"In Pursuit of Technical Excellence"

SMART HOME ROBOT

For the Degree of
Bachelor of Engineering
Information Technology

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GOVERNMENT COLLEGE OF ENGINEERING, AURANGABAD
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2017-18

CERTIFICATE

This is to certify that the project entitled **"Smart Home Robot"**, which is being submitted here with for the award of the '**DEGREE OF BACHELOR ENGINEERING'** in **'INFORMATION TECHNOLOGY'** of Government College of Engineering, Aurangabad which is affiliated to Dr. Babasaheb Ambedkar Marathwada University, Aurangabad. This is the result of the project work and contribution done by **PRAYUSH KALE, ROHIT MESHRAM, AMOL UBALE, SURAJ JADHAV** and **ATUL GABALE** under my supervision and guidance.

Place: Aurangabad

Date:

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DECLARATION

We hereby declare that we have formed, completed and written the project entitled **"Smart Home Robot"**. It has not previously submitted for the basis of the award of any degree or diploma or other similar title of this for any other diploma/examining body or university.

Place: Aurangabad

Date:

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LIST OF ABBREVIATION

PIR: Passive Infrred Sensor

IDE: Integrated Development Environment

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1. INTRODUCTION

1.1 INTRODUCTION

The term comes from a Czech word, *robota*, meaning "forced labor"; the word 'robot' was first used to denote a fictional humanoid in a 1920 play *R.U.R.* by the Czech writer, Karel Čapek. A Robot is a machine, especially one programmable by a computer capable of carrying out a complex series of actions automatically. Robots can be guided by an external control device or the control may be embedded within. Robots may be constructed to take on human form but most robots are machines designed to perform a task with no regard to how they look. Robots have replaced humans in performing repetitive and dangerous tasks which humans prefer not to do, or are unable to do because of size limitations, or which take place in extreme environments such as outer space or the bottom of the sea. But there are concerns about the increasing use of robots and their role in society.

The consumer market needs more personalized products, and want them faster, and as costs have dropped and executives have pushed for greater productivity through automation, mobile and vision-enabled robots are emerging and being deployed in many new application areas, particularly for SMEs and in logistics, but also in government, agriculture, surveying, construction and healthcare.

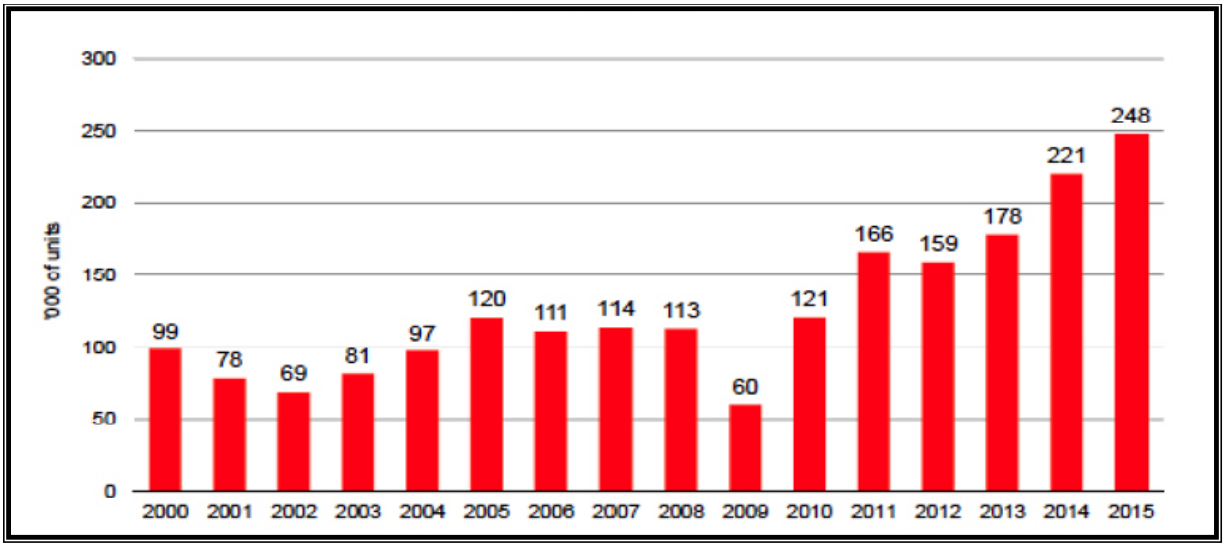


Figure 1. Worldwide annual supply of Robots 2000-2015

An analysis of 752 of The Robot Report‘s global database of robotics-related startup companies shows that 25% of the startups were focused on industrial robotics and 75% address new areas of robotics such as: unmanned aerial, land and underwater devices for filming, marketing, delivery, surveillance, security, surveying, and for the military, science and oil and gas industries (25%); robotics for the agriculture industry (6%); mobile robots as platforms for various uses (7%); personal service bots (3%); professional service bots (7%); medical, surgical and rehabilitation robots (7%); consumer products such as for home cleaning, security, remote presence and entertainment (9%); educational and the hobby market (5%); etc. Support businesses such as AI and software, engineering and design, component manufacturing, 3D printing, vision systems and integrators make up the remainder.

The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these objects to connect and exchange data. The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, virtual power plants, smart homes, intelligent transportation and smart cities.

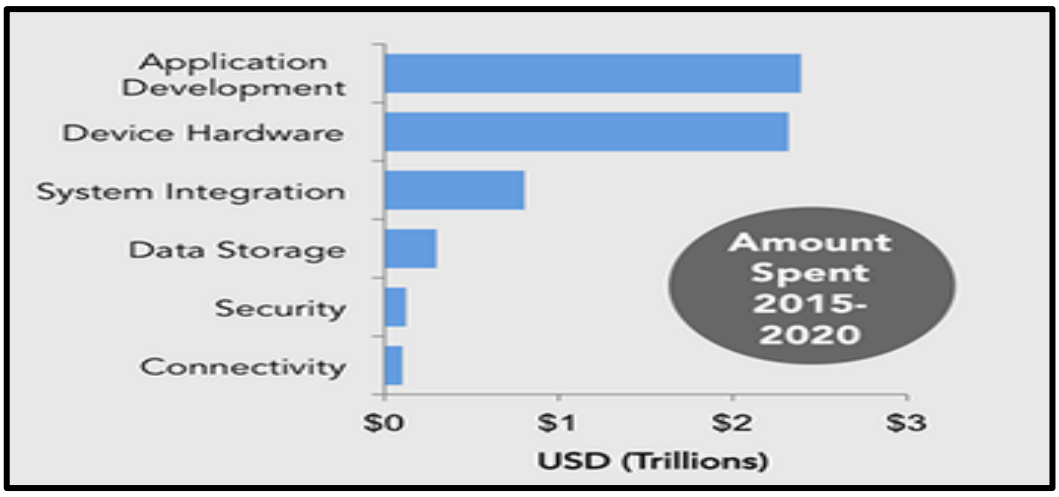


Figure 2.Expected Investments on IoT Development

"Things", in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, cameras streaming live feeds of wild animals in coastal waters, automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring, or field operation devices that assist firefighters in search and rescue operations. Legal scholars suggest regarding "things" as an "inextricable mixture of hardware, software, data and service".

The worldwide Internet of Things market is predicted to grow to $1.7 trillion by 2020, marking a compound annual growth rate of 16.9%. – IDC Worldwide Internet of Things Forecast, 2015 – 2020. An estimated 25 billion connected "things" will be in use by 2020. – Gartner Newsroom. Wearable technology vendors shipped 78.1 million wearable devices in 2015, an increase of 171.6% from 2014. Shipment predictions will be 215 million in 2019. – IDC Worldwide Quarterly Wearable Device Tracker. By 2020, each person is likely to have an average of 5.1 connected devices. – Frost and Sullivan Power Management in IoT and Connected Devices.

