

**Visvesvaraya Technological University Belgaum, Karnataka-590 018**



*A Project Report on*

**“Automated Vacuum Cleaner using Machine Learning”**

*Project Report submitted in partial fulfillment of the requirement for the award of the degree of*

**Bachelor of Engineering**

**In**

**Electrical & Electronics Engineering**

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**2019-2020**

**CMR INSTITUTE OF TECHNOLOGY**  
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## Certificate

Certified that the project work entitled “Automated Vacuum Cleaner using Machine Learning” carried out by Mr Divyanshu Garg (1CR16EE024) and Mr Mangesh Kumar(1CR16EE041) are bonafied students of CMR Institute of Technology, Bengaluru, in partial fulfillment for the award of Bachelor of Engineering in Electrical & Electronics Engineering of the Visvesvaraya Technological University, Belgaum, during the year 2019-2020. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report deposited in the departmental library.

The project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said Degree.

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**DECLARATION**

We, [Mr. Divyanshu Garg (1CR16EE024) and Mr. Mangesh Kumar (1CR16EE041)], hereby declare that the report entitled “**Automated Vaccum Cleaner using Machine Learning**” has been carried out by us under the guidance of Ms. **Geethanjali P**, Assistant Professor, Department of Electrical & Electronics Engineering, CMR Institute of Technology, Bengaluru, in partial fulfillment of the requirement for the degree of **BACHELOR OF ENGINEERING in ELECTRICAL & ELECTRONICS ENGINEERING**, of Visveswaraya Technological University, Belagaum during the academic year 2019-20. The work done in this report is original and it has not been submitted for any other degree in any university.

Place: Bengaluru

Date:

# Abstract

Today's households are getting smarter and more digital. Home automation adds flexibility and allows more time for people. Domestic robots are entering the homes and people's daily lives, but it is yet a relatively new and immature market. However, a growth is predicted and the adoption of domestic robots is evolving.

Our aim is to design the Automatic vacuum cleaners that will help to make household work convenient and much easier. This operates in both autonomous and manual mode, along with additional features such as time scheduling and dirt container with auto-dirt disposal mechanism. They are seen as more convenient to use because they can suck dust on their own. This work can be very useful in improving life style of mankind.

The purpose of this project is to design Automatic vacuum cleaners using digital image processing with the help of OpenCv technique. Vacuum Cleaner Robot is designed to make cleaning process much easier rather than by using manual vacuum. Automatic vacuum cleaners use open cv (Image based processing), raspberry pi camera, Dc Motor and control driver. It also includes a mop in one pass (sweep and mop combo) for wet cleaning, autonomous vacuuming and wet-mopping of a board. The water will slowly crawl into the mop, doing the mopping as humans do. As obstacles hit, they will immediately move away. The shape of the vacuum cleaner is of truncated shape. Automatic vacuum cleaners using image processing will have several criteria that are user-friendly.

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# CONTENTS

Title Page	i
Certificate	ii
Declaration	iii
Abstract	iv
Acknowledgements	v
Contents	vi-vii
<b>Chapter 1: INTRODUCTION</b>	<b>9–10</b>
<b>Chapter 2: LITERATURE SURVEY</b>	<b>11-22</b>
2.1 Types of sensors	15-17
2.2 NB-IoT	18-21
2.3 Modes of operation of NB-IoT	22
<b>Chapter 3: METHODOLOGY</b>	<b>23-48</b>
3.1 Block diagram	24-25
3.2 Hardware methodology	26-40
3.3 Software methodology	41-47
<b>Chapter 4: RESULTS AND DISCUSSIONS</b>	<b>48</b>
<b>Chapter 5: REFERENCES</b>	<b>49</b>

## LIST OF ABBREVIATIONS AND SYMBOLS

### Internet of Things

The Internet of Things is a collection of interrelated computing devices, mechanical and digital machines, objects, animals or individuals that have unique identifiers and the ability to transfer data over a network without needing human-to-human or computer-to-computer interaction.

### Narrowband IoT

Narrowband Internet of Things is a radio technology standard developed by 3GPP to enable a wide range of wireless devices and services. The specification was frozen in June 2016, in 3GPP Release 13. Certain 3GPP IoT systems are the eMTC and EC-GSM-IoT platforms.

### OpenCV

OpenCV is a software of programming functions that primarily target computer vision in real time. Originally developed by Intel, it later received funding from Willow Garage then Itseez. The library is cross-platform and is open-source BSD licensed for free use.

### NodeMcu ESP8266

NodeMCU is an open-source firmware and development kit designed to help you prototype or build IoT products. It includes firmware running on Espressif Systems' ESP8266 WiFi SoC, and hardware based on the ESP12 module. The firmware uses the language for Lua scripting.

### Raspberry Pi

The Raspberry Pi is a series of small single-board computers developed by the Raspberry Pi Foundation in the United Kingdom to promote basic computer science teaching in schools and developing nations.

## **CHAPTER 1**

# **INTRODUCTION**

In today life, time management is considered as one of the most important factors. A very notable household chore is floor sweeping that is often seen as a challenging and tedious task. In most cases, cleaners are employed to do the job, rather than the occupants of the home. The difficulty caused by this repetitive chore warranted the creation of a vacuum cleaner capable of assisting humans with such a task. A vacuum cleaner is an electromechanical device which is usually used by suction to clean walls, chairs, rugs and carpets. The electric motor inside the unit turns a fan that produces a partial vacuum and allows air to rush into the vacated space outside. That pushes any dirt or dust around the nozzle into or stuck to the outside of a bag inside the unit.

The demand to reduce manpower level has led to the design and development of automatic control systems, which enables unattended operations of the machinery. The current automatic integrated systems cover all aspects of Automatic vacuum cleaner operations.

Although efficient, current vacuum cleaners are rather voluminous and therefore require large manpower for proper functioning. The former vacuum cleaners using suction generation and collected dust with a spinning brush, the latter worked with a belt driven by hand-cranked fan making it difficult to use. More powerful sweepers fitted with limited suction power were developed in the late 1990s and early 2000s. The robotics vacuum cleaners are ideal for offices, hotels, hospitals and residences, depending on the design goal. However, for efficient operation, most cheap cleaners need a better cleaning pattern algorithm while the smart ones are rather complex, and thus beyond the scope of most homes.



The present robot vacuum cleaner was built from device parts, ultrasonic sensor and a relatively cheap NODEMECU 8266 microcontroller. This navigates the rooms using a patterned algorithm, and its cleaning system is improved by two side-by-side rotating sweepers.

The truncated form was carefully considered when assessing the usefulness in the design of the sweepers. The robot is designed keeping in mind following modules of operation:

