Chapter 1

INTRODUCTION

INTRODUCTION

1.1 Introduction

"A robot is a programmable, multi-functional manipulator designed to perform specialized tasks through variable programmed motions for the accurate and systematic performance".

Robots are increasingly being incorporated into industry working environment to replace humans especially to work on repeated actions along with the development of computer embedded technology. Automation using robots is considered as start of new, lucrative & high end technology.

In general robots are classified in the field of industrial and service robotics. Service robots are the robots which perform semi autonomously or fully autonomously -services useful for the humans and equipment, excluding manufacturing operations.

We have developed an autonomous robot which is capable of doing a task without any human interface. We have developed a robot and the control for this robot is an application based on the android. We are providing instructions or command through phone e.g. destination where robot must be present, then robot is finding the shortest and suitable path of its own, it is detecting the obstacle present over the path & by considering all the parameters it is going to the desired location. Such robot will play an important role in the field of any kind of automation.

In our proposed idea we have used Raspberry Pi controller for robot control where android operating system is used. Programming language is advanced java.

Basically, this is a sponsor project for a newly established start-up company, situated in Pune.

1.2 Project objectives

1) To build a robot based on a Raspberry Pi with a user friendly control Interface.

2) To make a robot which goes to the specified location by calculating distance and detecting obstacle.

3) Remotely controlled robot by using Wi-Fi and android application.

1.3 Project Motivation

1. Advancements in robotic automation.
2. Use of efficient and specific tools for interface.
3. Need of remotely controlled robots in industry.

1.4 Proposed System

Robotics and android based techniques can be used to deal with automation concept. Automation is defined as the technology by which a process or procedure is performed without human interface.

Also, embedded system like Raspberry PI helps us in fast and accurate processing of multiple tasks. We can use combination of these technologies in order to make system which proves to be really useful for home automation.

In our proposed system, we are going to use the exact combination of three technologies which are promising and quick to adapt. i.e - 1) Robotics 2) Android 3) Embedded System.

Chapter 2

LITERATURE REVIEW

2.1 WHAT IS AUTOMATION

- **AUTOMATION**

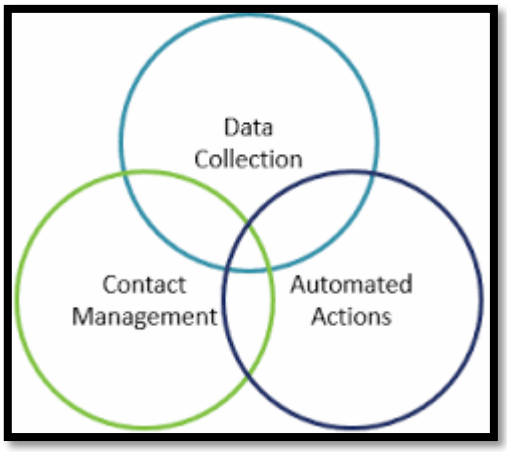


Fig 1. Automation

Automation or automatic control is nothing but the use of various control systems in industry for operating processors, boilers, heaters and ovens and other networks. This reduces the human intervention and also saves the time.

The biggest advantage of automation is that it saves labor, saves energy, raw materials and also increases productivity with improved quality. Automation can be done with the help of open loop control system or closed loop control system. In closed loop system feedback is used to calculate the error signal so that the process can be controlled.

- **TYPES OF AUTOMATION**

1. Discrete control(ON/OFF)

This is the most elementary control action mode which has only two fixed positions that are ON and OFF.

These are popularly used in large scale systems with slow process rate. Examples are the thermostats used on household appliances, liquid level controller system for large volume tanks.

2. Continuous control

The continuous control system is usually a feedback control system in which measurements are taken from sensors and compared with reference signal to generate an error signal. According to an error signal adjustments are done to improve the accuracy. Such kind of automation is used in manufacturing, aircraft, communications and other industries.

In this type of control action mode output of the controller changes smoothly in response to the input error or rate of change of error.

3. Open and closed loop

Open loop and closed loop are two types of control systems. In open loop control system feedback is not present while on other hand in closed loop system feedback from output is given and compared with reference signal to generate an error signal. According to an error signal adjustments are done to improve the accuracy.

2.2 What is android Things?

Android Things is a new IOT initiative based on Android announced by Google. Android Things supports three boards: the Intel Edison, the NXP Pico and the **Raspberry Pi 3**.

Since, requirement of our sponsors is to work with android & Raspberry PI 3, Android Things in combination with Raspberry PI 3 is selected.

Fig 2. Android Things

- The Android Things operating system was created with these challenges in mind. There are many challenges that limit adoption of IOT platforms, including

  1) Complex technologies that require a diverse range of technical expertise
  2) Various security vulnerabilities
  3) The lack of open standards for interoperability
  4) Fragmented services.

Android Things and Android Comparison

Table 1. Comparison of android Things and android

Comparison Point	Android	Android Things
1) Developer	Google, Open Handset Alliance	Google (an IOT initiative based on Android)
2) Source model	Open source (Kernel, UI, and some standard apps)	Open source
3) OS family	Linux	Linux on Embedded Systems, RTOS
4) Release Date	September 23, 2008	December 13, 2016
5) Programming Languages	100+	100+ & some newly included MISRA C, nesC, CAPL
6) RAM	Android Oreo (8.0) – 1GB RAM	Android 7.0 4 GB RAM
7) Languages and Database	Linux, OS X, Windows	Java, Kotlin, XML, C, C++, SQlite

2.3 PREFERRED RESEARCH

1. **Keerthi Premkumar et al.** proposed a method in which robotic arm can be controlled using Raspberry pi, android application and Wi-Fi. Raspberry pi is used for controlling of the overall system. Smart phone with Android application is used as input for the system. Using this application user can give input to the system through commands. By taking input from smart phone, raspberry pi controls the robotic arm according to given input. Android application and Wi-Fi is used for remote control.

2. From **Hayet Lamine et al.** paper, we understand that the controlling of remote equipment requires a "Raspberry pi" card. Smart phone with android application sends commands as input, and these commands are received by RPi card. Raspberry pi card can be communicated with shutter with the help of electronic card. The results show that domestic equipment such as a shutter have been successfully remotely controlled.

3. **Young-Hoon Jeon et al.** proposed the system in which Human-Robot Interaction (HRI) can be done with the help of Smartphone. In this system, motion state can be captured or acquired using the host computer of a robot. The voice can be generated by the help of host computer and is sent to smart phone, which is used as a client via Wi-Fi communication. The results show that, three types of interfaces are successfully implemented.

4. **Mohd Ezanee Rusli, Mohammad Ali2, Norziana Jamil, Marina Md Din et** Proposed a system of An Improved Indoor Positioning Algorithm Based on RSSI-Trilateration technique for Internet of Things (IOT).

Trilateration is one of the techniques available to determine the location of an object.

This paper proposes an improved Wi-Fi trilateration based method for indoor positioning system.

5. **Xiao Lu et al.** proposed the system in which smart phone is used for controlling of a robot. Smart phone with Android application is used for different robot operations such as singing, dancing with the help different commands. Robot motion can also be controlled with android application. Wireless network is used as the communication medium between smart phone and robot.