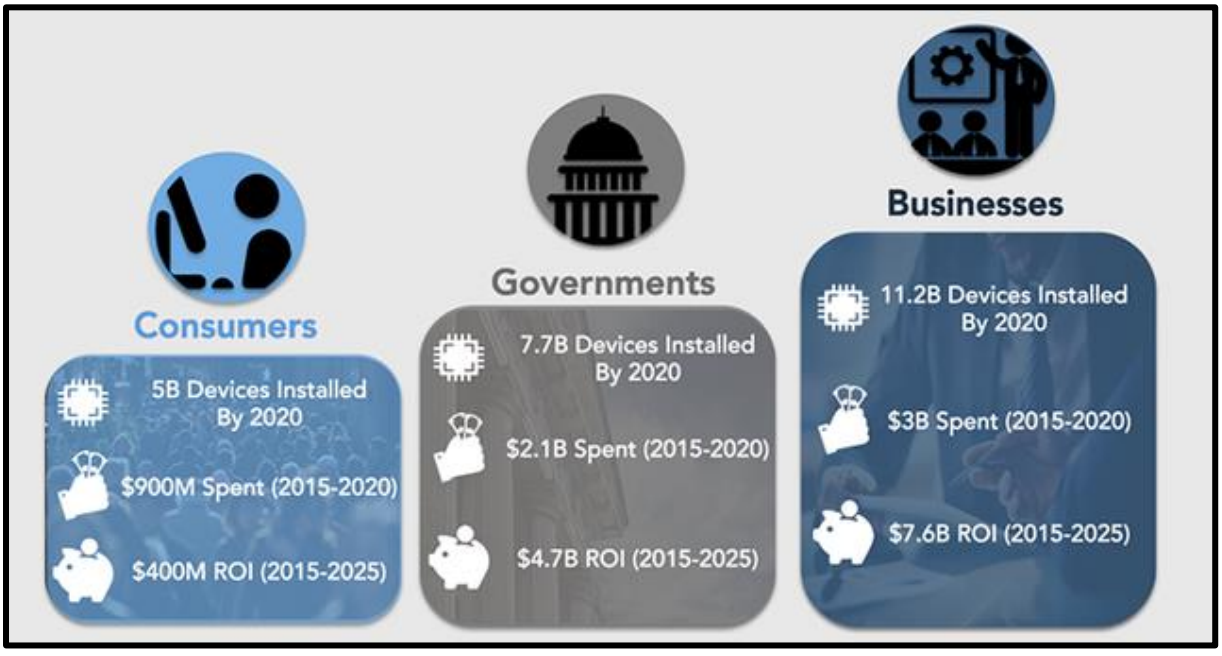


Figure 3.Number of IoT based Smart Devices used in various Organizations

Home security is a prime issue of concern because it's not just about your financial or monetary safety but much more than that. Everyone want the happiness and protection of their dear ones. No one can see their family members in danger or in problematic situation. This is the key reason why Home security is significant.

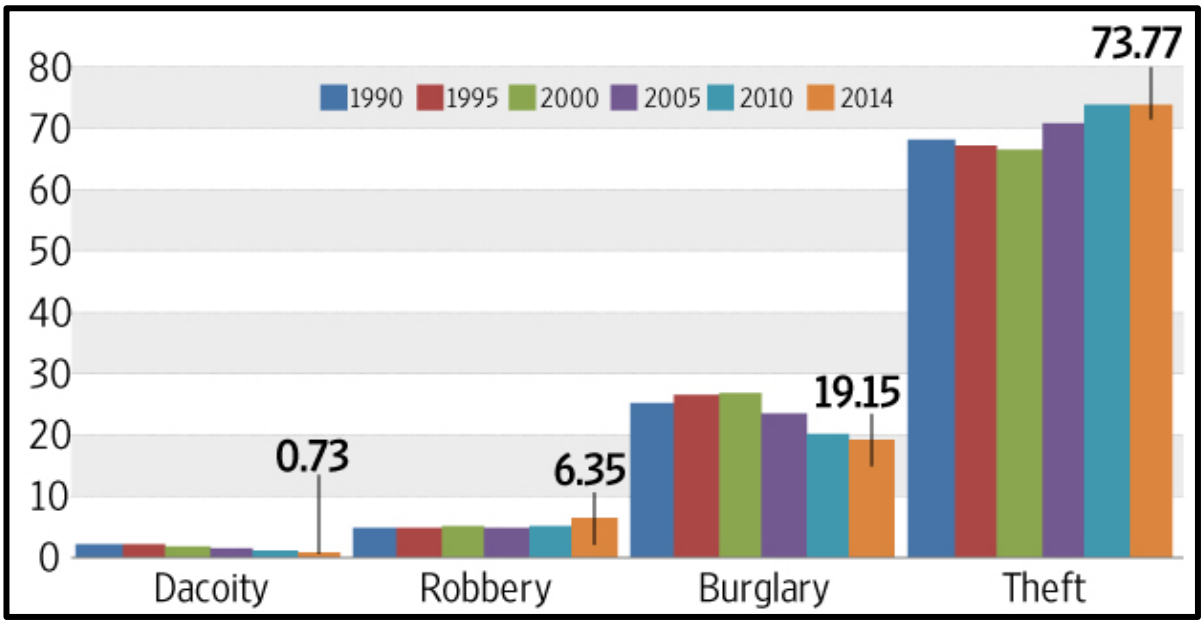


Figure 4. Cases of Home Thefts in India

Home Monitoring Systems allows the owners to monitor and manage their Home Security. They can be continously informed the whereabouts of their security concerns in the house.

The Project 'Smart Home Robot' aims to use the trending technologies of the future to be used in our Houses. The trends as depicted report that their will be a boom of these technologies soon. We aim to work on these technologies with the help of this project. Smart Home robot will allow daily Human Interaction with the Robot and also enable new opportunities of development in the field. It will bring functionality to the House and add productivity to its owners in a quite intuitive and interactive way.

1.2 NECESSITY

Robots are already here, capable of a wide variety of interactions, including health care and monitoring medication compliance, security monitoring, education, errands, and entertainment. Robots are, of course, used in manufacturing, in search and rescue missions, and in the military. But when we get away from industry and the military and discuss machines that are reasonably priced, most of these so-called applications are more imagination than reality, with unreliable mechanisms barely able to get through demonstrations. For everyday home applications, the use of robots is restricted to entertainment, vacuum cleaners, and lawn mowers. Note, however, that the definition of "robot" varies widely, often being used for anything mobile, even though controlled by a human. Three likely directions for the future are entertainment, home appliances, and education. We can start with today's existing devices and slowly add on intelligence, manipulative ability, and function. Start small and build. The market for robots that entertain by being cute and cuddly is already well established. The second generation of vacuum cleaners is smarter than the first. Sony's dog gets smarter and less expensive with each new version. We don't yet think of washing machines, microwave ovens, and coffee makers as robots, but why not? They don't move around the house, but they are getting better and smarter every year.

Education is a powerful possibility. There is already a solid basis of educational devices that aid learning. Today's robots can read aloud in engaging voices. They can be cute and lovable witness the responses to the multiple quasi-intelligent animals on the toy market. A robot could very well interact with a child, offering educational benefits as well. Why not have the robot help the child learn the alphabet, teach reading, vocabulary, pronunciation, basic arithmetic, maybe basic reasoning? Why not music and art, geography and history? And why restrict it to children? Adults can be willing and active learners.

Now this is a direction worthy of exploration; Robot as teacher. Not to replace school, not to replace human contact and interaction, but to supplement them. The beauty here is that these tasks are well within the abilities of today's devices. They don't require much mobility nor sophisticated manipulators.

1.3 OBJECTIVES

- Provide a platform to explore the field of Robotics in Household applications
- To help add Automation services to Homes
- Control and operate Electronic devices by Voice
- Provide facility to automatically control Appliances based on usage consumption and personal needs
- Adds security features such as Threat Notification, Home Monitoring etc.
- Open new opportunities for Education through Robotics
- Help take care of the Elderly and the Little by Monitoring their activities
- Entertaiment on the go with a Playful robot

1.4 THEME

Smart Home Robot “Chitti” once deployed in a Home can run autonomously thanks to its three Ultrasonic sensors that gives distance data. The robot can be controlled by Voice commands. All the features of the robot can be explored by talking to it. Interaction with the robot allows a homely and intuitive enviroment to work around with it. The robot can adjust speeds based on its current commands and the set mood. Vision based applications allows for further advanced features such as face detection and recognition. The main aim of the robot is to provide a digitally intuitive platform to add the new arriving technologies to the House.

1.5 ORGANIZATION

The report is divided into five chapters. Each parts deals with the different aspects of Document management system. Each chapter explains various parts in detail.

Chapter 1: INTRODUCTION introduces and explains introductory part of document management system which includes the system introduction, necessity, theme and objective.

Chapter 2: LITERATURE SURVEY introduces the Literature survey done behind the Projects work

Chapter 3: SYSTEM DEVELOPMENT introduces the robot development which contains methodology, System diagram, Data flow diagram, Use case diagram, hardware and software requirements of the system.

Chapter 4: PERFORMANCE ANLYSIS introduces the Robots Interface and Testing Regimes used.

Chapter 5: CONCLUSION provides a brief conclusion along with future scope and applications.

2. LITERATURE SURVEY

2.1 ROBOTICS FACTS

What does the future hold for robotics? It's hard to say, given the rapid pace of change in the field as well as in associated areas such as machine learning and artificial intelligence. But one thing seems certain: Robots will play an increasingly important role in business and life in general.