- cleaning mechanism
- directional control with automatic obstacle avoidance

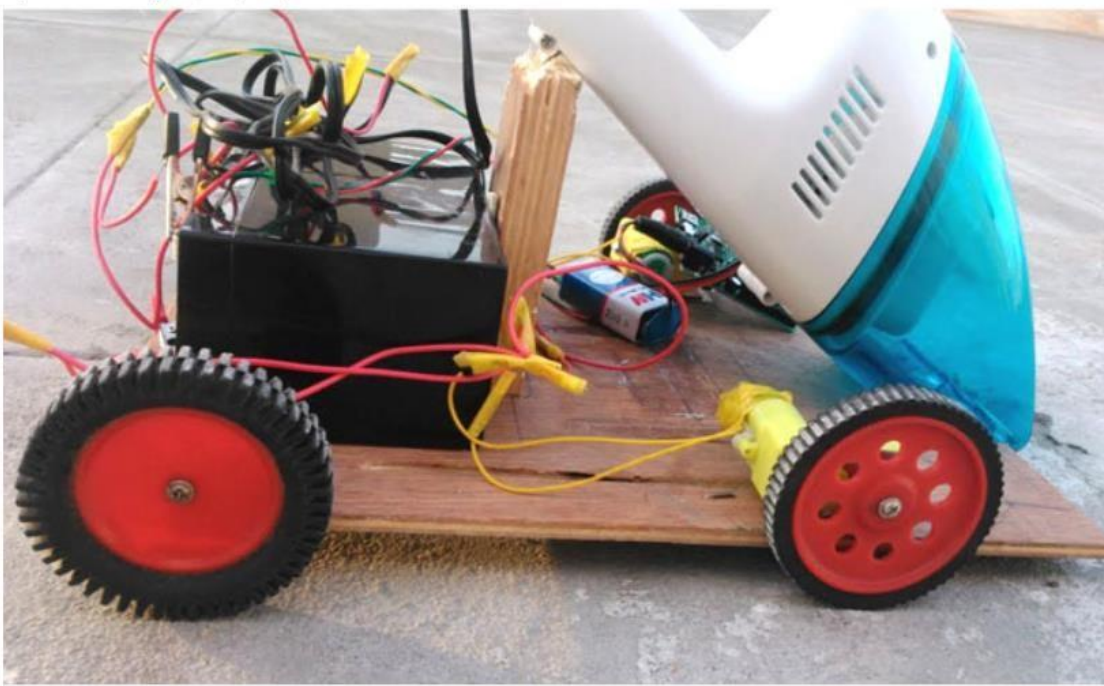


Fig 1.1 AUTOMATIC VACUUM CLEANER MODEL

## CHAPTER 2

# LITERATURE SURVEY

In this chapter comprehensive study of latest technological trends and efficient systems have been shown in which study of automatic vacuum cleaner parameters, such as sensors, raspberry pi module, raspberry pi camera and how to connect raspberry pi with NodeMcu are described. A well-planned literature survey has ensured availability of information for efficient system performance, technology usage, specialization and management of available resources. IOT based systems are also studied for automatic vacuum cleaner system.

The study includes the current knowledge, findings, as well as different methods for development of automatic vacuum cleaner using image processing. It involves concept development, which is a set of activities carried out in the system engineering to collect parameters of operational needs and develop suitable system for implementation.

Design of smart vacuum cleaner which are available in the market are using Arduino Uno, Motor, Ultrasonic Sensor, and IR Sensor . Vacuum cleaner Robots have several functions that are user-friendly.

Vacuum cleaner robot is able to navigate randomly through a vicinity with minimum human involvement, the following important function are found with such robot cleaners

- Obstacle avoidance
- Floor avoidance
- Collision Detection

- Dry cleaning
- Wet cleaning
- Status display
- Automatic system

Four motors are used for the purpose like movement of robot, water pump. Relays are used to drive water pumps and motor cleaners. LM293D IC is used for motor wheel drive. All the details is shown on LCD. Such criteria are compatible with some of the behaviors expected to be programmed into the robot.

This consists of four dedicated wipers fixed to the board. One of the wipers is cylindrical, and the others are geometrically square. The flat wipers are mounted symmetrically at the bottom of the Platform, positioned in ' V' shape to ensure efficient cleaning and dust collection. The roller wipers are mounted with proper ties and driver motor at the end of the platform. Using wet wiping method, cleaning is rendered effective. This device uses a small bottle which carries water within it. That ensures a full surface cleaning. Only the front wipers are rendered watery. It means that the rear wiper removes the water from the surface.

The robot works in both autonomous and manual mode, along with additional features such as precise time scheduling and bagless dirt containers with auto-dirt disposal function. This work can be very useful in the development of human life style.

The proposed design is in dual mode operation. In one of the modes, the robot is fully autonomous and makes decisions based on the outputs of infrared proximity sensors, ultrasonic sensors and tactile sensors after Arduino (mega) controller is processed and the actuators are controlled (2 DC encoder motors) by the H-bridge

driving circuitry.

The robot can also be used to clean a particular area of a room by manually monitoring it from a laptop using the Visual Studio Graphical User Interface (GUI). (C# programming language) via Bluetooth connectivity.

The following figure shows the working model of CLEAR:



Figure 1. Mechanical Design of CLEAR.

The base of the body comprises of acrylic sheet, two encoder motors along with Teflon tires having O-rings on them for avoiding friction, two ball casters of adjustable height having frictionless steel balls, aluminium angular brackets and aluminium holders for two lead acid batteries of 12V and 1.2Ah rating.

A DC geared motor, sprockets for moving chain from geared motor to spinning brush and two aluminum rods for supporting vacuum cleaner mechanism and dirt compartment are included in the cleaning system.

Components are installed at the bottom of the acrylic sheet, so that the center of gravity is lower and the robot is stable

In some of the vacuum cleaners, AT89S52 Micro-Controller manages both hardware and software operations .

RF modules were used for remote (manual) and robot wireless communication with a range of 50 m. This robot is equipped for obstacle detection and automated

water sprayer pump with IR sensor. It uses four motors, two for cleaning, one for water pumping and one for wheels. Dual relay circuit used to drive the motors one for water pump and another for cleaner. All the operations themselves are managed in the automatic mode robot and the lane changes in case of hurdle detection and moves back. The keypad is used in manual mode to accomplish the intended task and to run robot. The RF module was used to transmit and receive information between remote and robot, and to display information on the LCD relevant to hurdle detection.

Unlike other floor cleaner robots this is not a vacuum cleaner robot; it performs sweeping and mopping operation. Detachable mop is used for mopping. Robot performs all of the operations itself in automatic mode. First, the robot begins, moves forward and carries out cleaning operation. These have been used to track obstacles and to clear hurdle IR sensors.

If any obstacle is detected then the robot will automatically change the lane, will not stop and will start cleaning. This assumes zig-zag trajectory.

For the convenience of the user, automatic water sprayer is attached which automatically sprays water for mopping, so no need to reattach wet cloth for mopping. Four motors have been used to perform valued operations such as moving the device, water pumping and cleaning.

Relays are used to operate water pumps and engine cleaners. LM293D IC is used for motor wheel driving.

All the details is displayed on LCD. In manual mode, the robot is controlled by the user itself. RF module have been used to transmit and receive the signal

In the manual mode, if any hurdle is detected, then signal of hurdle detection is displayed on the LCD of remote via RF module.

All the information displayed on LCD. In the manual mode, user itself operates the robot. RF module have been used to transmit and receive the signal to operate the

robot through remote. In the manual mode, if any hurdle detected, then signal of hurdle detection displayed on the LCD of remote via RF module.

In the following research paper which we have studied for the reference and help for our project uses following sensors:

- **OBSTACLE SENSORS**
- **CLIFF SENSORS**
- **WALL SENSORS**
- **WHEEL SENSORS**

**Obstacle sensors:** From the point of view of a robot vacuum, our homes represent an obstacle course of chair legs, coffee tables, sofas and discarded toys. Sensors located on or near the shock-absorbing bumpers of the vacuum allow it to navigate through those obstructions without slowing down. The sensor is triggered when the bumper impacts an object, and the robot vacuum knows how to turn and move away until it finds a clear pathway. Direction does it take depends on where the bumper makes contact. For example, if a vacuum enters an object with its bumper's left side, it will generally turn right because the object has been determined to be to its left. And maneuvering around items can often leave uncleaned swaths of concrete.

Some manufacturers take different approaches to obstacles, literally, to minimize this. For example, an iRobot Roomba can slow as its encounters an obstacle. "The beauty of Roomba is that we handle things softly, because what we find is that you can move through soft items such as curtains and bed skirts," said Ken Bazydola, product management director for iRobot. This gives us better coverage .

