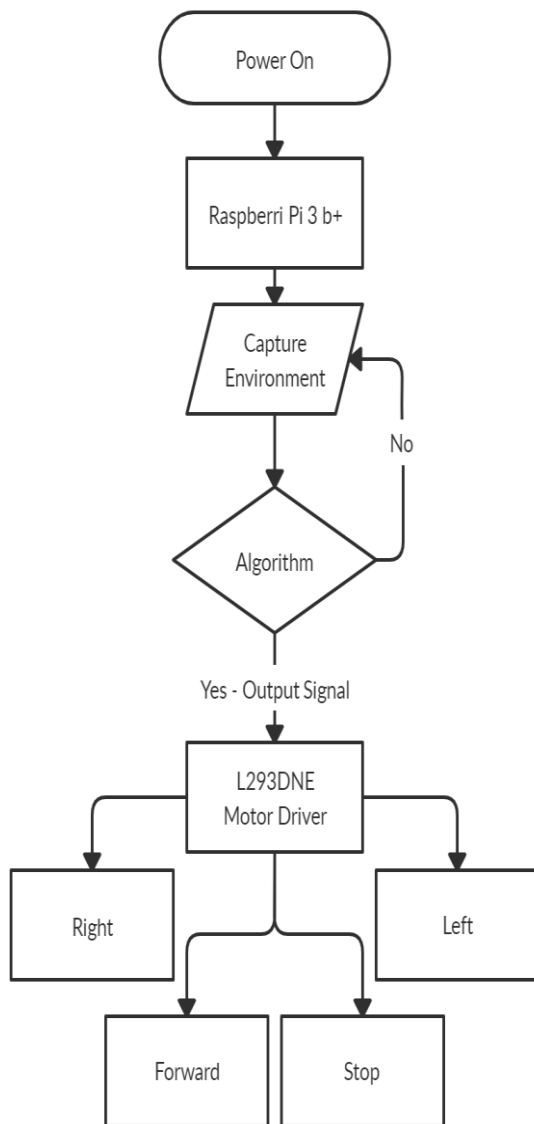


Fig -1: Flow-chart of Modus Operandi

### B. Software Working

#### Computer vision:

Computer Vision is a field study that enables computers or machines/ robots to see. It is a subset of artificial intelligence which collects information or data from images or video and processes them to define attributes. It uses images processing algorithms to perform tasks/

The entire process of computer vision involves images acquisition, Image processing, analyzing and extracting information. This information which is obtained from visual content is translated into an explicit description. Information gathered in a multi-dimensional form which can be related to multidimensional arrays. These steps are explained below:

1. Image acquisition: Image acquisition is the first step in any image processing or computer vision system. It captures

the physical world into digit data. It converts the analogue world into digital content [].

2. Image processing: This method performs operation image or video to enhance their features by using algorithms like edge detection, noise reduction, background subtraction, segmentation, classification and color tracking.

3. Analyzing and extracting information: In this step image or video is analyzed and important information is extracted and the decision is taken to perform the operation by providing instruction in the form of a program.

Here we have used algorithms like color tracking, objection recognition and object tracking.

#### Open-Cv:

Open-Cv is a library in python to solve computer vision problems. The version of Open-Cv we have used is cv2. It supports all the old and new features updated in newer versions making it easy to write code in python which are more readable and efficient. NumPy is used in Open-Cv, it is a highly optimized library for numerical operation with MATLAB style syntax. All the arrays in Open-Cv are converted into NumPy arrays for easy operation and to integrate with other deep learning and data-visual libraries such as sickie learn and Matplotlib respectively.

#### C. Flow of Algorithm

Step1. The captured video is converted to Hue Saturation Value (HSV) from Red Green Blue (RGB) color model.

Step2. The geometric shapes are detected. The shapes are separated from the background using a color tracking algorithm. Here lower range and upper range are defined to identify specific color. Range: Lower [0, 70, 50], Upper [10,255,255].

Step3. Find the contours. Contour connects all the points on the boundary of an object or region of image. This makes it easier to detect objects. In our project we have used contour detection to detect red color which makes it easy to detect red objects and subtracts the background. The contours are found using cv2.findcontour() command. cv2.findContour() function that helps in extracting the contours from the image. Sorted function helps to detect the largest contour and ignore the other small function so that our region of interest is emphasized. Inside the sorted function lambda function is passed as an argument to achieve above desired output.