Research firm International Data Corp's (IDC) Manufacturing Insights Worldwide Commercial Robotics program recently unveiled its top 10 predictions for worldwide robotics for 2017 and beyond. The list has some interesting forecasts, and if they come true, they will likely have a significant impact on business and society.

"Technological development in artificial intelligence, computer vision, navigation, MEMS sensor, and semiconductor technologies continue to drive innovation in the capability, performance, autonomy, ease of use, and cost-effectiveness of industrial and service robots," said Jing Bing Zhang, research director of worldwide robotics at IDC Asia/Pacific.

"Robotics will continue to accelerate innovation, thus disrupting and changing the paradigm of business operations in many industries," Zhang said. IDC encourages companies to "embrace and assess how robotics can sharpen their company's competitive edge by improving quality, increasing operational productivity and agility, and enhancing experiences of all stakeholders," he said.

Zhang shared top predictions and major robotics trends that are set to present opportunities and challenges to organizations in 2017 and beyond:

1. Growth of "robot as a service." By 2019, 30 percent of commercial service robotic applications will be in the form of a robot-as-a-service (RaaS) business model. This will help cut costs for robot deployment.

2. Emergence of the chief robotics officer. By 2019, 30 percent of leading organizations will implement a chief robotics officer role and/or define a robotics-specific function within the business.

3. An evolving competitive landscape. By 2020, organizations will have a greater choice of vendors as new players enter the $80-billion information and communications technology market to support robotics deployment.

4. The coming robotics talent crunch. By 2020, robotics growth will accelerate the talent race, leaving 35 percent of robotics-related jobs vacant, while the average salary increases by at least 60 percent.

5. Robotics will face regulation. By 2019, government entities will begin implementing robotics-specific regulations to preserve jobs and to address concerns about security, safety, and privacy.

6. Rise of the software-defined robots. By 2020, 60 percent of robots will depend on cloud-based software to define new skills, cognitive capabilities, and application programs, leading to the formation of a robotics cloud marketplace.

7. More collaborative robots. By 2018, 30 percent of all new robotic deployments will be smart collaborative robots that operate three times faster than today's robots and are safe for work around humans.

8. Growth in robots outside the factory. By 2019, 35 percent of leading organizations in logistics, health, utilities, and resources will explore the use of robots to automate operations.

9. Robotics for Ecommerce. By 2018, 45 percent of the 200 leading global ecommerce and omni-channel commerce companies will deploy robotics systems in their order fulfillment warehousing and delivery operations

2.2 SOME TRENDING TOPICS

1) Artificial intelligence and robotics:

With the global robotics industry forecast to be worth US$38 billion by 2018, a large portion of this growth is down to the strength of interest and investment in artificial intelligence (AI), one of the most controversial and intriguing areas of computer science research. The technology is still in its early stages, but tech giants like Facebook, Google and IBM are investing huge amounts of money and resources into AI research.

2) Machine learning:

Machine learning is closely related to (and often overlaps with) computational statistics, which also focuses on prediction-making through the use of computers. It has strong ties to mathematical optimization, which delivers methods, theory and application domains to the field. Machine learning is sometimes conflated with data mining, where the latter subfield focuses more on exploratory data analysis and is known as unsupervised learning.

3) IoT:

The IoT allows objects to be sensed or controlled remotely across existing network infrastructure and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, virtual power plants, smart homes, intelligent transportation and smart cities.

4) Home security :

It is a term referring to both the security hardware in place on a property as well as personal security practices. Security hardware includes doors, locks, alarm systems, lighting, motion detectors, security camera systems, etc. that are installed on a property; personal security involves practices such as ensuring doors are locked, alarms activated, windows closed, extra keys not hidden outside, etc.

2.3 RESEARCH PAPERS REFERRED

Paper Name: Three omni-directional wheels control on a mobile robot
Year: September 2004

Traditional two wheels differential drive normally used on mobile robots have manoeuvrability limitations and take time to sort out. Most teams use two driving wheels (with one or two cast wheels), four driving wheels and even three driving wheels. A three wheel drive with omni-directional wheel has been tried with success, and was implemented on fast moving autonomous mobile robots. This paper deals with the mathematical kinematics description of such mobile platform, it describes the advantages and also the type of control used.

Paper Name: IOT BASED MULTIFUNCTIONAL ROBOT USING RASPBERRY-PI
Year: March 2017

Our population is aging swiftly. By 2020, more than 700 million people around the world will be over the age of 65. And many in this population will live with chronic diseases, requiring care and assistance in their lives to perform daily tasks. At the same time, machines that surpass humans' ability to perform daily tasks. In this paper a robot using Raspberry Pi 2 model B is proposed to perform some of the daily tasks like face detection with live streaming for home security, voice recognition and pdf reading like a story, newspaper, article, recording and detection of events etc.

Paper Name: Build and Interface Internet Mobile Robot using Raspberry Pi and Arduino
Year: 2015

The increasing use of wireless applications and the demand for a system that could easily connect devices for transfer of data over a long distance without cables became worldwide. This paper presents the Build and interface of a real time wheeled mobile robot installed above it an arm and a camera. Software system can be built in three various programming languages

and controlled via the internet using webpage protected with a username and password to make sure it cannot be hacked. The webpage is designed to control the mobile robot remotely through the internet by any web browser such as Mozilla Firefox. Camera is mounted on the animated base in two axes in order to have better visibility

Paper Name: Domestic Applications for Social Robots - an online survey on the influence of appearance and capabilities
Year: 2008

Can you imagine a useful task you would like a social robot to perform for you? This paper presents an internet survey where participants were asked this question to identify applications for social robots. The applications mentioned by the participants are based on the appearance of four social robots (AIBO, iCat, BIRON, and BARTHOC) and the information they received about their basic capabilities. It was found that AIBO and iCat seem to be suitable for domestic applications whereas suggested applications for the more functional mobile robot BIRON are situated also in public environments. The anthropomorphic robot BARTHOC mainly seems to be appropriate for public usage. The papertries to explain how the appearance and the capabilities of the robot influence what applications are ascribed to them.

2.4 FOREWORD

By looking towards the fields of the robotics and there importance in our daily life due to there use in some complex jobs, we are going to apply this smart home robot concept in our project for solving some day to day life problems due the merits of the robotics and IOT technologies. As it is able to solve some complex jobs, so obviously it is having a better future scope .So we are trying to explore the new things with some trending technologies using the basic concept of robotics .

3. SYSTEM DEVELOPMENT

3.1 METHODOLOGY

The Project aims to bring the latest technology features to the Household. Smart Home robot "Chitti" is a combination of Medium category Hardware and Software. Since all the functioning of the Robot needs to take place inhouse on its system , the project uses Raspberry Pi 3 Model B. The processor has enough power to capture video data; give, receive and process voice data and allows parellel inputs and outputs on GPIO pins. The microprocessor works at an operating voltage of 3.3V and thus is incapable of giving signals to the attached sensors. An Arduino Uno is used as a middleware to control sensors operating at 5V input. The design of chasis consists of a Three Wheel Omni drive that gives it a free locomotion in any direction. This also allows the robot to display a playful locomotion that wins the heart of the User. A combination of the most affordable microprocessing unit i.e. the Raspberry Pi and the most popular microcontroller on the Market i.e. Arduino makes the Robotic system open to any and all kind of additive functionality. As Humans have Sensory organs that touch, feel, view; similarly the Robot can be adjoined with a vast number of Sensors to give it super powers. For example a Orientation sensor would allow the Robot to have a sense of direction like we humans have. To add another example a Ambient Light sensor would allow the Robot to detect if it is bright light or in darkness.

The Robots structure can be divided into the following parts:

- Chasis – A triangular chasis is made up of Acrylic sheet of 3 mm thickness
- Motor and Wheel Mountings – It is a Three Wheel Omni directional chasis mounting
- Raspberry Pi and supported electronics – This module of the system forms the main controller mind of the robot
- Arduino and supported electronics – It controls the rugged electronics of the system
- Power supply and Cooling fan

3.2 HARDWARE COMPONENTS

3.2.1 Raspberry Pi 3 Model B

Figure 5. Raspberry Pi 3 Model B

Specifications:

- Quad Core 1.2GHz Broadcom BCM2837 64bit CPU
- 1GB RAM
- BCM43438 wireless LAN and Bluetooth Low Energy (BLE) on board
- 40-pin extended GPIO , 4 USB 2.0 ports
- 4 Pole stereo output and composite video port

It has been used as the main microprocessing unit of the Robot. All the data is collected and processed by this controller unit.

3.2.2 Mobile Speakers

Figure 6. Audio Speaker

Used to give Voice , Music output by the Robot

3.2.3 Arduino Uno

Figure 7. Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button.