**Cliff-sensors:**

Stairs are perhaps the biggest hazard for robot vacuums; a tumble could damage the vacuum and anyone in its path. As a result, cliff sensors are a safety requirement on all robot vacuums. They measure the distance to the ground by constantly sending infrared signals to its surface.

If the signals do not bounce back immediately, the robot believes it has hit a stairway or some other "cliff" and will change direction.

**Wall-sensors:**

The sensor can sense walls, using infrared light again, so they can follow them along. It helps them to clean up along the edges where the floor meets the wall. Most of all, it helps them to do that without bumping and scuffing the wall, as we often do with vacuums that stand up.

Wall sensors can also help the vacuum follow around open doorways in models with mapping capabilities, and discover new areas for cleaning.

**Wheel-sensors:** A vacuum robot uses light sensors to measure rotation of the wheel. With this number and the diameter of the wheel, it can calculate how far it has gone. Sensor navigation had been the way all robot vacuums worked at one time. Today it is mostly limited to the lower-end models of the manufacturer, because it is not particularly efficient although it is reliable. Because these robot vacuums react to sensory input, they tend to grope their way through a room, vacuuming in haphazard paths. To get full coverage and clean each area at least once they take multiple passes across a room whenever their battery life allows. This usually meant longer vacuuming times in our experiments, and inconsistent cleaning in the case of larger rooms, since some areas received more attention than others.

“Since all the above listed projects follow zigzag route where we can't predict whether our vacuum cleaner has completely cleaned our room or not”.

Whereas in our proposed work we can conform ourselves that our floor has been cleaned by vacuum cleaner completely because in our project we will be using range of interest which will help our vacuum cleaner in determining the obstacles and selecting proper path to move.

## **NB-IOT**

For the improvement of IoT foundation through cellular networks and to tussle with existing LPWA technologies like LORA, SigFox, RPMA, introduction of NB-IoT was done.

This cellular technology reuses existing LTE infrastructure and operate in licensed spectrum. With low power consumption NB-IoT can handle massive connection . Along with that it is also helpful in avoiding congestions and offering reliable service by using licensed bands. As hardware complexity in NB-IoT can be reduced by 90% in comparison of LTE Cat-1. Hence we can say, NB-IoT can reduce the cost and energy consumption, which are the main limitation of cellular network technology for IoT devices.

### **NB-IoT FRAME STRUCTURE**

**Downlink** -: In time domain, radio frame is comprised of 10 Sub-frames, each having length of 1ms, in which each subframe consists of 2 slots with a time slot of seven OFDM symbol. Here the range of OFDM symbol within a frame is from 0 to 13. These radio frames which ranges from 0 to 1023 are referred as system frame number(SFN). Once the SFN counter reaches the value of 1023, the counter is reset to 0 and then hyper SFN counter is increased. The hyper SFN range is found between 0 and 1023. In each radio frame, the subframes are labeled between 0 to 9 and their slot are taken as 0 to 19. In frequency domain, one physical resource block consists of 12 consecutive subcarriers. Here Spacing can be given of 15KHz.



**Uplink** -: In uplink resource, 15KHz and 3.75KHz are two subcarrier spacing options. If we take a look into time domain with a subcarrier spacing of 15KHz each slot will be having duration of 5ms. Number of subcarriers will be 12 which is similar to time domain. However, for 3.75KHz subcarrier spacing, total number of subcarrier in the frequency domain is 4 times. The slot duration found is 2ms.

## **NB-IoT Connection Process**

### **1) Cell Selection Process**

A device can be in idle or connected while you are searching for the camping cell. If the device wakes up from a deep sleep then cell selection protocols provide information about the latest cells (MRUs) used. If none of the cells were found to be suitable or if a system is first powered up, a full frequency check is necessary to find a new camping cell. Cell discovery is primarily intended to classify and synchronize with an appropriate NB-IoT cell. The first move is to synchronize time and get an approximate CFO cost in this sense. The autocorrelation capabilities must be used to achieve NPSS synchronization. Therefore when the computer syncs the date, it calculates the CFO by using the following images. A large number of NPSS frames must be observed for devices placed in severe exposure situations. Once the period for the symbols is determined and the CFO has been paid for the belt or guard unit, a raster offset up to 7,5 kHz will be applied. This raster difference also pushes the symbol duration either forwards or backwards owing to overcompensation or adjustment for the carrier speed. As a consequence, the quality of NPBCH identification is severely degraded. This can lead to more delay than CC (Cyclic Prefix) and a lack of OFDM symbol orthogonality lost on downlink. The complexity of the detection device must therefore be increased to make the hypothesis of raster offset testing possible.

Once the NPSS synchronizer has been completed, though, the system knows

subframe #9 whether a radio structure is odd or even numbered. It does not have the necessary information. Because NB-IoT has 504 cell-ids, the algorithm for NSSS detection will therefore make a total of 4032 hypotheses. Afterwards, it is possible to detect a system by correlating the signal obtained corresponds to every NSSS waveform hypothesis. The unit hereafter has cell-id and also has NRS position data. Now that the NB-PCH has been demodulated for obtaining the MIB-NB, the device requires eight hypotheses, which are also called blind decoding. The 34 bit MIB-NB is broadcasted across 64 radio blocks. The key data gathered from the MIB is a) 7-bit control mode, i.e. stand-alone, in-band, system security. b) SIB1 scheduling details defined by 4 bits. c) the 5 bits quality mark (d) The control barring (AB) information allowed is shown or not by 1 bit. e) Timing of the schedules: 4 SFN MSBs and 2 H-SFN LSBs. f) eleven

extra parts for potential expansions. Furthermore it also shows the width of the transport block and the amount of repetitions in the MIB. Thus the computer will find and decode SIB1-NB if it is received by the MIB-NB. Each SIB1-NB contains 8 SIBs of the H-SFN, a 28-bit cell ID and data on another SIB to specifically identify a cell in a PLMN. The SIB1-NB holds each SIB1-NB. In subframe #4 of each other frame, the SIB1-NB transmitted in 16 constant lines. In turn, the programming shall be broadcast at a fixed schedule of 2560 ms (256 radio frames). Cell-id is used in the evaluation of the first SIB1 communication unit. The device achieves complete synchronization with the acquisition of SIB1-NB.

If any change is made, either the fee or adjust the label values will be shown. The unit has in a manner achieved a synchronization of time and frequency with errors which in successive transmission and receipt operations do not substantially deteriorate the output of linked mode or idle mode operation

## 2) Random access procedure

We can initiate this procedure by MAC layer. But before initialization of this process, we need to collect information about available set of PRACH resources through UE. Principles behind selecting PRACH resource is to specify the enhanced coverage level support by the serving Cell. Device uses two thresholds values which is used to determine the NPRACH configuration.

Along with that we also analyze the maximum coupling loss corresponding to different coverage levels by using RSRP thresholds. In NB-IoT the end can support maximum 3 number of NPRACH repetitions out of {1,2,4,8,16,32 and 64}. After acquiring CE level information UE instructs the physical layer to a preamble while specifying the number of repetitions required for transmission per preamble, preamble index and preamble received target power. In NPRACH, RA preamble is transmitted to determine the transmission time of the device to e Node B. On each symbol group of RA preamble frequency hopping is applied so that individual group is transmitted on a different subcarrier. As we already discussed, retransmission depend on CE level. When preamble sequence is received by eNB, it transmits RAR message to UE which provide information about TA(TIMING ADVANCE), scheduling information about radio resource that device can use to transmit the request for connection. After that UE transmits Msg 3 to eNB on NPUSCH including its identity submitted from upper layer and start the contention resolution process.