6. **Carlos Parga et al.** described robot arm controlling based on interaction between Human and machine using smart phone. This robot can be controlled by giving different commands with help of Wi-Fi. Robot control can be done using a different type of sensors such as gyroscope, accelerometer, etc. These sensors were used for measurement of position as well as direction. The arm movement can be controlled with the help of a servo controller. Smart phone can communicate to robot using wireless LAN. The overall system results show that gyroscope and accelerometer errors are successfully estimated. Also position and displacement have been successfully measured as well as communication between smart phone and robot was successfully checked. The propose system shows that robot arm can be efficiently controlled remotely using HMI.

Chapter 3

WORKING WITH RASPBERRY PI 3

3.1 RASPBERRY PI-3

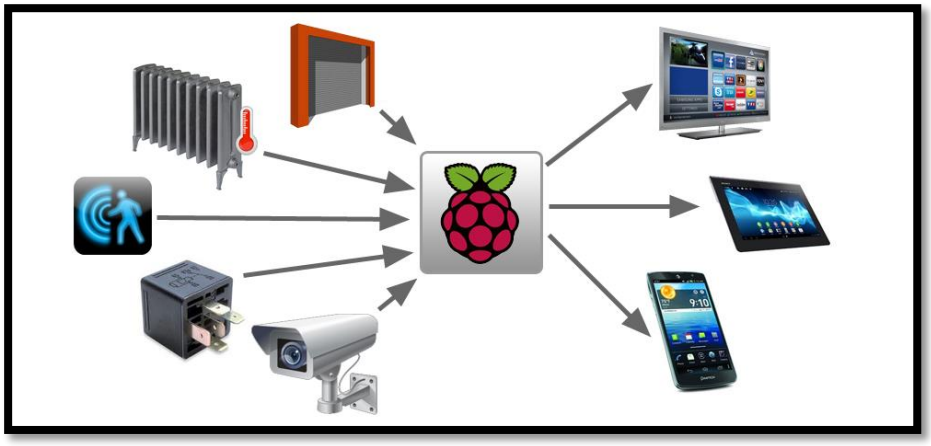


Fig 3. Raspberry PI used in automation

Table 2. Comparison of different Raspberry PI modules

Parameter	R-Pi	R-Pi 2	R-Pi 3
CPU	ARM1176JZF-S	ARM Cortex-A7	ARM Cortex-A53
CPU speed	700MHz single core	900MHz quad core	1,200MHz quad core
RAM	512MB	1GB	1GB
GPU	BCM Video core IV	BCM Video core IV	BCM Video core IV
Storage	SDHC slot	Micro SDHC slot	Micro SDHC slot
USB Ports	2	4	4
Wi-Fi	No built-in Wi-Fi	No built-in Wi-Fi	802.11n & Bluetooth 4.1

Raspberry PI
3.2 GPIO pins

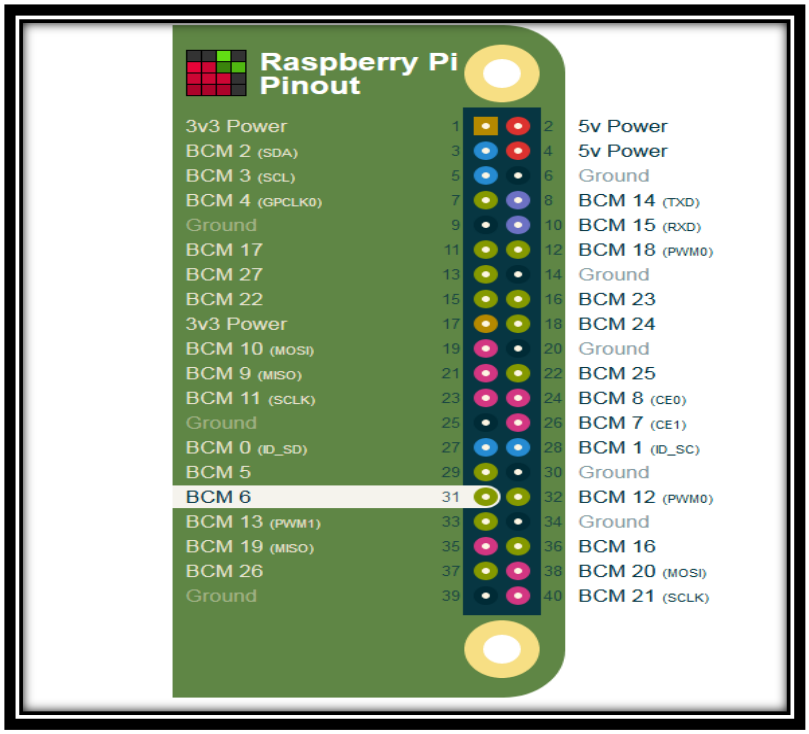


Fig 4. Raspberry PI pin out diagram

Table 3. Raspberry PI GPIO pins

BCM PIN	PHYSICAL PIN	SPECIFICATION
1) BCM 2	3	I2C Data
2) BCM 3	5	I2C Clock
3) BCM 4	7	GPCLK0
4) BCM 5	29	GPCLK1
5) BCM 6	31	GPCLK2
6) BCM 7	26	SPI Chip Select 1
7) BCM 8	24	SPI Chip Select 2
8) BCM 9	21	SIPO MISO
9) BCM 10	19	SIPO MOSI
10) BCM 11	23	SPI0 SCLK
11) BCM 12	32	PWM0
12) BCM 13	13	PWM 1
13) BCM 14	8	UART Transmit
14) BCM 15	10	UART Receive
15) BCM 16	36	FL0
16) BCM 17	11	FL1
17) BCM 18	12	PWM0
18) BCM 19	35	SPI Master In

19) BCM 20	38	SPI Master Out
20) BCM 21	40	SPI Clock
21) BCM 22	15	SD0 Clock
22) BCM 23	16	SD0 CMD
23) BCM 24	18	SD0 DAT 0
24) BCM 25	22	SD0 DAT 1
25) BCM 26	37	SD0 DAT 2
26) BCM 0	27	HAT EEPROM I2C Data
27) BCM 1	28	HAT EEPROM I2C