Specifications:

- Microcontroller ATMega 328P
- Operating Voltage 5V
- Flash Memory 32 KB
- SRAM 2 KB
- EEPROM 1 KB
- Clock Speed 16 MHz

Arduino Uno is used as a kind of middleware between the rugged hardware and Raspberry Pi. It takes commands sent by Raspberry and performs actions likewise.

3.2.4 Li-Po Battery

Orange 3000mAh 3S 30C/60C Lithium polymer battery Pack (LiPo) batteries are equipped with heavy duty discharge leads to minimize resistance and sustain high current loads. Orange batteries stand up to the punishing extremes of aerobatic flight and RC vehicles. Each pack is equipped with gold plated connectors and JST-XH style balance connectors. All Orange Lithium Polymer batteries packs are assembled using IR matched cells.

Figure 8. Orange 3 Cell LiPo Battery 12 V

Specifications:

- Model No: ORANGE 3000/3S-30C
- Weight : 215.0g
- Voltage : 11.1V
- Max Continuous Discharge : 30C(90.0A)
- Max Burst Discharge : 60C(180.0A)

Used as the main power supply of the Robot. It has enough capacity to power the robot for upto 6 hours on one single charge.

3.2.5 LiPo Voltage Checker

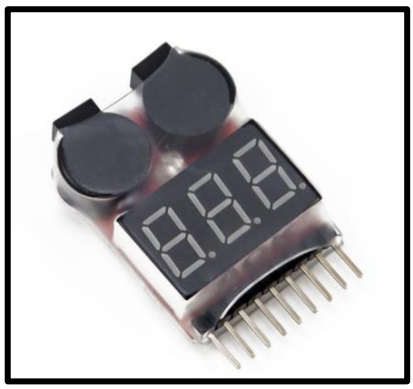


Figure 9. LiPo 3S-8S Voltage Checker

The Lipo Voltage Checker 1S-8S with Buzzer Alarm is a quality product available designed to measure and display the voltage of LiPo battery packs. This voltage checker can measure the voltage of battery pack as well as the voltage of every single cell of the battery pack.

3.2.6 Dual DC Motor Driver 20A

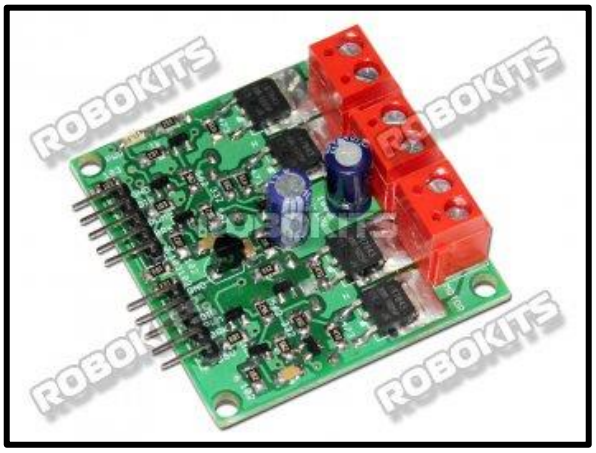


Figure 10. Dual DC Motor Driver 20 A

Add raw power and simple connectivity to your robotics applications with this 6V - 18V compatible 20A capable Dual DC motor driver. It is ideal for application where two motors are required for up to 20 Amperes of current during startup and during normal operations.

Used to control the Direction and speed of Three motors used for locomotion of the robot.

3.5.7 Johnson Motor - 300 RPM

Figure 11. Johnson Motor (Made in India) 300 RPM

Specifications:

- 18000 RPM Base Motor
- Torque – 5kgcm to 20kgcm (depending on RPM)
- Voltage – 6 to 24 (Nominal Voltage – 12v)

Used to drive the robot wheels and eventually provide locomotion facility to the Robot

3.2.8 Omni Wheel 58mm Diameter

Figure 12. Omni Wheel LEGA NXT 58 mm

The 58mm Plastic Omni Wheel for LEGO NXT and Servo is a latest design of 58mm LEGO compatible Omni directional robot wheel, it's useful as they roll freely. The 58mm plastic omni wheel is a robust, durable and double row wheel that provides easy 360° movement proper with rotational and sideways manoeuvrability.

3.2.9 Tower Pro SG90 Servo Motor

Figure 13. Tower Pro SG90 Servo motor

Specification:-

- 3 pole ferrite, all nylon gear
- Operating Voltage: 4.8V~6.0V
- Operating speed: 0.12sec/60 degree
- Output torque: 1.6kg/cm 4.8V

3.2.10 Ultrasonic Sensor HC-SR04

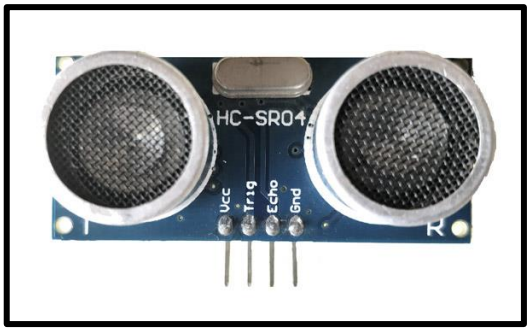


Figure 14. Ultrasonic Sensor HC-SR04

Ultrasonic Distance Sensor provides very short (2CM) to long-range (4M) detection and ranging. The sensor provides precise and stable non-contact distance measurements from about 2cm to 4 meters with very high accuracy. It can be easily interfaced to any microcontroller.

Specifications:

- Voltage: 5V
- Detection distance: 2cm-400cm (0.02M - 4.0M)
- High precision: up to 0.3cm

Used to detect the distance between robot and the obstacles around the robots environment.

3.2.11 Bluetooth Module HC05

Figure 15. Bluetooth Module HC05

HC-05 Bluetooth Module is most demanding and popular due to its low price and extremely high features.This module can be used in Master or Slave Mode and easy switchable between these two modes, By default Slave mode is configured.

3.2.12 DHT11 Temperature and Humidity Sensor

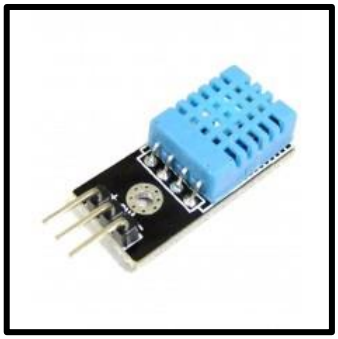


Figure 16. DHT11 Temperature Sensor

DHT11 is a Humidity and Temperature Sensor, which generates calibrated digital output. DHT11 can be interface with any microcontroller like Arduino, Raspberry Pi, etc. and get instantaneous results. DHT11 is a low cost humidity and temperature sensor which provides high reliability and long term stability.

It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and outputs a digital signal on the data pin (no analog input pins needed). Its very simple to use, and libraries and sample codes are available for Arduino and Raspberry Pi.

3.2.13 Passive Infrared Sensor (PIR Module)

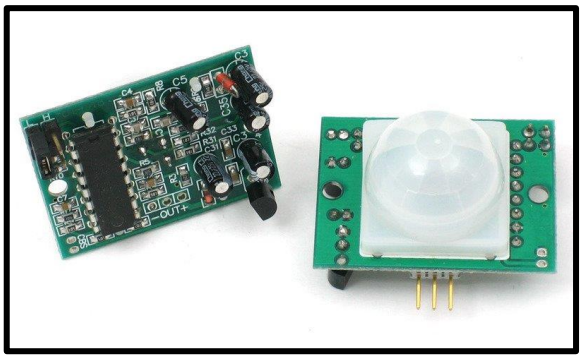


Figure 17. Passive Infrared Sensor

PIRs are basically made of a pyroelectric sensor which can detect levels of infrared radiation. Everything emits some low level radiation, and the hotter something is, the more radiation is emitted. The sensor in a motion detector is actually split in two halves.

- Output: Digital pulse high (3V) when triggered (motion detected) digital low when idle (no motion detected). Pulse lengths are determined by resistors and capacitors on the PCB and differ from sensor to sensor.
- Sensitivity range: up to 20 feet (6 meters) 110° x 70° detection range

3.2.14 KY-009 RGB SMD Module

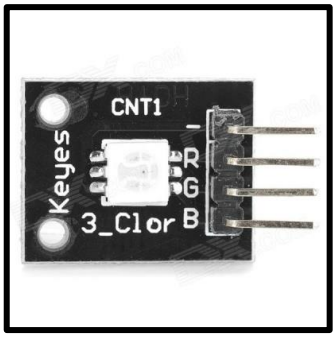


Figure 18.RGB SMD Module

SMD RGB LED module consists of a full-color LED made by R, G, B three pin PWM voltage input can be adjusted. Primary colors (red / blue / green) strength in order to achieve full color mixing effect. Control of the module with the Arduino can be achieved Cool lighting effects.