#### The mode of finding contour:

cv2.RETR\_TREE retrieves all of the contours and reconstructs a full hierarchy of nested contours.

#### Contour approximation method-

CV\_CHAIN\_APPROX\_SIMPLE method is chosen as it removes all redundant points and compresses the contour thereby saving the memory.

Step4. Drawing the contour. Contour is drawn using cv2.drawcontour() function. Here contours drawn under a square boundary. Arguments passed inside this function are used to edit the thickness and color of the contour drawn.

cv2.boundingRect() function helps in drawing contours inside a rectangular region while cv2.contourArea() function is used to calculate the contour area.

Area of contour is used for further robot movement.

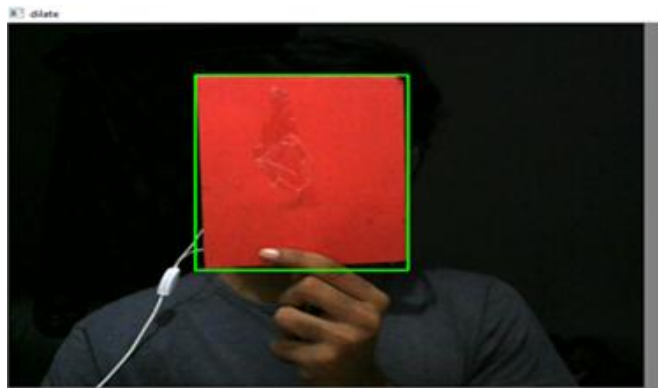


Fig -2: Drawing Contour

Step5. Identifying the geometric shapes. The shapes are identified using Cv2.approxPolyDP() command. Cv2.approxPolyDP() function uses the Douglas-Peucker algorithm. This function is used to detect the polygon by approximating the polygon or curve with another polygon or curve with less vertices. This function is helpful in detecting different geometric shapes[1].

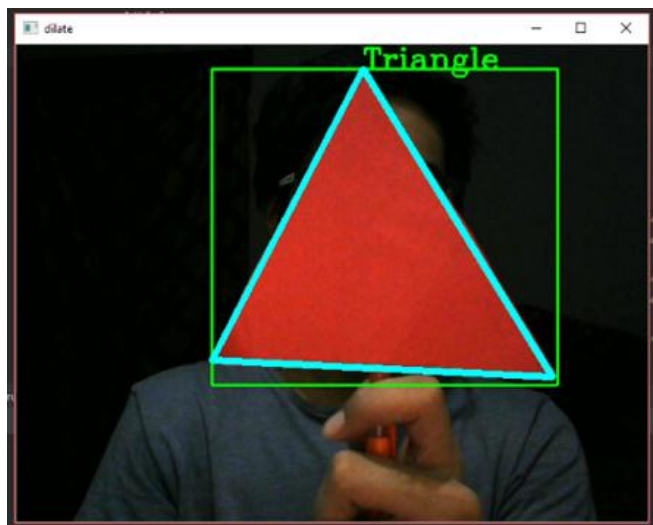


Fig -3: Identifying Geometric Shape

Step 6. Mobilizing the robot. Based on the geometric shape detection, area of contour and object identification an output signal is sent to the motor driver for its movement in various directions i.e. left, right, forward, stop maintaining a safety distance.