3.3 Project Circuit

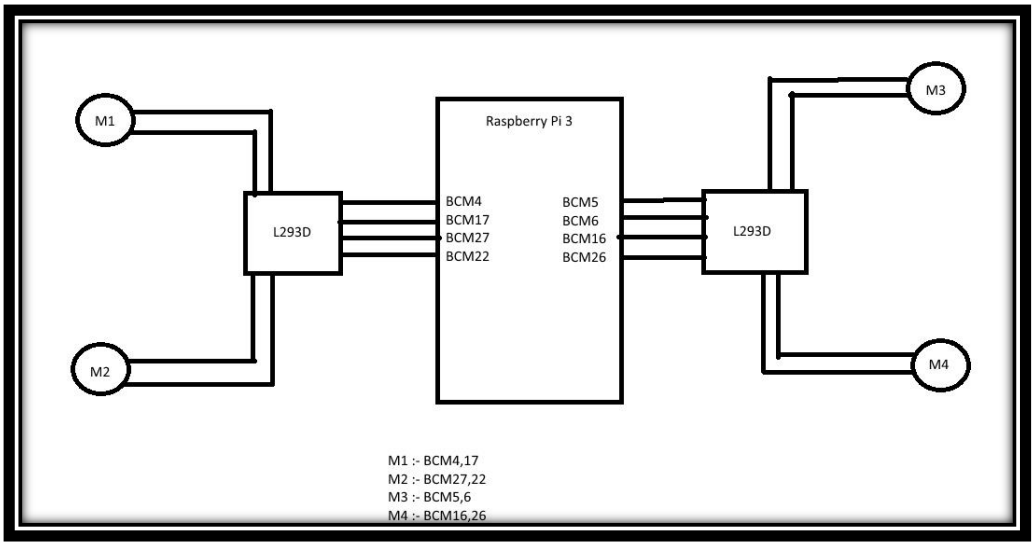


Fig 5. Project Circuit

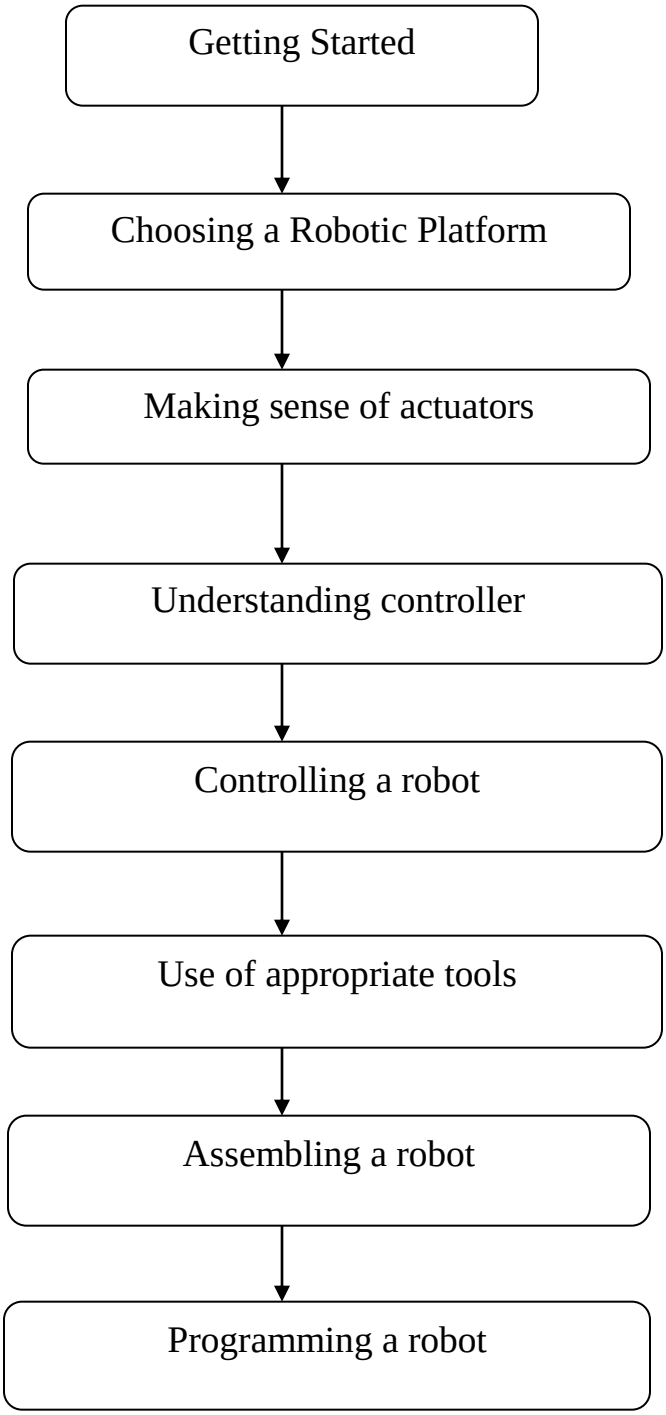
M1, M2, M3, M4- DC Motors

L293D- Motor Driver

Chapter 4

PROJECT DESIGN FLOW

4.1 Design flow



A) Getting Started and choosing a robotic platform

In this methodology, we have started with selecting an appropriate operating system and selected platform is android Things which is an IoT Initiative based on android announced by Google.

Booting process

1. Download appropriate Android Things image for board. (i.e to download 'img' file)
2. Writing .img file in a microSD card.
3. Insert card in Raspberry PI, connecting to monitor (via HDMI) and connect the power.
4. Android Things loading screen showing three pulsating dots will appear, which ultimately tells booting process is completed.
5. Screen showing Ethernet and Wi-Fi connections will appear.

B) Understanding Controller

Selection of Raspberry PI 3 since built in Wi-Fi module is present & GPIO pin configuration.

C) Controlling a robot, Programming a robot & assembling a robot

(Hardware and Software)