3.2.15 Breadboard

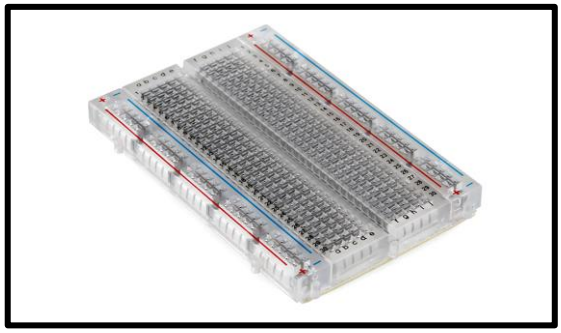
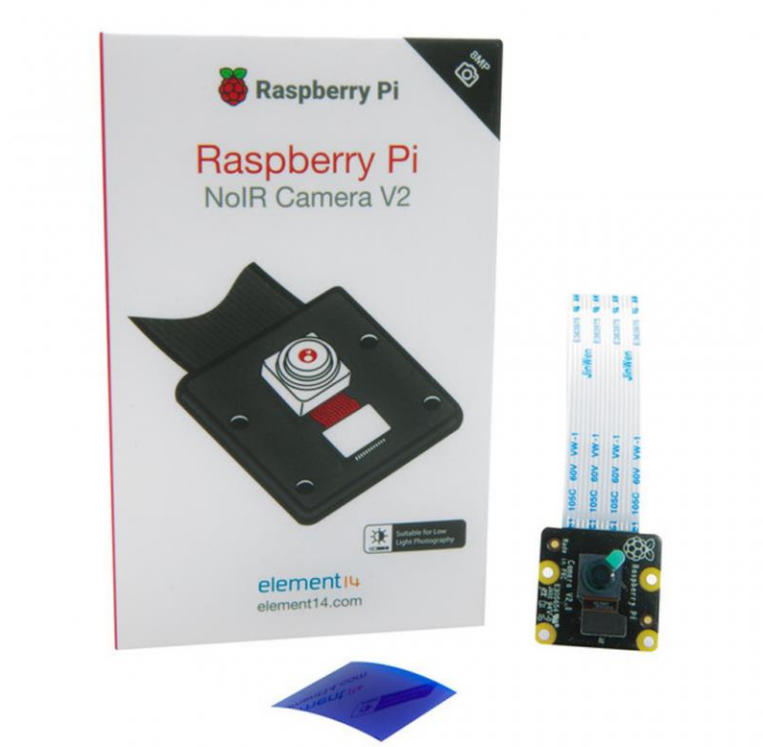


Figure 19. Breadboard

A breadboard is a solderless device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate. The breadboard has strips of metal underneath the board and connect the holes on the top of the board. The metal strips are laid out as shown below. Note that the top and bottom rows of holes are connected horizontally and split in the middle while the remaining holes are connected vertically.

3.2.16 Raspberry Pi No-IR Camera Module



8 megapixel camera capable of taking infrared photographs of 3280 x 2464 pixels Capture video at 1080p30, 720p60 and 640x480p90 resolutions All software is supported within the latest version of Raspbian Operating System

Applications:

- Infrared photography
- Low light photography

3.3 SOFTWARE REQUIREMENTS

3.3.1 Python IDE

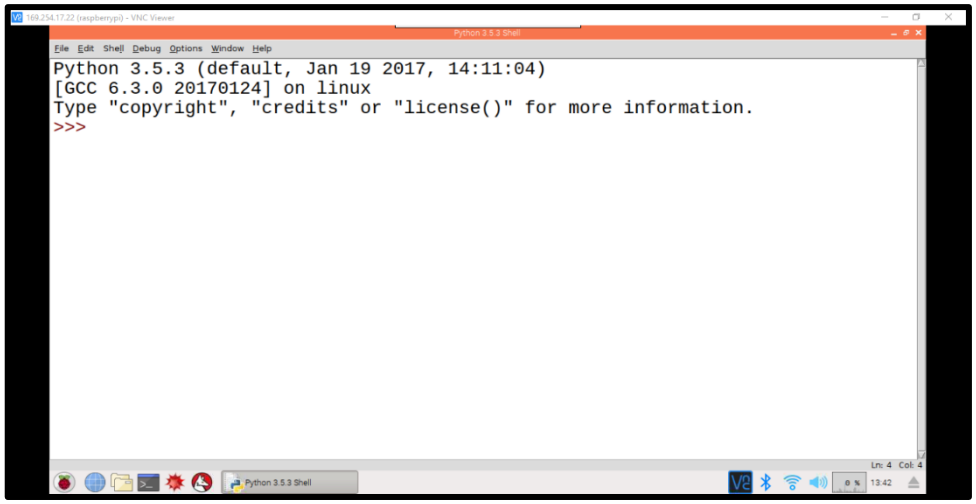


Figure 20. Python IDE

Thonny is a new IDE (integrated development environment) bundled with the latest version of the Raspbian with PIXEL operating system. Using Thonny, it's now much easier to learn to code. Thonny comes with Python 3.6 built in, so you don't need to install anything.

3.3.2 Arduino IDE

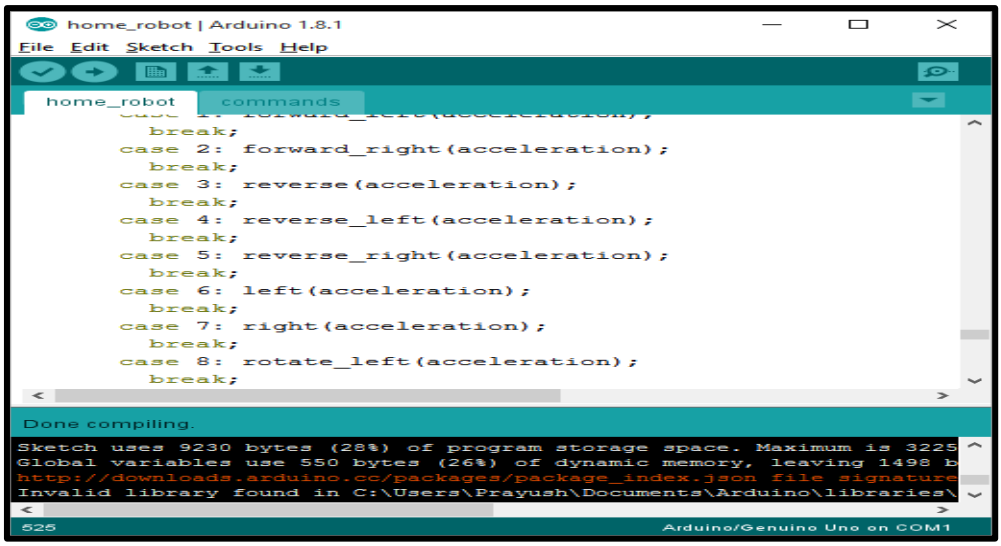


Figure 21. Arduino IDE

The Open Source Arduino (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, Linux. The environment is written in Java and based on Processing and other Open Source Software.