## 3) Connection Establishment

UE shows that by sending RRC-Connection-Request, it wants to connect to the network. Notwithstanding the establishment cause, the UE likewise demonstrates its ability to support multi-tone traffic and multi transporter support. The eNB will send the RRC Connection message-Setup message After that, the UE will acknowledge by sending the full connection configuration message and by sending

an add request to your NAS.Piggy is backed in NAS ATTACH REquest by PDN-CONNECTIVITY-REQUEST message.The PDN connection is a new feature in 3GPP Rel-13 that allows UE to remain connected with CIoT optimization without a connection with PDN.A PDN connection as part of the attachment procedure is not required in this EU. The connection can also be freed by UE and MME without EPS.In addition, UE and MME will open the link until EPS is released. This allows for a wide range of devices to remain inactive for a long time and rarely transmit data [ 72 ].The encryption system EPS is started hereafter.The standard CONTEXT REQUEST message will then be restored in NAS.

#### **4) Data Transfer**

In Rel-13, ability was added by 3GPP to send data over control plane. CIoT EPS optimization are used for the transmission of data through NBIoT. CIOT consists of control plane and user plane optimization.

In control plane optimization,data packets are sent by UE in non access stratum for conveying non radio signal to MME for a service request whereas in CIoT EPS optimization is suitable for short as well as large data transaction. Before that it needs to establish RRC connection and create access stratum and radio bearer between a network and UE. Once RRC connection is established two control procedures connection suspends and resume are used.

### **Modes of operation of NBIoT**

We can deploy NBIoT in three modes-:

- (a) standalone
- (b) In-band
- (c) guard band

**Standalone Operation-:** Here, either we reserve radio access technology like GSM or we use dedicated spectrum for deployment of NB-IoT carrier.

**In-band Operation-:** Here deployment of NB-IoT carrier is done within LTE carrier. Sharing of resource block can result in efficient use of spectrum which will increase the capacity.

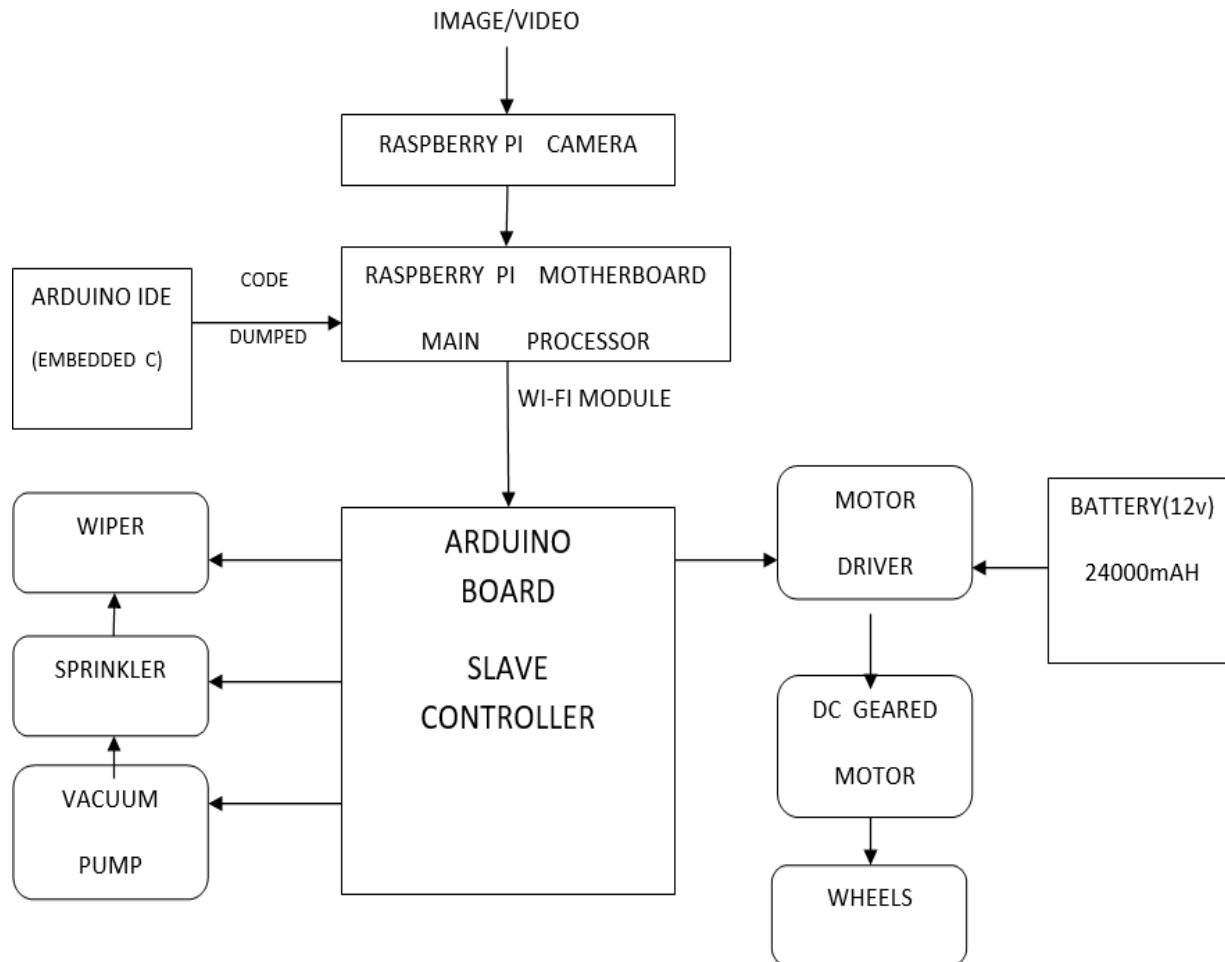
**Guard Band Operation-:** To avoid interference, we locate NB-IoT carrier within guard band of LTE carrier. If we compare it with inband this mode delivers better downlink throughput.

High flexibility is offered in NB-IoT because if spectrum is migrated to LTE , carrier deployed in one mode can continue working via either of the other modes.

## CHAPTER 3

# METHODOLOGY

### BLOCK DIAGRAM:



The above diagram shows the working of the Automatic Vacuum Cleaner.

The image of dust is sensed as input by Raspberry Pi camera which later on undergo processing in Raspberry Pi Module, in which the information related to how to clean up that sensed dust is given by using Open Source Software.

The wheels and wipers are the output of the real time system proposed above.

The Wheel is connected to DC geared motor which is driven by DC Motor Driver. And The DC Motor is being rotated as per the code fed in NODEMCU 8266 and a result of which the wheels are moving in the sensed direction.

The sprinklers and wipers are also attached to the proposed model in which when the wheels are moving in any particular direction of the floor, the floor under the vacuum cleaner model also gets cleaned up with the help of wipers. And sprinklers are used to pour water at the time of cleaning the floor by wipers.

## **HARDWARE METHODOLOGY**

### **DC MOTOR**

A DC motor is one of a class of electrical rotary machines which converts electrical direct current into mechanical energy. The most common types depend on magnetic field effects. Almost all types of DC motors have some internal mechanism, either electromechanical or electronic, to change the direction of current flow in a part of the motor periodically. DC motors were the first commonly used type of motor, as they could be driven from existing direct-current distribution systems. The speed of a DC motor can be regulated over a wide range, either by using a variable supply voltage or by changing the current force in its field windings. Small DC motors are used in vehicles, devices and toys. The universal motor is capable of operating on direct current but is a lightweight brushed motor used for portable power tools and appliances. Larger DC motors are commonly used in electric vehicle, elevator and hoist propulsion, and in steel rolling mill drives. The advent of power electronics has made possible in many applications the replacement of DC motors with an ac motor.