a) Hardware

1. Selection of robot assembly
2. Use of raspberry pi 3 controller
3. Using DC motors and motor drivers
4. Battery

5. Use of sensors

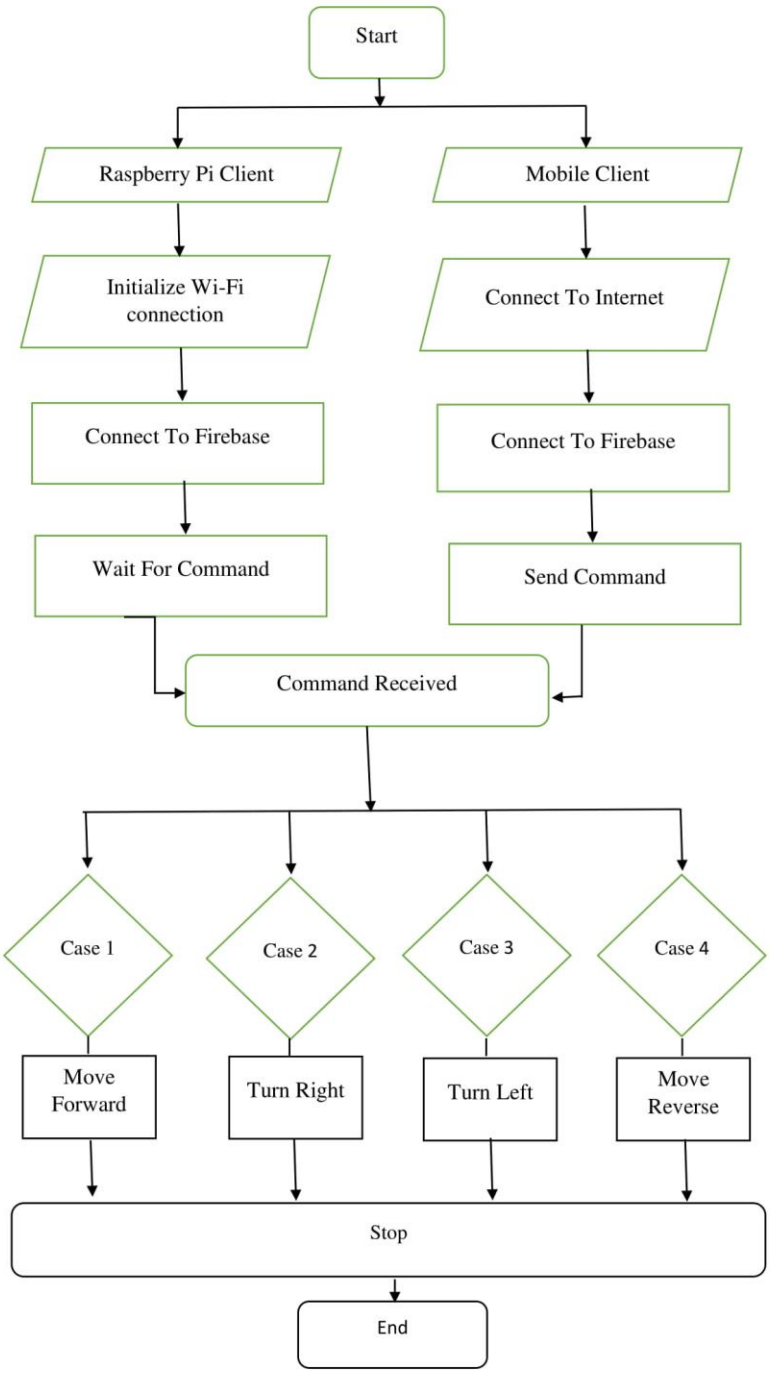
b) Software

1. Programming in Android Studio
2. Firebase

D) Other Components

1. Single stand wires
2. Jumpers (Male-Female, Female-Female)
3. Soldering gun and wire

4.2 FLOW CHART



Chapter 5

PROJECT IMPLEMENTATION

5.1 Block Diagram:

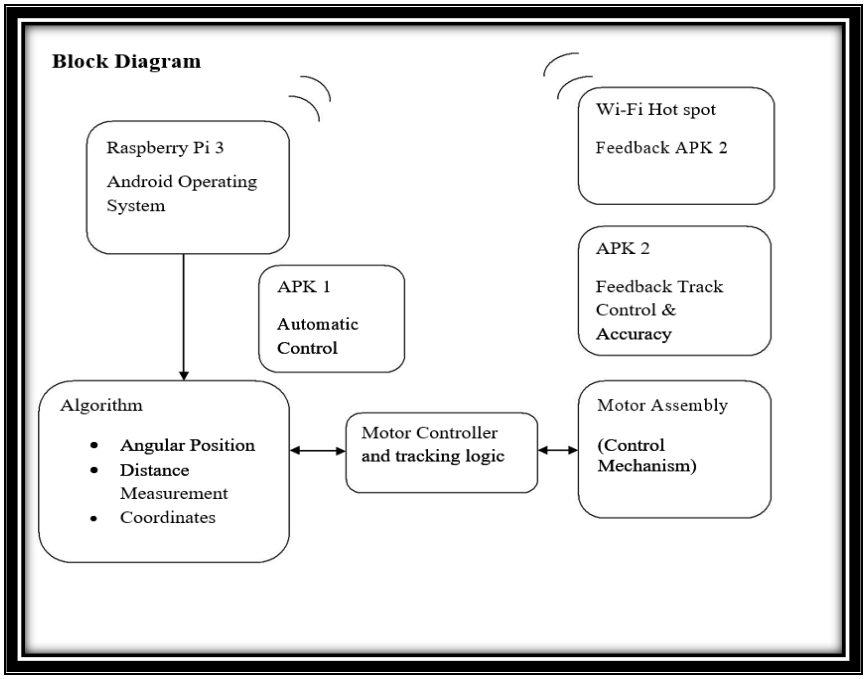


Fig. 6 Block Diagram

1) Main Assembly

Main assembly and control mechanism starts with raspberry PI 3. We have used Android Studio software and developed the code in advanced java for controlling the motions of our robot.

The code includes forward, reverse, left and right buttons for locomotion of robot. Two separate modules are built -1) RPI Client and 2) Mobile Server.

They are assembled in their respective domains.

2) Motor control and tracking logic

Four motors of 300 rpm are used to enhance booster function for robot. The tracking logic is segmented into three sections:-

a) Angular position

b) Distance Measurement

c) Coordination

3) APK 1

This Android Application Package File is dumped in Raspberry PI client and is used for automatic control. It implements the basic Main Activity function.

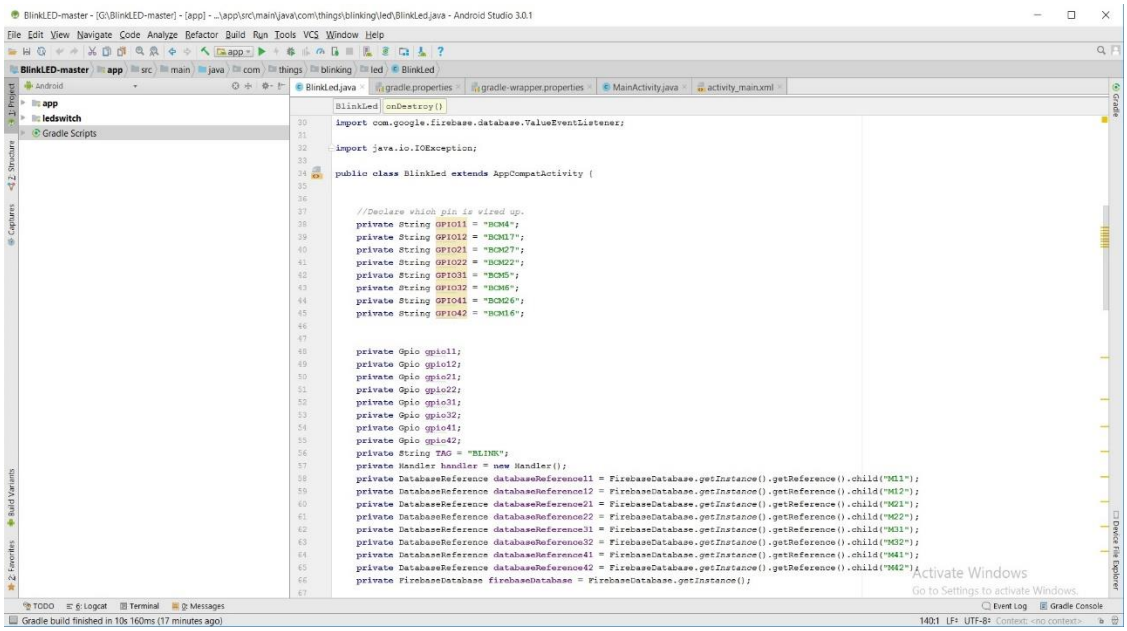


Fig. 7 Raspberry PI client code

4) APK

APK 2 includes:-

1) Feedback

2) Track control

3) Accuracy

It interrogates the link between mobile client and robot.

5) Wi-Fi

APK 2 and robot are connected to same hot spot. Since the exclusive connection is established, feedback from APK 2 is transferred through Wi-Fi to robot. This approximated changes can be observed on Firebase.

5.2 Hardware Used

1. Raspberry PI 3 is Linux based but working with ANDROID is our task. So we have installed android on Raspberry PI using Windows.

2. Raspberry Pi 3 is heart of the system. Controlling of robot is fully depending on RPI. The Raspberry Pi 3 Model B brings a more powerful processor, 10x faster than the first generation Raspberry Pi. Additionally it adds wireless LAN & Bluetooth connectivity.