3.4 SYSTEM DIAGRAM

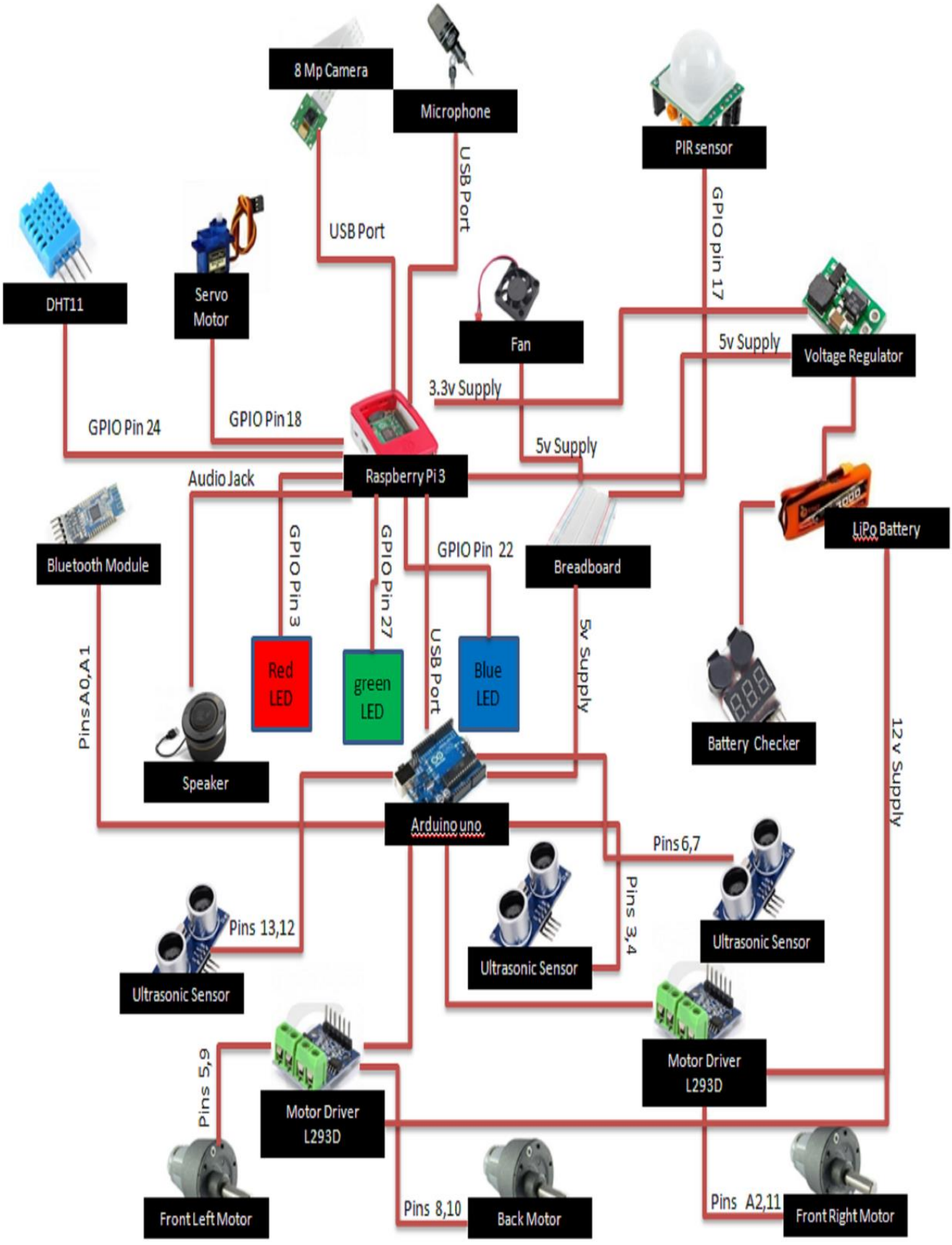


Figure 22. Complete System of the Robot

3.5 DEVELOPMENT AND WORKING

3.5.1 Taking the Voice Input from User

The project uses PiAUISuite by Steven Hickson to record and process the Audio input. The Audio input is taken by a Microphone. Raspberry Pi 3 does not support audio input by the provided audio jack thus we use a USB Mic Module instead.

The commands should be in the format speech=command.

Ex: music=xterm -e pianobar
Doctor Who=playvideo -r -f Doctor Who

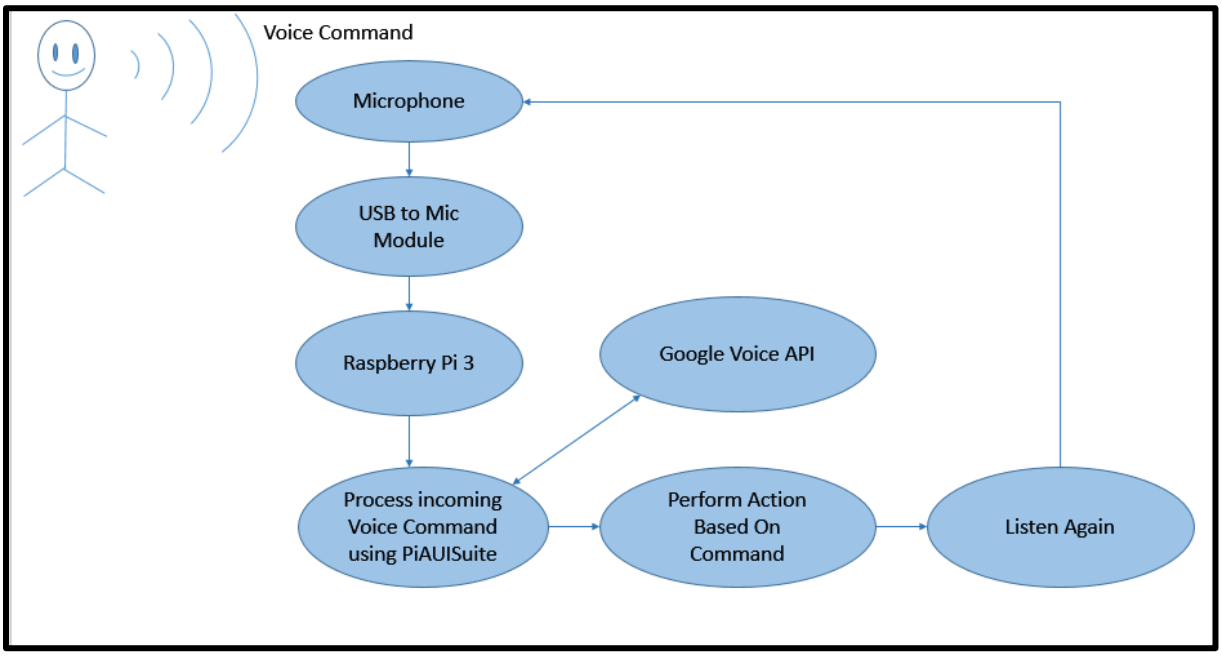


Figure 23. Voice command flow

The library connects to Google Voice API service and processes the audio. It provices a text output after processing which can be used to decide what task needs to be performed by the robot.

3.5.2 Voice Output by the Robot

For this purpose the project uses eSpeak library. eSpeak is a compact open source software speech synthesizer for English and other languages. eSpeak uses a "formant synthesis" method. This allows many languages to be provided in a small size. The speech is clear, and can be used at high speeds, but is not as natural or smooth as larger synthesizers which are based on human speech recordings.

Features:

- Includes different Voices, whose characteristics can be altered.
- Can produce speech output as a WAV file.
- SSML (Speech Synthesis Markup Language) is supported (not complete), and HTML
- Compact size. The program and its data, including many languages, totals about 2 Mb

Usage:

// Import library into our file:

```
from espeak import espeak
```

// Provide the text for speech synthesis

```
espeak.synth("Smart Home Robot Program Started")
```

3.5.3 Serial Communication between Raspberry Pi and Arduino

Raspberry Pi and Arduino both provide Serial communication capabilities. This allows us to send text commands to and from the Raspberry to Arduino. First we need to make sure that Serial communication is turned on in raspi-config

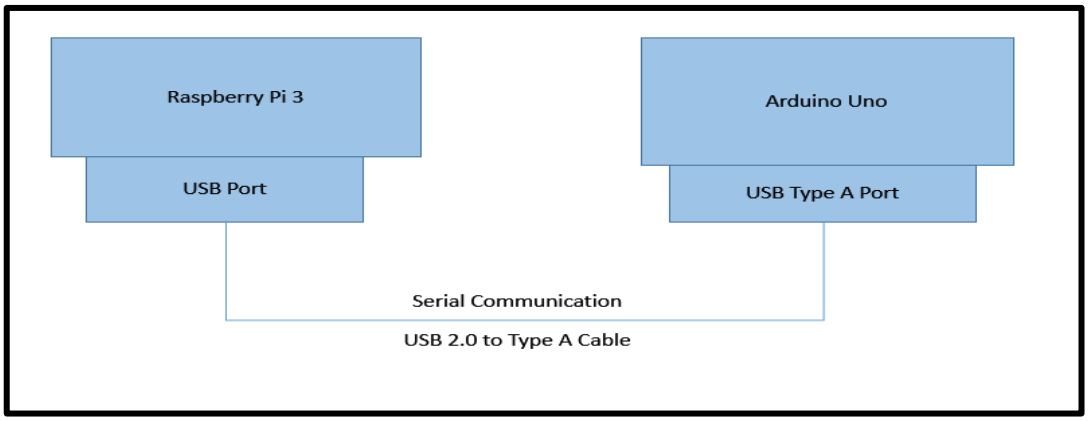


Figure 24. Serial Communication between Arduino and Raspberry Pi

Usage:

Raspberry pi :

```
// import the serial library
import serial
// set the USB port at which arduino is connected and baudrate
ser = serial.Serial('/dev/ttyACM0',9600)
// read data sent from Arduino
input = ser.read()
// send data to Arduino
ser.write('a')
```

Arduino:

```
// set the baudrate of communication
Serial.begin(9600);
// read data from Raspberry pi
char ch = Serial.read();
// write data to Raspberry pi
Serial.print("data");
```

3.5.4 Getting data from DHT 11 Temperature Sensor

The sensor uses a single signal pin to send the temparature data to raspberry pi. Adafruit provides a convenient easy to use library to take the Temperature data. Connect the Data pin to any GPIO pins available o raspberry pi.