Fig. DC GEAR MOTOR

In this project DC motor is used for wheel movement. For convenient wheel movement the high torque dc motor is used. Since the weight of the automatic vacuum cleaner is about 5-6 kg, we need a dc motor series that generates high torque. Dc motor is also used to power automatic vacuum cleaner wheel speed.

Dc motor is used to transform electric energy directly into mechanical energy. DC motor works on the principle that "whenever a current carrying conductor is placed in a magnetic field, it experiences a mechanical force." Fleming's Left-hand Rule gives the direction of the mechanical force induced in a dc motor and its magnitude is given by  $F = BIL$  Newton.

Dc motor is connected to NodeMcuEsp8266 by means of the dc motor driver which is connected to the battery further. Dc motor is able to rotate the wheel in both clockwise and anticlockwise motion. As the load driven by Dc motor is more necessary by the armature current, it will also require more as a result of high torque dc motor to bear a heavy load.



## DC MOTOR DRIVER

A dc motor driver is a device that serves to conduct in some predetermined manner the performance of a dc motor. A dc motor driver can be use to control the starting and stopping or in forward or reverse rotation of a wheel, regulating the speed of the wheel, limiting the torque and protecting against overloads and faults either a manual or automatic.

Common features of dc motor driver are:

- precise closed loop position control
- fast acceleration rates
- precise speed control dc motors may be made from several motor types, the most common being:
  - brushed DC motor
  - brushless DC motors

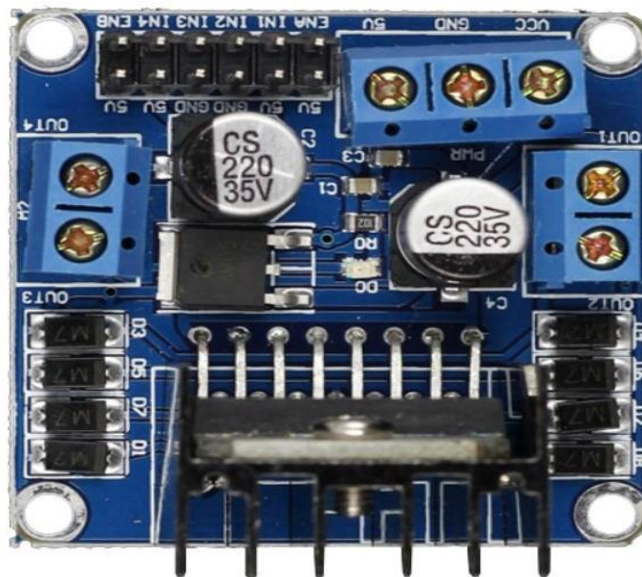


Fig. L298N MOTOR DRIVER MODULE

The L298N is an integrated monolithic circuit in a 15-lead Multi-watt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic level and drive inductive loads such as relays, solenoids, DC and stepping motors. There are two functional inputs that activate or disable the system independently of the input signals. The emitter of each bridge's lower transistors are wired together, and the corresponding external terminal can be used to connect an additional sensing resistor. For the logic to operate at a lower voltage, an additional supply input is given.

## **Features**

- 1) High operating voltage, which can be up to 40 volts;
- 2) Large output current, the instantaneous peak current can be up to 3A;
- 3) With 25W rated power;
- 4) Two built-in H-bridge, high voltage, large current, full bridge driver, which can be used to drive DC motors, stepper motors, relay coils and other inductive loads.
- 5) Using standard logic level signal to control.
- 6) Able to drive a two-phase stepper motor or four-phase stepper motor, and two-phase DC motors.
- 7) Adopt a high-capacity filter capacitor and a freewheeling diode that protects devices in the circuit from being damaged by the reverse current of an inductive load, enhancing reliability
- 8) The module can utilize the built-in stabilivolt tube 78M05 to obtain 5v from the power supply. But to protect the chip of the 78M05 from damage, when the drive voltage is greater than 12v, an external 5v logic supply should be used.
- 9) Drive voltage: 5-35V; logic voltage: 5V

## NODE MCU ESP8266

NodeMCU is an IoT framework which is open source. This includes firmware running on Espressif Systems ' ESP8266 Wi-Fi SoC, and hardware based on the ESP-12 board. By default, the term "NodeMCU" refers to the firmware and not the development kits. The software uses the language for Lua scripting. It is based on the eLua project, and is based on the ESP8266 Espressif Non-OS SDK. It uses many open source projects, such as lua-cjson and spiffs [7].

The module is mainly based on ESP8266 that is a low-cost Wi-Fi microchip incorporating both a full TCP/IP stack and microcontroller capability. It is introduced by manufacturer. The module is based primarily on ESP8266, a low-cost Wi-

Fi microchip that incorporates both a full TCP / IP stack and microcontroller capability. It is introduced by Espressif Systems manufacturer, manufacturer based in Shanghai, China.

This is where NodeMCU comes handy with builtin WiFi support, making it easy to build IoT applications according to your technical needs.

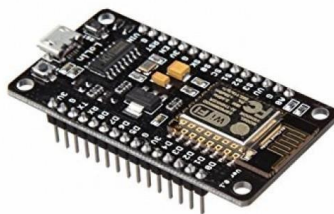


Fig. NodeMCU

- Then open source firmware gives you the ability to change, adjust then restore the original module and keep changing the whole interface until you manage to customize the software according to your needs.

- The USB to UART converter is attached to the module which helps translate USB data into UART data which mainly understands the serial communication language. MicroUSB port is included in the module, instead of the regular USB port, which connects it to the computer for dual purposes: programming and powering the board. The board includes status LED, which automatically blinks and turns off, showing you the module's current status if it is running properly when connected to the device. The ability of module to establish a flawless WiFi connection between two channels makes it an ideal choice for incorporating it with other embedded devices like Raspberry Pi.

## NODEMCU PIN

NodeMCU V3 comes with a number of GPIO Pins. Following figure shows the Pinout of the board.

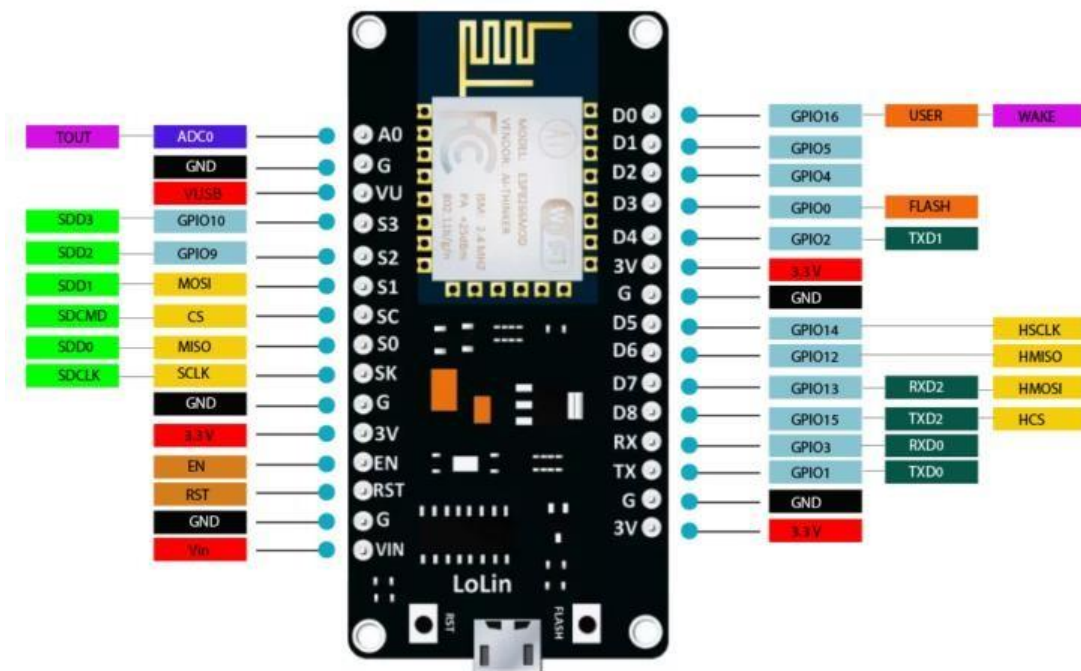


Fig. NodeMCU pin configuration

There is a clear difference between  $V_{in}$  and  $V_U$ , where the former is the controlled voltage that can stand between 7 and 12 V, whereas the latter is the USB power voltage that must be maintained about 5 V.