3. DC motors are used for the movement of the robot in the desired direction.

4. A motor driver is a current amplifier; the function of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor.

5. Power bank is used for continuous activation of Raspberry Pi 3.

➢ Raspberry Pi-3 Module :

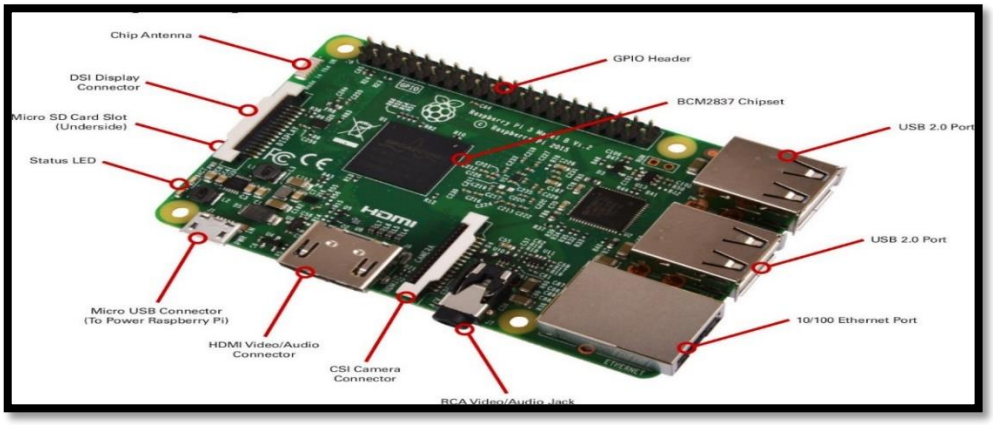


Fig 8. Raspberry PI-3 module

The Raspberry Pi 3 Model B is the third generation Raspberry Pi. It is powerful credit-card sized single board computer which can be used for many applications such as automation, robotics.

The Raspberry Pi 3 Model B has more powerful processer and it is 10 times faster than the first generation Raspberry Pi. Also it has inbuilt wireless LAN & Bluetooth connectivity which makes it more powerful.

- **Specifications**

1. Processor: - Broadcom BCM2387 chipset.
2. GPU: - Dual Core Video Core IV Multimedia Co-Processor.
3. Memory:-1GB LPDDR2.
4. OS: - Boots from Micro SD card, running a version of the Linux operating system.
5. Power: - Micro USB socket 5V1, 2.5A.

- **Connectors**

1. Ethernet:-10/100 Base T Ethernet socket
2. Video Output :-HDMI (rev 1.3 & 1.4 Composite RCA (PAL and NTSC)
3. Audio Output:- Audio Output 3.5mm jack, HDMI USB 4 x USB 2.0 Connector
4. GPIO Connector :- 27 GPIO pins as well as +3.3 V, +5 V and GND supply lines
5. Camera Connector :-15-pin MIPI Camera Serial Interface (CSI-2)
6. Display Connector:- Display Serial Interface (DSI) 15 way flat flex cable connector with two data lanes and a clock lane

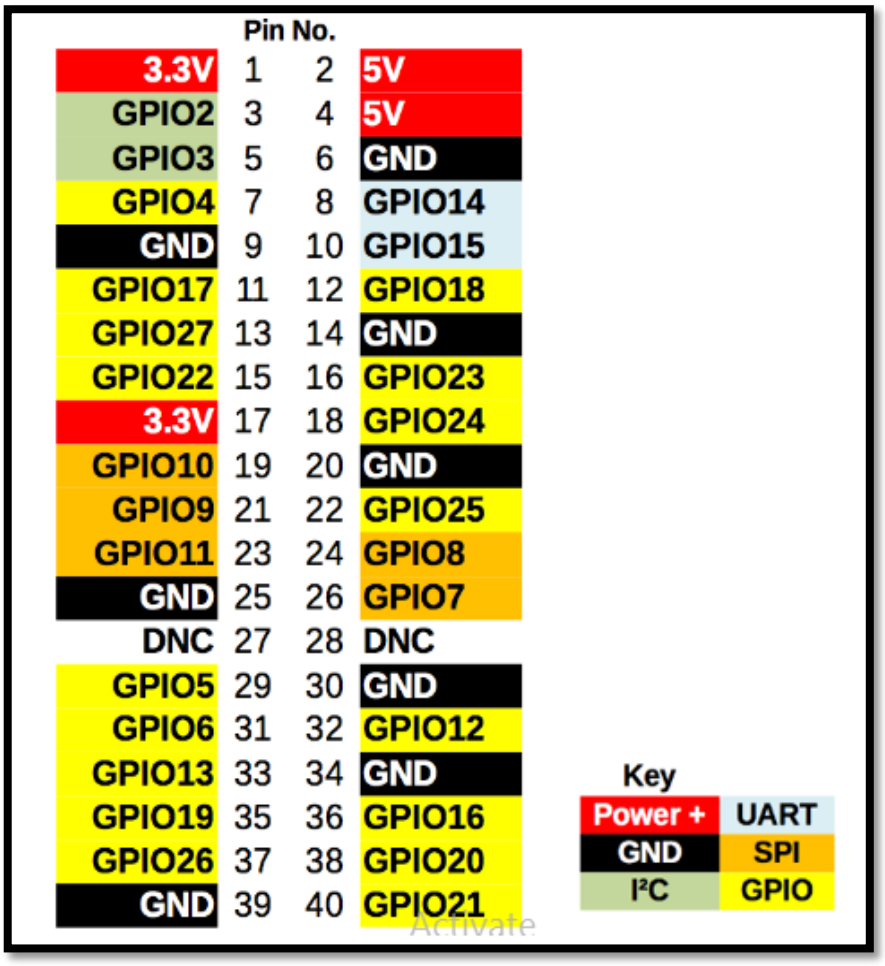


Fig. 9 GPIO pins

➢ DC Motor

Fig 10. DC Motor

A **DC motor** is nothing but a class of rotary electrical machines. Which converts the direct current electrical energy into mechanical energy. DC motors consists either electromechanical or electronic mechanism as internal mechanism, which changes the direction of current flow periodically in part of the motor.

Speed of DC motors can be controlled, by changing the strength of current or by using either a variable supply voltage in its field windings.

DC motors have several applications like DC motors small in size are used in tools, toys, and appliances. The universal motors required direct current to operate but those motors are lightweight motor, used for portable power tools and appliances. Some application like Propulsion of electric vehicles, elevator and hoists, drives for steel rolling mills used the large DC motors.

For robotics applications DC Geared motors are used. These motors are very easy to operate and easily available in market with standard size. Dc Geared motor is available with nut and threads on shaft to connect and internal threaded shaft for connecting it to wheel.