Fig -4: A. Move Forward as Geometric Shape is Detected



Fig -5: B. Turn Left

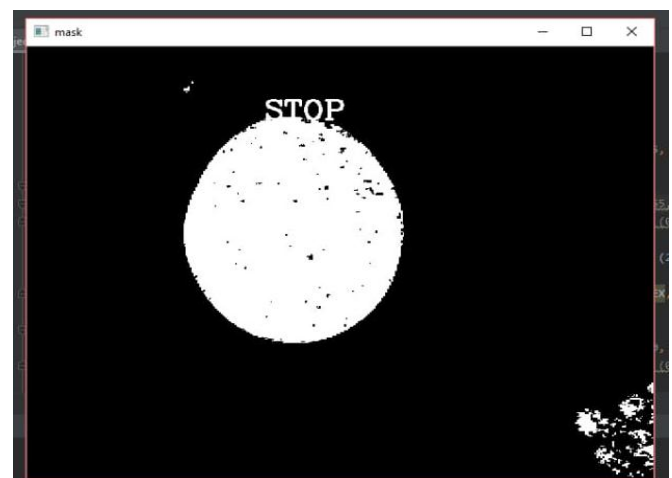


Fig -6: C. Stop

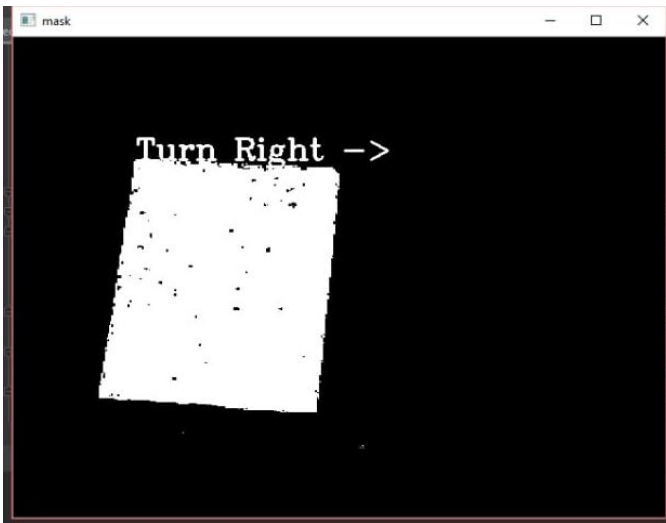


Fig -7: E. Turn Right

### 3. SOFTWARE IMPLEMENTATION

The circuit consists of an usb HD camera which is connected to raspberry pi 3 model b+. H-bridge motor driver L298N is connected to raspberry pi using jumper wires at various gpios. 4, 300 rpm 12v dc geared motors are wired to the motor driver. A 12v battery supplies power to the motor through the driver. The raspberry pi is powered by a 10,000 mah power bank. This completes our system. These components are mounted on a custom built acrylic chassis, 10 cm above ground level.

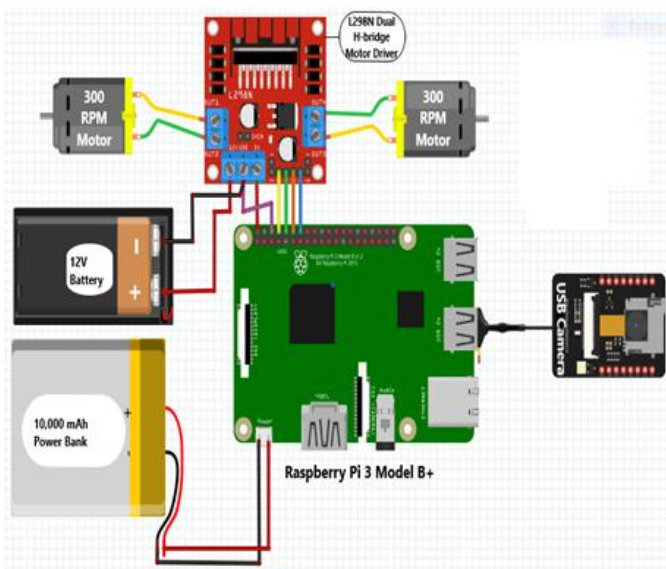


Fig -8: Circuit Diagram

#### A. Raspberry Pi 3 Model b+

A raspberry pi is used in industrial automation, mini projects like building a drone or autonomous robot etc. In this project we are using raspberry pi version 3 with a 1.2 GHz ARM Cortex-A53 processor. It is little similar to android running smartphones as it uses a hardware architecture named ARM

(advanced risc machine), more precisely a Broadcom system on chip. There are 23 operating systems which we can run on raspberry pi. Raspberry pi has usb host, HDMI port, micro usb, SD card slot, Ethernet and GPIO, s. we have choose to do work on this because we can work with many different languages such as c, c++, java, python, Perl etc. whereas mostly c is used for many microcontrollers. Operating system can be easily switched on a single raspberry pi board.