Usage:

```
// import the library
import Adafruit_DHT
// receive data from the connected GPIO pin
humidity, temperature = Adafruit_DHT.read_retry(11, dht11_pin)
```

3.5.5 Playing sound on the Speakers

The inbuilt vlc media player in Raspbian OS is capable of playing mp3 , mp2 and any kind of music files.

Usage:

// import the vlc library

```
import vlc
```

// select music file to play

```
p = vlc.MediaPlayer("Music/startup.mp3")
```

// play the file

```
p.play()
```

3.5.6 Display robot expressions fullscreen

Smart Home Robot "Chitti" displays facial expressions depending on its mood or the operation it is performing. Facial expressions include smiling, sad, naughty, crying, sleepy, laughing, general , etc.

It uses the Python Image library to display various expressional images fullscreen.

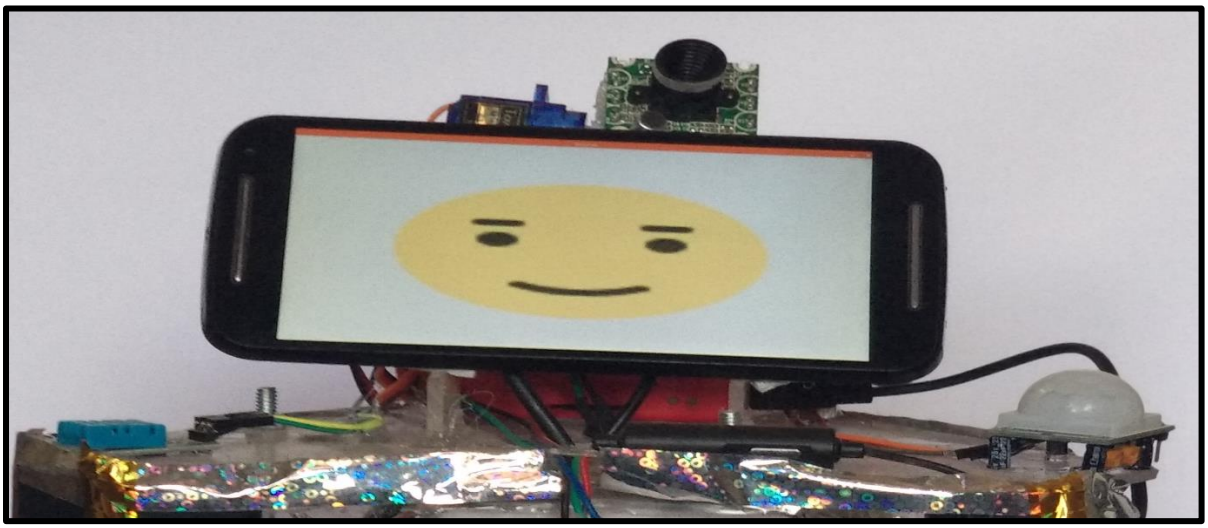


Figure 25. Facial expressions on Mobile display using VNC Viewer App

Usage:

// import the Python Image Library

```
from PIL import Image
```

// display the image fullscreen

```
img = Image.open('emoji/normal.png')
```

3.5.7 Detecting Human Motion using PIR

Passive Infrared Sensor allows detection of Human by the robot. This is powerful tool for the application of this robot. When the robot detects that a Human is present, it automatically switches to Command mode. In command mode the User is able to provide Voice commands to the Robot. If the Sensor detects no motion it will know that no Human is present near it and will thus enter autonomous mode. In Autonomous mode the Robot uses the Ultrasonic sensors to judge its environment and move freely avoiding any hit to obstacles.

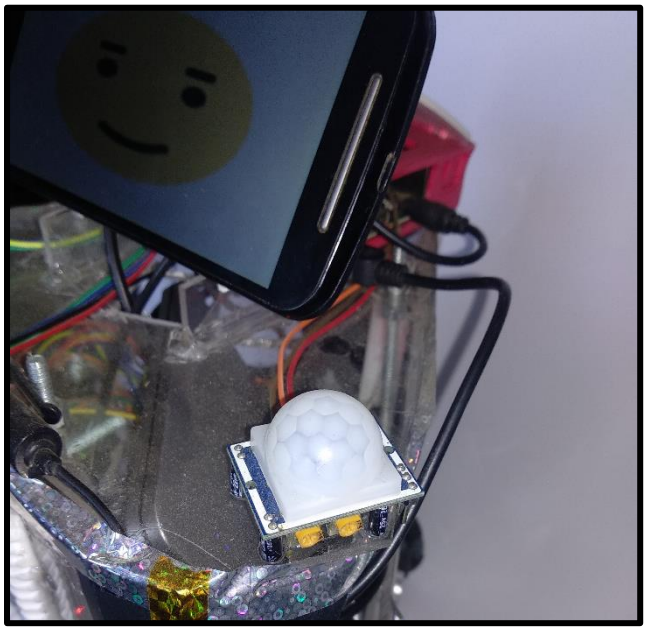


Figure 26. PIR Sensor mounted on the robot

The sensor also allows detecting unusual activities such as attempt of Theft, Robbery or Intrusion at Home. Since we can detect Motion it allows user to be notified of uncertain activities happening at a set time.

Usage:

// set sensor pin to Input mode

```
GPIO.setup(pir, GPIO.IN)
```

// read sensor data

```
GPIO.input(pir)
```

// if above line returns true then motion is detected else no moton detected

3.5.8 Reading data from the Camera Sensor

Camera adds a multitude of features to the Robot or any other application. We can do Face detection, Facial Recognition, Text Recognition, Object detection etc to name a few. The project uses an 8 MP No-IR Filter Camera module. The module is capable of Night vision thus it can also help detect unusual activities at Night time.

Raspbian supports various libraries for Image acquisition and Computer Vision. OpenCV is the most popularly used Computer vision library which can also be used with Python.

Usage:

Configure raspi-config to use the Camera Module

// import the PiCamera library

```
from picamera import PiCamera
```

// create an abject of picamera library, it automatically detects the camera module

```
camera = PiCamera()
```

// start camera preview

```
camera.start_preview()
```

```
// stop the preview
```

```
camera.stop_preview()
```

3.5.9 Controlling the Tilt of Camera Sensor using Servo motor

Like humans the robot should also be able to move its eyes around to have a look at its surroundings. The robots chasis allows it to have the Pan (Horizontal) movement , but does not allow Vertical movements. For this purpose we use a Plastic gear Servo motor which provides a Tilt motion to the Camera sensor.

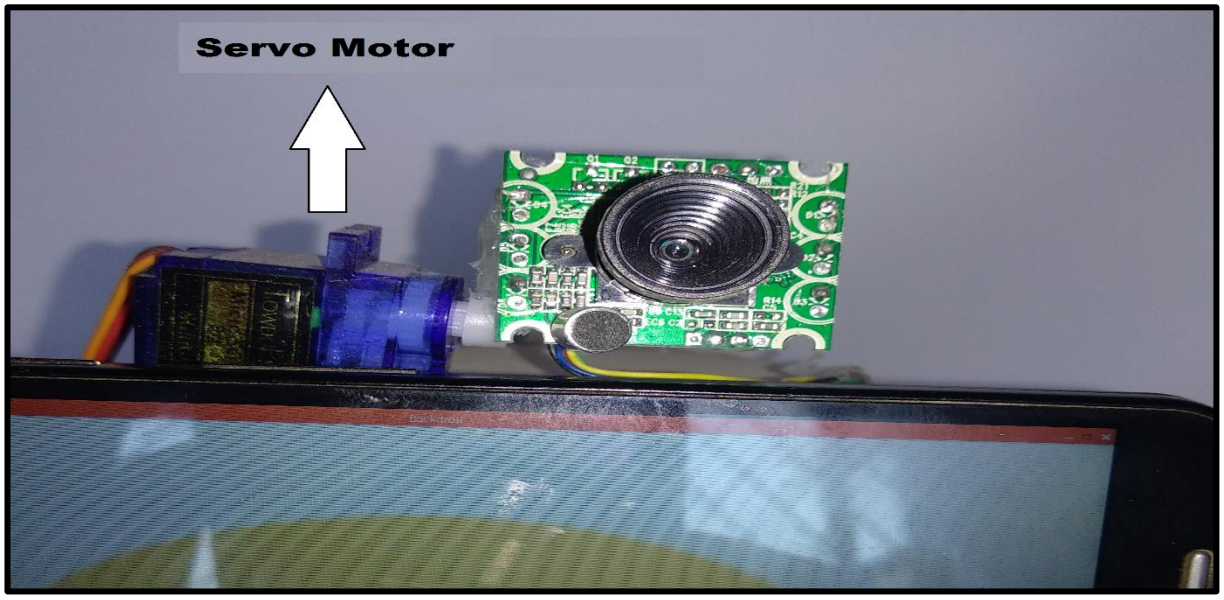


Figure 27. Servo Motor to Control Camera Tilt

Usage:

// set the Servo pin as Output

```
GPIO.setup(servo_pin, GPIO.OUT)
```

// set the freq rate of data

```
pwm=GPIO.PWM(servo_pin, 50)
```

// start giving signals

```
pwm.start(0)
```

// function to set the angle of servo motor

```
def setAngle(angle):
    duty = float(angle) / 10.0 + 2.5
    pwm.ChangeDutyCycle(duty)
```

// sets the Servo motor angle to given value

```
setAngle(x)
```

3.5.10 Controlling Motors using Arduino

The L293D IC based motor drivers have been used for this purpose. The drivers allow to control both the motors direction as well as speed of Rotation.