## HOW TO POWER NODEMCU

From the pinout image above, there are five ground pins on the board, and three 3V3 pins.

**USB Power.** It proves to be an ideal choice for loading programs unless the project you aim to design requires separate interface i.e. disconnected from the computer.

**Provide 3.3V.** This is another great option to power up the module. If you have your own off-board regulator, you can generate an instant power source for your development kit.

**Power  $V_{in}$ .** This is a voltage regulator that comes with the ability to support up to 800 mA. It can handle somewhere between 7 to 12 V. You cannot power the devices operating at 3.3 V, as this regulator is unable to generate as low as 3.3V.

## FEATURES OF NODEMCU ESP8266

- Open-source
- Arduino-like hardware
- Status LED
- MicroUSB port
- Reset/Flash buttons
- Interactive and Programmable
- Low cost
- ESP8266 with inbuilt wifi
- USB to UART converter
- GPIO pins

## **NB-IOT SHIELD**

NB-IoT Shield is an expansion board to connect NB-IoT technology to Arduino.

Users can easily study / evaluate with NB-IoT Shield and Arduino, and do POC for NB-IoT solution.

The NB-IoT Shield is loaded with offshore NB-IoT module. include:

They use Quectel BC95-B5/B8 and B20 module Nb-IoT Bee QB05, QB08, QB20. The module is only intended for use in NB-IoT network. And different reference suffix for different NB-IoT unit.

Nb-IoT Bee 95G, it uses Quectel BC95-G module. This module is a global regions module can work on different operators.

Nb-IoT Bee QG96, it uses module Quectel BG96. This module supports multi bands. Except for NB-IoT, LTE Cat M1 & EGPRS is also supported.

## **Features**

- Support different NB-IoT Bands, can use world widely Low power consumption
- Wide area coverage
- AT command to control Auto support 3.3v or 5v Arduino board  
Compatible with Arduino Leonardo, Uno, Mega2560

## **RASPBERRY PI 3B**

The Raspberry Pi is a series of small single-board computers developed by the Raspberry Pi Foundation in the United Kingdom to promote basic computer science teaching in schools and developing nations. The original model became far more popular than expected, selling uses such as robotics outside of its target market.

It does not include peripherals or cases (such as mice and keyboards). Nevertheless, several official and unofficial shipments included several accessories.

There are two sides to the company behind the Raspberry Pi. The Raspberry Pi Foundation has created the first 2 versions. After the release of the Pi Model B, the Foundation set up Raspberry Pi Trading to create the third model, the B+, with Eben Upton as its CEO. Raspberry Pi Trading is responsible for the technology development while the Foundation is an educational charity that promotes basic computer science teaching in schools and developing countries. More than 5 million Raspberry Pi's have been sold as of February 2015, making it the best-selling British computer, according to the Raspberry Pi Foundation. They had sold 11 million units by November 2016, and 12.5 m by March 2017, making it the third best-selling "general purpose computer" Sales climbed to nearly 15 million in July 2017. Sales hit 19million in March 2018. The Raspberry Pi 3 Model B is the third generation-Raspberry-Pi.

This powerful single board computer sized by credit card can be used for many applications and replaces the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B.

While the Raspberry Pi 3 Model B maintains the popular board format, it brings you a more powerful processor, 10x faster than the Raspberry Pi first generation.

*It adds wireless LAN & Bluetooth connectivity which makes it the ideal solution for powerful connected designs.*

### ***Raspberry Pi 3 - Model B Technical Specification***

- Broadcom BCM2387 chipset
- 1.2GHz Quad-Core ARM Cortex-A53
- 802.11 bgn Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)
- 1GB RAM
- 64 Bit CPU
- 4 x USB ports
- 4 pole Stereo output and Composite video port
- Full size HDMI
- 10/100 BaseT Ethernet socket
- CSI camera port for connecting the Raspberry Pi camera
- DSI display port for connecting the Raspberry Pi touch screen display
- Micro SD port for loading your operating system and storing data
- Micro USB power source

### **Raspberry Pi 3 - Model B Features**

- Now 10x Faster - Broadcom BCM2387 ARM Cortex-A53 Quad Core Processor powered Single Board Computer running at 1.2GHz!
- 1GB RAM so you can now run bigger and more powerful applications
- Fully HAT compatible
- 40pin extended GPIO to enhance your “real world” projects.
- Connect a Raspberry Pi camera and touch screen display (each sold separately)



- Stream and watch Hi-definition video output at 1080
- Micro SD slot for storing information and loading your operating systems.
- 10/100 BaseT Ethernet socket to quickly connect the Raspberry Pi to the Internet



Fig. Raspberry pi 3b

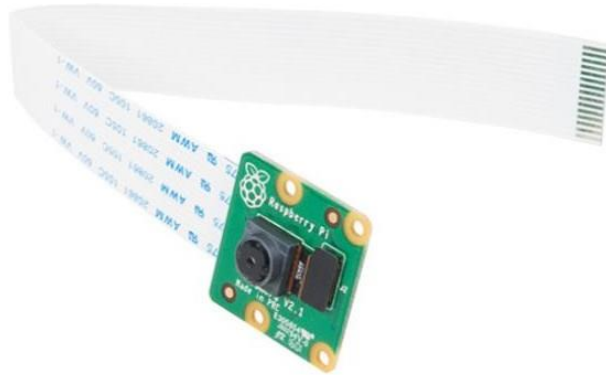
## RASPBERRY PI CAMERA V2

The Raspberry Pi Camera v2 is the new official Raspberry Pi Foundation camera board released online.

This 8mp camera module can accommodate 1080p video and still images that directly connect to your Raspberry Pi. This is the latest version of the Raspbian operating system which is plug-and-play compatible, making it ideal for time-lapse photography, video recording, motion detection and security applications. Connect the included ribbon cable to your Raspberry Pi's CSI (Camera Serial Inter

face) port, and you're good to go!

The board itself is thin, weighing around 25 mm x 23 mm x 9 mm and just over 3 g, making it ideal for mobile or other applications where size and weight are relevant. The sensor has an 8megapixel native resolution, and a fixed focus lens is on board. The camera is capable of 3280 x 2464pixel static images when it comes to still images, and also supports 1080p30, 720p60 and 640x480p90 video.



## **BATTERY**

The Skycell Premium LiFePO<sub>4</sub> Rechargeable Battery Pack is a 12s 5p battery pack with a nominal voltage of 36V and can be fully charged up to 43.8V. This battery pack has 60 cells which gives it a capacity for 1C (30A) continuous discharge and 3C (90A) discharge for a few seconds. The nominal capacity of the battery pack is 30000mah. The battery pack has an in-built BMS which prevents the battery from over charging above 43.8V and also prevents it from over discharging below 33.5 volts.