Fig -9: Raspberry Pi 3 Model b+

#### B. L298N Motor Driver

It is also known as dual H-bridge motor driver. By the help of this motor driver we can run two dc motors with the same IC. It is a 16 pin motor driver. It is a bidirectional driver with voltage ranging from 4v to 36v. We can use it for application by interfacing l293d with any controller. The operation of a motor depends on codes. H-Bridge is typically an electric circuit that enables a voltage to be applied across a load either direction to an output.it works by having 4 elements in the circuit commonly known as corner: high side left, high side right, low side right and low side left. By using this combination of these we are able to start, stop and reverse the current.

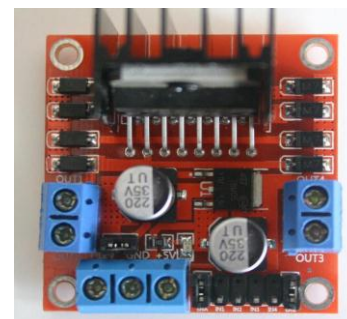


Fig -10: L298N Motor Driver

#### C. Li-Po Battery

Li-po is for lithium polymer, the -po ending refers to cathode. A li-po battery has a polymer as cathode and a solid electrolyte.li-po is regarded as more advanced battery with

higher specs and provide higher level of safety. li-po battery is used in mobiles phones and also it is use in autonomous car for their lighter weight and faster discharge rates, for massive amperages, for more power. We have used 12v li-po battery 2200mAh, 3 cell and it is rechargeable.



**Fig -11:** 12v Li-Po Battery 2200mAh

#### D. Usb HD Webcam

The webcam means a small camera which is used to deliver an image or video in real time through a computer. We have used a Logitech C270 720HD camera for accurate results. In this project the camera will detect the given geometry shape and according to that it will give the direction to our car for further movement.



**Fig -12:** USB HD Camera 720P /30FPS

#### E. Power bank

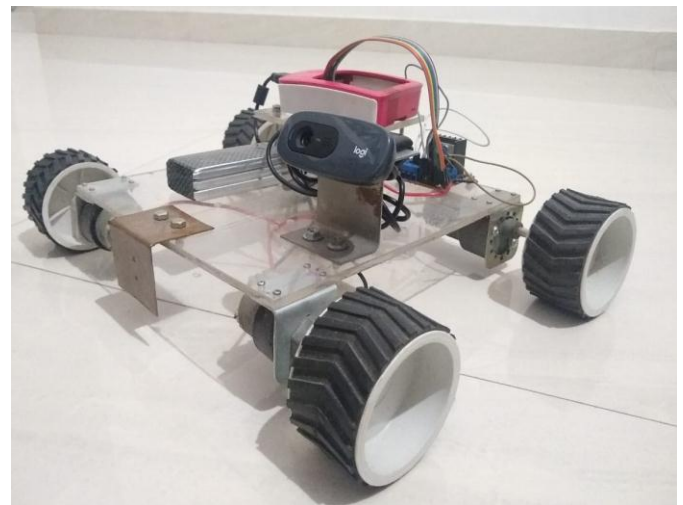
A portable power bank is a charger for a device. Power bank is actually an additional charge for electronic devices and gadgets. In this project the raspberry pi is powered by a 10,000 mah power bank.

#### F. DC Geared Motor

A dc geared means it is the combination of motor and the gearbox. The gear box is used to reduce the speed of the motor shaft and increase the motor's ability to output torque. In this we have used a Johnson high torque motor 12v 300rpm.



**Fig -13:** 12v 300rpm Geared Motor



**Fig -14:** Paraphernalia Setup of Robot

## 4. EXPERIMENTAL RESULT

For verifying the success of the proposed method, the experiments were carried out, snap-shots of the experiment are given in the II. Software Implementation, in C. Flow of Algorithm.

## 5. CONCLUSION

Computer vision is the booming technology which will change the industry and appears to be more promising for human safety and accurate results. The Robot will follow simple geometric shapes along the captured environment by using an usb HD camera. OpenCV is the image processing tool used for the video captured and sends signals for further mobility of robot.

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