➢ DC Motor Driver

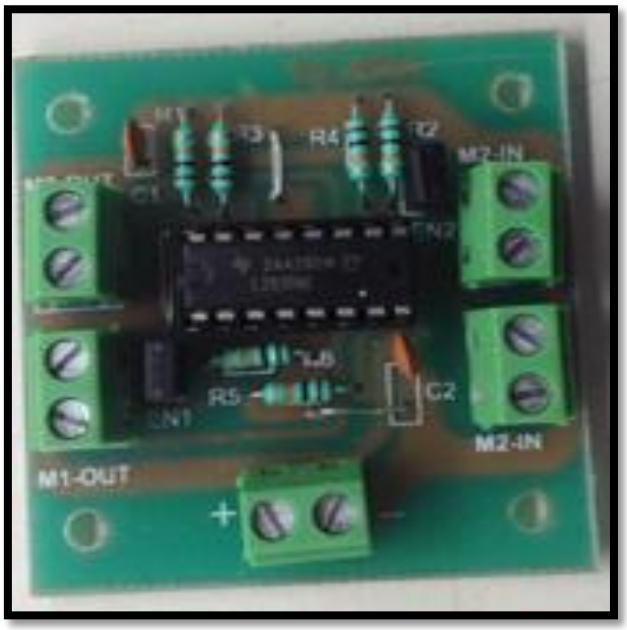


Fig 11. DC motor driver

To connect the motors IC L293D is a typical Motor driver IC is used. Which permits the DC motor to drive on either direction. It is a 16 pin IC which provides the control of two DC motors simultaneously in either directions. It means that there is control two DC motor with a single L293D IC.

It operates on the H-bridge concept. IC consists the H-bridge circuit. The circuit allows the voltage to be flow in either directions It requires to change the direction of the motor to rotate the motor in clockwise or anticlockwise direction. H-bridge IC are ideal for controlling two DC motors simultaneously and independently. Its size is also compact due to this it is used in robotics application.

- **Voltage specification**

VCC is the internal voltage that is 5v required for the operation, Motor driver IC L293D does not use this voltage for driving the motor. Separate power supply VSS is required for driving the motors provide motor. IC L293d use this supply to drive the motor. If you want to operate a motor at 12V then it requires Supply of 12V across VSS Motor supply.

The maximum 36 voltage supply for VSS motor. It can supply a max current of 600mA per channel. Hence it drive motors Up to 36v and it is possible to drive big motors with this L293D.

Pin 16 is the VCC voltage used for its own internal Operation. The maximum voltage range is from 5v to 36v.

- **L293d IC(Motor Driver)**

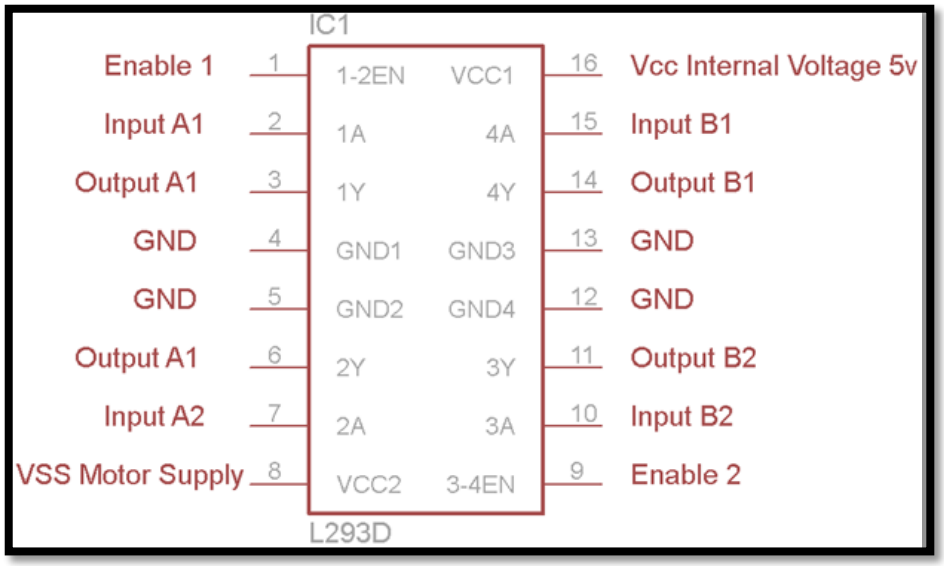


Fig 12.Pin Diagram L293D.

As shown in the pin diagram there are 4 input pins of L293D, pin no 2 & 7 on the left side and pin no15 &10 on the right side. Left input pins are used to regulate the rotation of the motor which is connected across left side and right input pins

are used to regulate the motor on the right hand side. LOGIC 0 or LOGIC 1 are the logic at input pins which regulate the motors in either direction.

L293D Logic Table

Pin 3 & 6 are output pins where Motor connected on left side output pins. Logic 1 and Logic 0 are the logic used for rotating the motor in clockwise.

•**Clockwise Direction: -** Pin 2 = Logic 1 &Pin 7 = Logic 0 |

• **Anticlockwise Direction**:-Pin 2 = Logic 0 &Pin 7 = Logic 1

• **Idle [No rotation] [Hi-Impedance]:**-Pin 2 = Logic 0 &Pin 7 =Logic 0 • **Idle [No rotation]:**-Pin 2 = Logic 1 &Pin 7 = Logic 1

Similarly the motor connected on right side on pin 15 & 10 can also operate.

Two Enable pins on L293D. Pin 1 and pin 9, are enable 1 and enable2 pins respectively used for driving the motor, it must be high. In H-bridge left side motor can drive setting the pin 1 i.e. enable 1 to high. And for right H-Bridge it need to make the pin 9 i.e. enable 2 to high. It operates like switch. If anyone of the either pin1 or pin9 goes low then the motor in the relative side was get suspend its working or stop working.

- **Ultrasonic Distance Sensor**

The presence of the object is sensed by using an Ultrasonic Sensor. Ultrasonic sensor HC-SR04 is used for distance measurement.

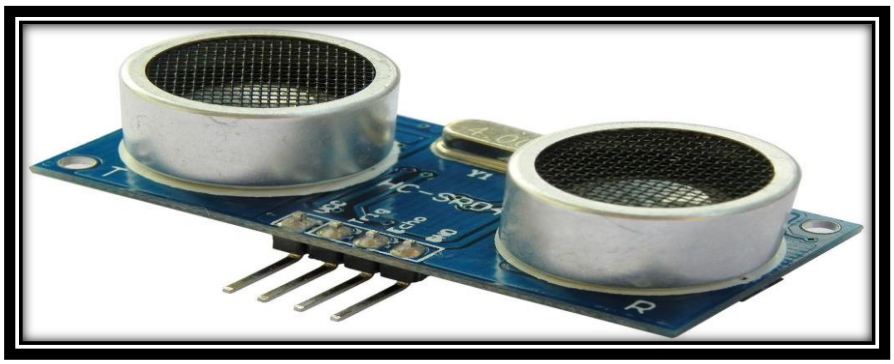


Fig 13. Ultrasonic Sensor.

Specifications of Ultrasonic Distance Sensor

- Working Voltage: 5V (DC)
- Static current: Less than 2mA.
- Output signal: Electric frequency signal, high level 5V, low level 0V.
- Sensor angle: Not more than 15 degrees.
- Detection distance: 2cm-4m
- High precision: Up to 0.3cm
- Weight: 10g
- Size: 45x 21mm (L x W)

Applications of ultrasonic Sensor

- Robotics Barrier
- Object distance measurement
- Level Detection
- Public Security
- Parking Detection

Connection with Raspberry Pi

- Hardware:

- HC-SR04 Module
- Resistors (330Ω and 470Ω)
- Jumper wire

5.3 Software used

Android Studio

1.1) Introduction

Android Studio is an official integrated development environment (IDE) for Google's android operating system. It is built on JetBrains' IntelliJ IDEA software and designed for android development.