The Skycell Premium LiFePO<sub>4</sub> Rechargeable Battery Pack is made using Skycell High Quality Lithium Iron Phosphate (LiFePO<sub>4</sub>) rechargeable cells which are one of the most powerful and most stable cells available along with an amazing life cycle of approximately 3000 cycles. The High Quality LiFePO<sub>4</sub> is a 6000 mah cell with a 1C(6A) continuous discharge and 3c(18A) peak discharge. These cells can work in high temperature environments which might not be favourable for the Li-

ion or Li-po cells. The cell is available in the 32650 / 32700 size which means that the diameter of the cell is 32mm and height is 70 mm which is quite compact for the power it gives. With a life cycle of approximately 3000 cycles with good performance, this is a fit and forget solution for our battery packs.

The benefits of the LiFePO<sub>4</sub> cells over Li-ion and Lead acid batterie are:

- LiFePO<sub>4</sub> cells are much more stable chemically and non combustible. At high temperatures or if the battery is mishandled the phosphate based cathode material will not burn. Hence LiFePO<sub>4</sub> are much more safe for E- Vehicles and mobile robots
- LiFePO<sub>4</sub> cells offer much longer lifetime as compared to a Lead Acid or a Li-ion cell. The LiFeP<sub>0</sub>4 provides approximately 3000 cycles under proper handling and upto 70% DOD( Depth of Discharge). Also the shelf life of the cell is much longer with a lower self discharge rate.
- The LiFePO<sub>4</sub> cells offer higher performance compared to a normal 1C Li- ion 18650 cell. The commonly available Li-ion cell are rated for 2 A discharge rate whereas the LiFePO<sub>4</sub> 1C cell provides a 6A discharge rate. There is also very little voltage drop during discharge which is much higher in a lead acid battery.

The LiFePO<sub>4</sub> is a nontoxic material, non contaminating material which contains no rare-earth minerals. This makes it a much more environment friendly choice compared to the lead acid and Lithium batteries.

*Battery Specifications:*

- Nominal Voltage of battery : 36V (12s5p)
- Maximum Voltage of battery : 43.8V(at full charge)

- Operating Voltage: 33.5V -43.8V
- Minimum voltage allowed by BMS : 33.5 V ( BMS will cutoff the supply once battery pack is discharged up till 33.5 V)
- Continuous Current Capacity : 30 A (1C )
- Peak Current Capacity : 90 A (3 C) only for few seconds)
- Norminal Battery Capacity: 30000mAh
- Max Charging Current(Continuous): 1C (30A)
- Dimension: 330mm\*200mm\*80mm
- No of charge/discharge cycles : approximately 3000 cycles for 70% DOD. This means that if the battery pack is used once daily then the life is approx 8 years for same.

### Applications of LiFePO4 battery

- Light electric car, e-bike, electric scooter, e-rickshaw,electric golf cart, forklift, cleanness car, electric wheelchairs.
- E-tools like electric drill, electric saw, lawn mower and so on
- Remote control cars, boat aircraft, toys.
- Solar and wind power generation energy storage devices
- Small medical equipment and portable equipment



## WHEEL

Wheel is used for the movement of the body from one place to another with the help of Dc motor. A wheel is usually of circular shape and hard and made up of durable material whose center has a circular hole through which an axle bearing is placed about which the wheel rotates and when a moment is applied by the torque to the wheel about the axis, thereby making together and also easy movement of the automatic vacuum machine. When wheel is placed vertical axis under a load-bearing platform, the wheel turning on the horizontal axis makes it possible to transport heavy loads efficiently, when placed horizontally, the wheel turning on its vertical axis makes it possible to control the spinning motion used to shape materials, when mounted on a column connected to a chassis mounted on other wheels, one can control the direction of a automatic vacuum cleaner, when connected to a engine, a wheel can store, release or transmit energy.



# **SOFTWARE METHODOLOGY**

## **Image Processing**

### **1. Image Capturing**

We will make use of some basic parameters over camera so for example the resolution, brightness, contrast and the frame rate. After that we used some default values for our brightness, contrast and saturation. You can play with these parameters adding your own. Next is frame per second. So its default value is 0 means our camera will try to capture as many frames it can.

But if you have to capture 30 frames per second then we can specify 30 as a parameter. Let's say if we want to capture 100 frames so we can specify a hundred here. But we will specify the zeros so that our camera can try to capture maximum frames as much as it can.

### **2.Video Capturing**

In this section, we have to access a video from a raspy cam. Here we are not going to make use of any different function. Rather than that we will use a different approach. Initially we read video before displaying. In OpenCV, video can either

be read by using feed from camera or by reading a video file. After reading, we will display the video frame by frame. The frame of a video is simply an image and we display each frame the same way we display image that is we use functions like `imshow()`, in which window automatically fits to image size. As with picture, we use the `waitKey()` to pause every frame in the video. In the case of image, we pass "0" to the `waitKey()` function, but in order to play a video, the wait function needs to pass a number greater than "0".

So we need to move the waitkey function number greater than "0." This number is equal to the time we want each frame to display in milliseconds. In rare cases, we may want a delay higher than one millisecond when the replay needs to be at a certain frame rate.

We will use it 360 by 240 resolution for our image processing for this project. We're not going to process our images in high quality or full HD, because our Raspberry Pi can't handle high bit-rate image processing.

We can see at high resolution and most importantly 360 by 240 frame is enough to capture every detail we want.

### **3.Calculation of Frames Per Second**

Now in this step we will calculate the total frame rate for our video stream. FPS can be defined as the number of full screen images that are displayed each second. It has wide range of application in video and playback and is also used to measure the game performance. Here, this function is just created to make the processor busy.

Each frame is a still image; it creates the illusion of motion by showing frames in a quick succession. The more frames per second (fps), the smoother the motion appears.

The minimum fps required to prevent jerky movement is usually around 30.

## **4.Convert Image Signature**

The function `cvtColor` in C++ converts the image given as input from one color space to another. When we want transformation of color space from RGB to any other color space we have to mention it explicitly(RGB OR BGR). By default the color format in OpenCV is RGB but the bits are actually reversed i.e BGR . Therefore the first byte in standard color image is 8-bit Blue component ,next is Green and the third component will be Red. For linear transformations we don't need to explicitly provide the range for RGB color image but in case of non- linear transformations the image should be properly normalized to a proper pre- defined value of range to get the proper results.If we use this function for 8-bit images some information will be lost during conversion. So it is better to use `cvtColor` function with 32-bit images so that information is retrieved and is not lost. This function will automatically convert the image before operation for the applications that will provide the full range of colors.

## **5.Threshold Operations**

Thresholding is one of the simplest segmentation method used in OpenCv4. It has wide range of applications in separating the areas of an image corresponding to the object we want to analyze.This separation principle is based on the difference in the intensities of object pixels and background pixels. For differentiating the pixels from an image which we want to remove the intensities values are compared with respect to a threshold value which is determined according to the problem which we solve. Once the pixels are separated out properly we can provide them

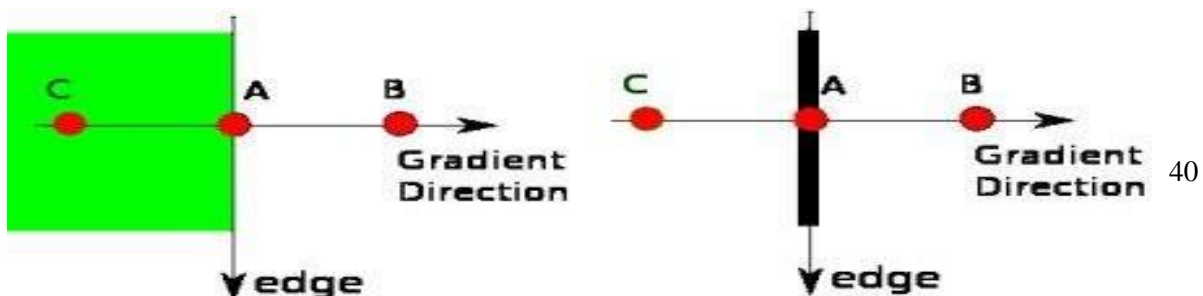


predetermined value so that it becomes easy to identify them. In OpenCV4 the function thresholds perform different thresholding operations. They are namely Threshold Binary , Threshold Binary(Inverted) , Truncate , Threshold to Zero and Threshold to Zero(Inverted).

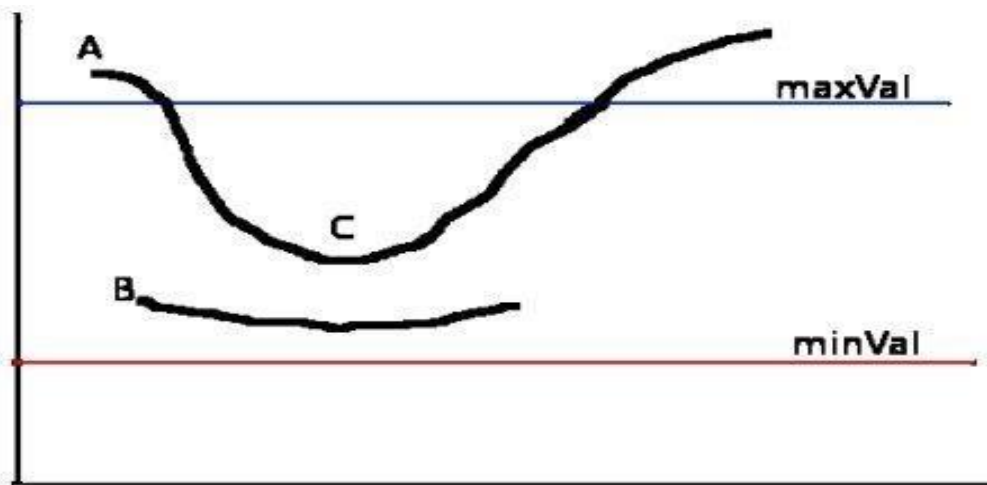
## 6. Canny Edge Detection

It is a popular edge detection algorithm which is been used in OpenCV4. The function used for such detections are cv.Canny(). It is a multistage process which can be explained through the below following steps:-

- **NOISE REDUCTION** :- In the very beginning since the edge detection is sensitive to noise therefore it is essential to remove noise in the image using a Gaussian filter of dimension (5\*5).
- **FINDING INTENSITY GRADIENT OF THE IMAGE** :- Now the smoothed image is filtered in both horizontal and vertical direction using Sobel Kernel to get the first derivative in horizontal and vertical directions respectively. Using these images we find edge gradient and direction for each pixel in the image. The Gradient direction is always perpendicular to the edges of the image object .
- **NON-MAXIMUM SUPPRESSION** :- After determining the magnitude of gradient and direction the image is scanned and unwanted pixels are removed which does not comprises of the image. At every pixel point it is been verified that its local maximum is in the neighbourhood direction of its gradient.

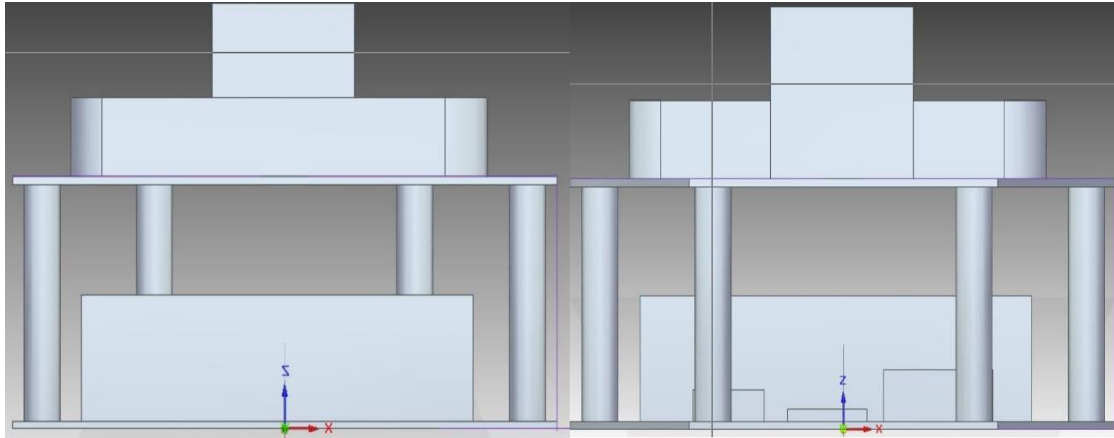


- **HYSTERESIS THRESHOLDING** : As the name suggest this stage decides whether the edges are real or not. The edges are evaluated on the basis of two threshold values which are minVal and maxVal. The edges which have intensity gradient more than maxVal are sure to be edge while thos edges which have intensity gradient less than minVal are non- edges I.e not real edges. For those edges whose intensity lie between the specified interval value are considered to be a part of edges and are sure- edges. Otherwise they too can be discarded.

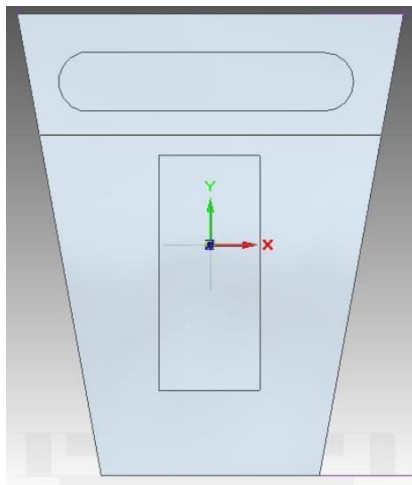


# AXIAL REPRESENTATION OF ROBOT

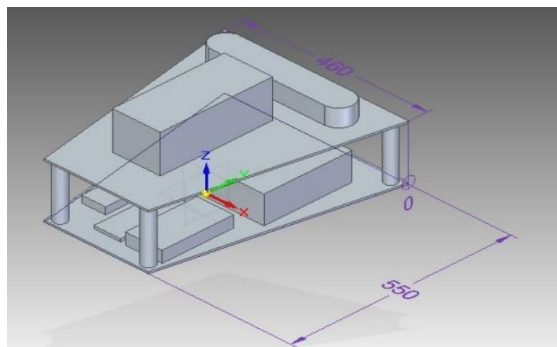
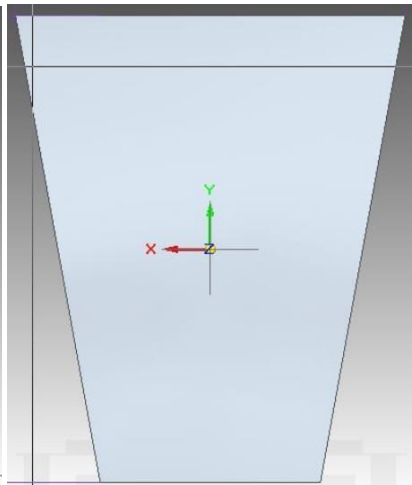
(b)



(c)



(d)



(e)

## CHAPTER 4

# RESULTS & DISCUSSIONS

- Our project facilitate efficient floor cleaning with sweeping and mopping operations.
- It work only in automatic mode, either with the help of remote control or with the help of image detection through camera.
- Our project provide the hurdle detection in case of any obstacles that comes in its way.
- Our design is helpful in overcoming the limitation of the existing technology,  
i.e. instead of zigzag movement of the robot, our system is following straight path (edge detection).
- SAlong with that our robot consist of vacuum pump, which will help in sucking the dust, and this suction of dust will take place from the front side of model.
- With the help of Narrow band iot we will able to control(switch on and off), from a wide distance also.

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