It is available for Windows, mac OS & Linux systems. Android studio version used in project is 3.1.1

Fig 14. Android Studio

Installation

1) For .exe file, to launch, double click.
2) If .zip file is downloaded, unpack the ZIP, copy android studio folder in program files.
3) For 64 bit machines, launch studio64.exe and for 32 bit machines, launch studio.exe by opening android-studio>bin folder.

4) Follow setup wizard in android studio and install SDK package.

Project Structure

Project Structure contains modules like:

1) Android app module
2) Library module

For quick access to project files, android studio displays project files in android project view.

1.2) What is Gradle?

It is a dependency management and module organization tool having many features.

- **Manifests** - Contains the AndroidManifest.xml file.
- **Java** - Contains the Java source code files.
- **Res** -Contains all non-code resources, such as XML layouts, UI strings, and bitmap images.

1.3) Sample code for led blinking

Blinking of LED

1) Open Android Studio
2) Create project
3) Building gradle.
4) Finding SDK file and changing SDK path with Android Studio.
5) To fix denied access in command prompt, writing IP address of Raspberry Pi.

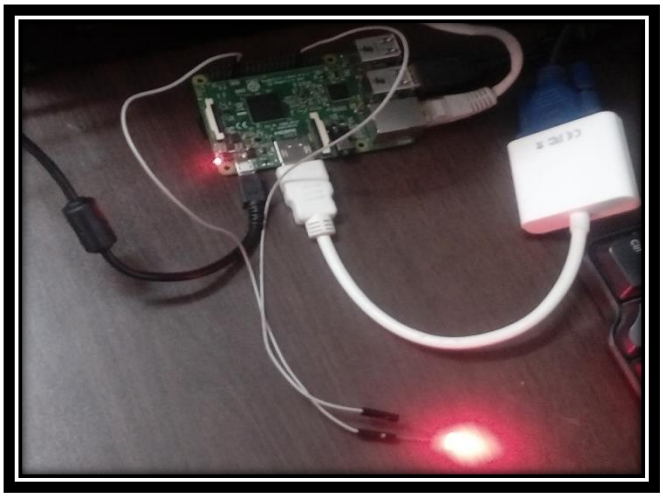


Fig 15. Simple led blinking

Firebase

The Firebase real time Database is a cloud-hosted database. Data is stored and synchronized in real time to every connected client. When someone builds cross-platform apps with Android and JavaScript SDKs, all clients share one real time Database instance and automatically receive updates with the newest data.

Features:

1) Real time
2) Accessible from Client Devices
3) Scale across multiple databases
4) Quickly include clients via gradle

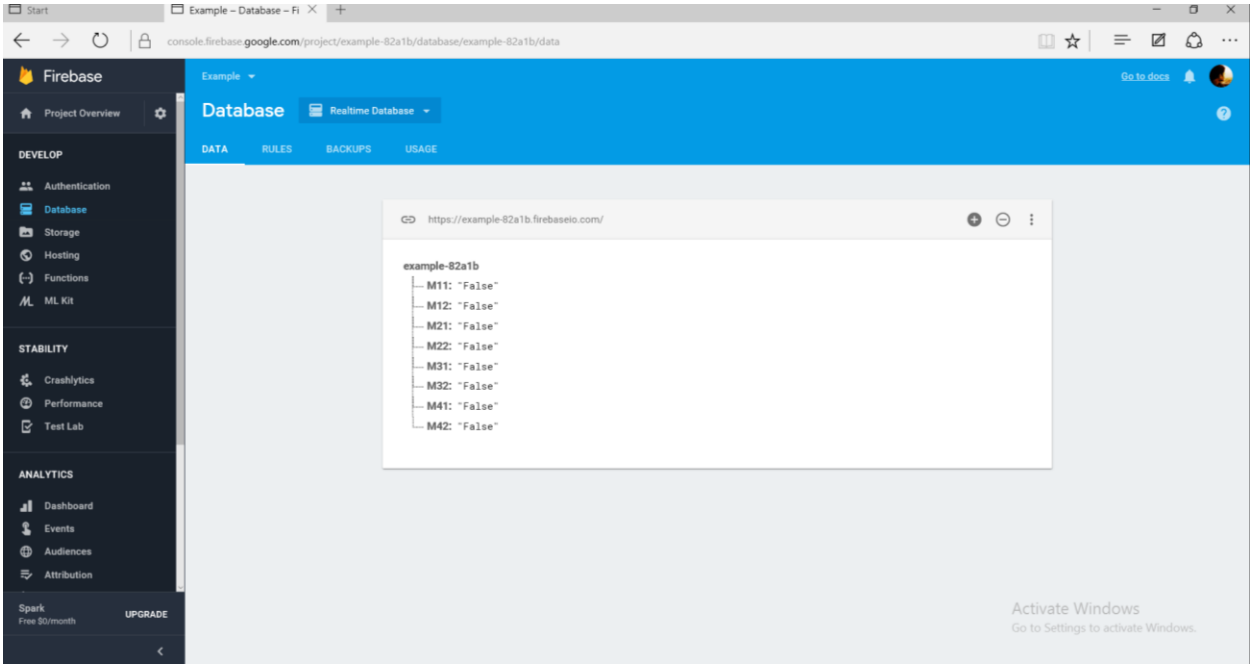


Fig 16. Firebase Console (Database)

Chapter 6

RESULTS AND DISCUSSION

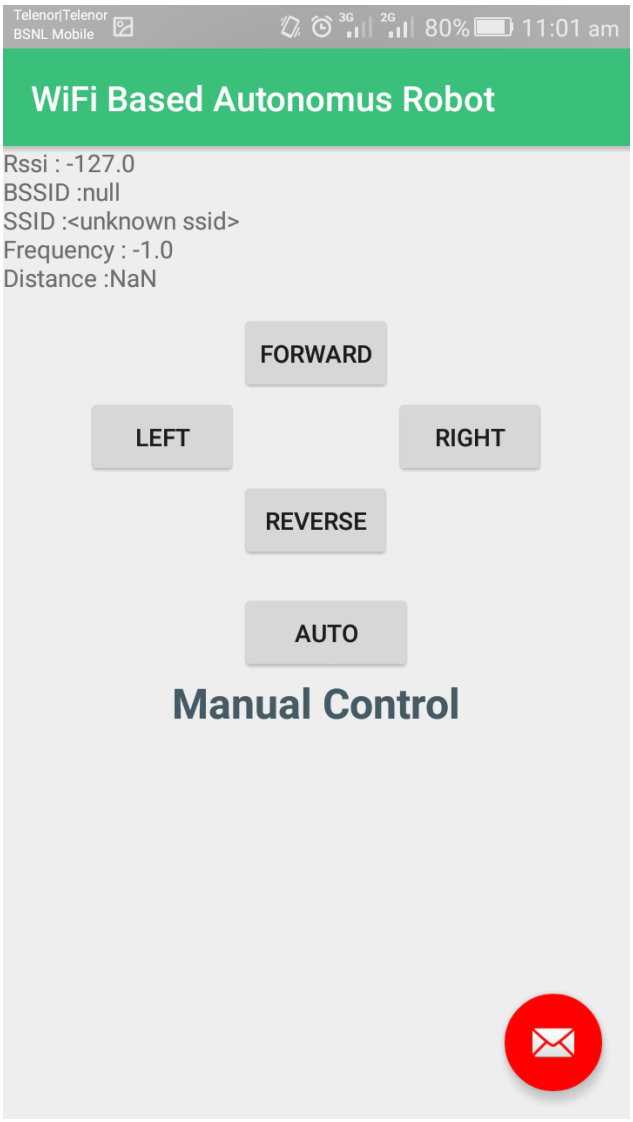


Fig 17. App for robot control

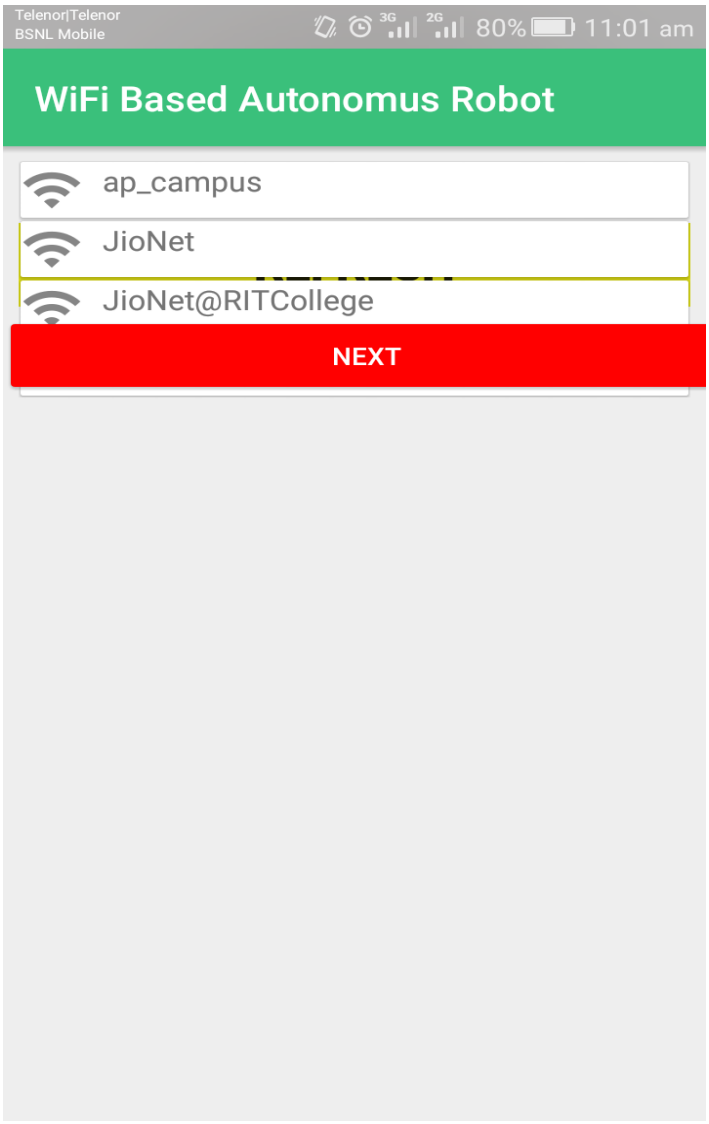


Fig 18. Distance and Wi-Fi strength

6.3 Approximate cost

Table 4. Approximate Cost

Sr no.	Name of component	Cost
1	Raspberry Pi Model B+	3000/-
2	Memory Card	409/-
3	Actuators	800/-
4	Robot Assembly	280/-
5	Battery	850/-
6	Power Bank	339/-
7	Other Electronics	634/-
	Total	6312/-

6.4 Troubleshooting

The most important part during development of any project is troubleshooting. It can be categorized by,

1. Hardware troubleshooting
2. Software troubleshooting

Hardware Troubleshooting

- Problem during battery selection-

Firstly, we used 9V dc supply but it was not sufficient due to voltage drop issue within motor driver assembly. So, we have used 12 V battery having current ratings of 2.5 Ah

Table 5. Hardware Troubleshooting

For single motor:

Input voltage (V)	Output voltage (V)	Current (mA)
12.3	12.3	36.2

For four motors:

Input voltage (V)	Output voltage (V)	Current (mA)
12.4	12.36	125

Software Troubleshooting

Since android platform was new to us we faced many problems during writing codes, compilation of codes, giving appropriate paths and adding dependencies.

- Problem during cloning of code (solution- installation of Git)
- Missing of SDK file. (solution- install SDK file and update android version)
- Error: SDK path not available

  (solution- changing of SDK path with android studio we followed

  1) File >> Project Structure

     SDK location window will appear.
  2) Android SDK location

     c:\users\Appdata

     some path exist already, do not change that path.
  3) Copy that path, cut SDK folder and paste it in another drive.
  4) Now follow Tools >> android >> sync, file will be available.
- Error: To fix access denied in cmd
  1) Instead of android local, write IP address of Ethernet

     c:users\username\Appdata\local\Android\SDK\platform tools > adb connect android.local
- To uninstall *adb*,

  adb uninstall < package – name> your package.name

Chapter 7

CONCLUSION AND REFERENCES

Conclusion

We have developed an autonomous robot by using Raspberry PI 3 and android platform. This project is applicable in office area where they have segmented and bustling work of file transfer. This task can be further extended to industrial application. For object displacement by enhancing robot along with implementation of sensors and by upgrading its ranges.

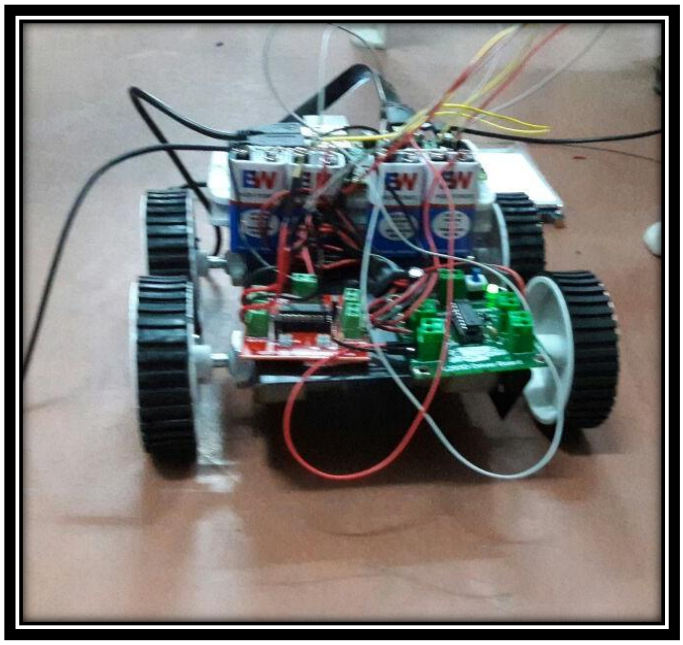


Fig 19. Developed robot

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