Usage:

// set the pins as output

pinMode(LEFT_MOTOR_DIR, OUTPUT); pinMode(LEFT_MOTOR_PWM, OUTPUT);

// depending on desired direction set pin LOW or HIGH

digitalWrite(LEFT_MOTOR_DIR, LOW);

// to adjust speed set the pwm value, min is 0 and max is 255

analogWrite(LEFT_MOTOR_PWM, pwm);

3.5.11 Taking data from the Ultrasonic sensors

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave reflected back to sensor it can calculate a approx distance in cm with an error of just +-3mm.

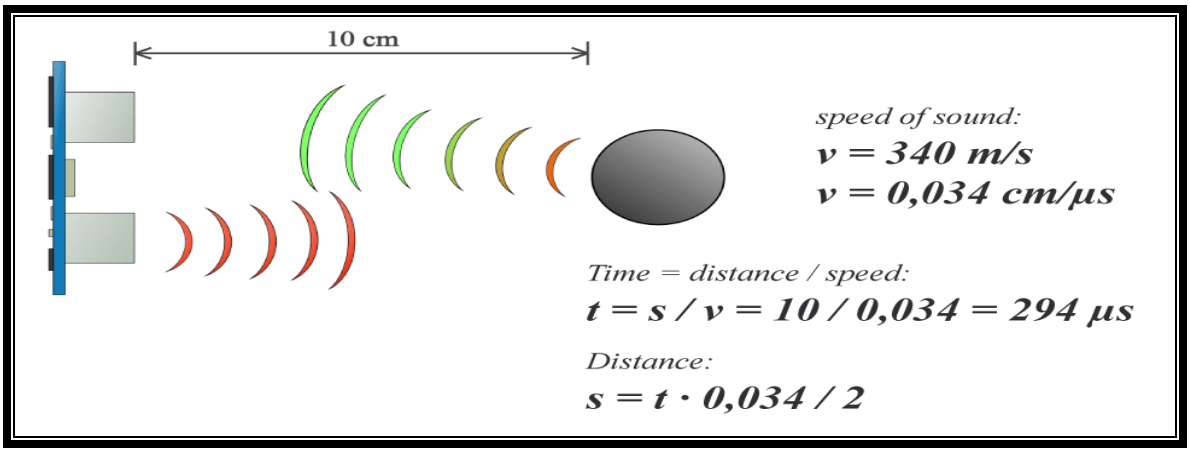


Figure 28. Ultrasonic Sensor Calculations

Usage:

// set the echo pin as Input and trigger pin as Output

```
pinMode(trig_L, OUTPUT);          pinMode(echo_L, INPUT);
```

// send a pulse of 10 microseconds to sensor , this sends a sound burst from the sensor

```
digitalWrite(trig_L, LOW);

delayMicroseconds(2);

digitalWrite(trig_L, HIGH);

delayMicroseconds(10);

digitalWrite(trig_L, LOW);
```

// calculate the distance by seeing the time taken for sound to return back

```
duration = pulseIn(echo_L, HIGH);

distance_left = duration * 0.034 / 2;
```

3.5.12 Autonomous Drive using data from Three Ultrasonic sensors

For Automatic manuever of our Smart Home Robot we have used Three Ultrasonic Sensors that provide Distance data to the Robot from Three angles.

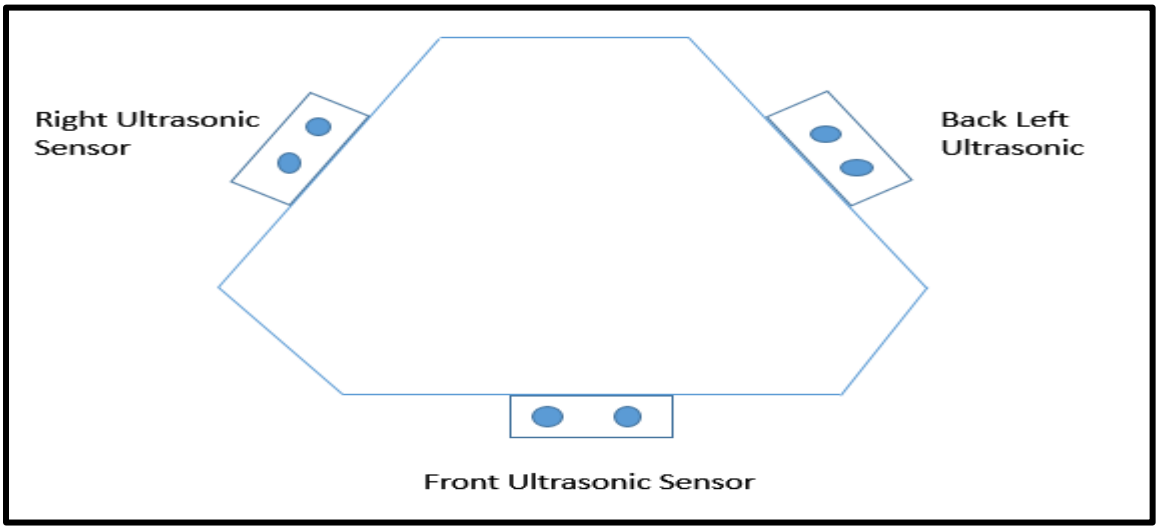


Figure 29. Mounting of Ultrasonic Sensors

Basically it takes data simlutaneously from all three sensors and tries to avoid any obstacles. Since the Robot supports functionality of voice , display and LED's , it gives various voices and emoji's depending on current locomotion. The data from ultrasonic sensors defines the Robots modd either Sad, Happy, Angry, Annoyed, etc. which is then used to give out various voices and facial expressions by the robot.

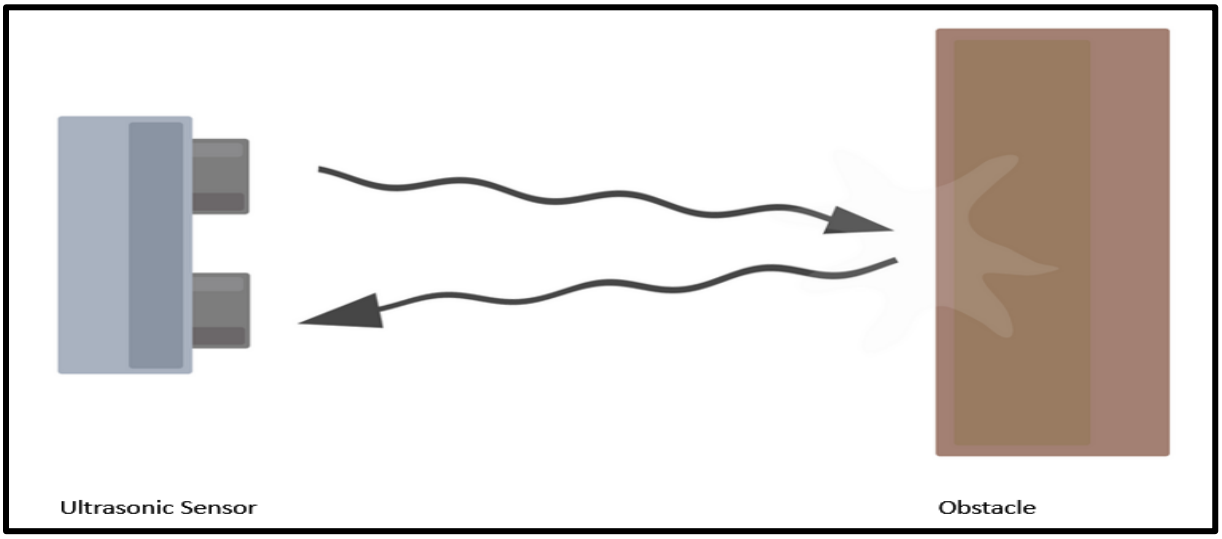


Figure 30. Detection of Obstacle by Ultrasonic Sensor

3.6 ALGORITHMS USED

3.6.1 Raspberry Pi Sequence

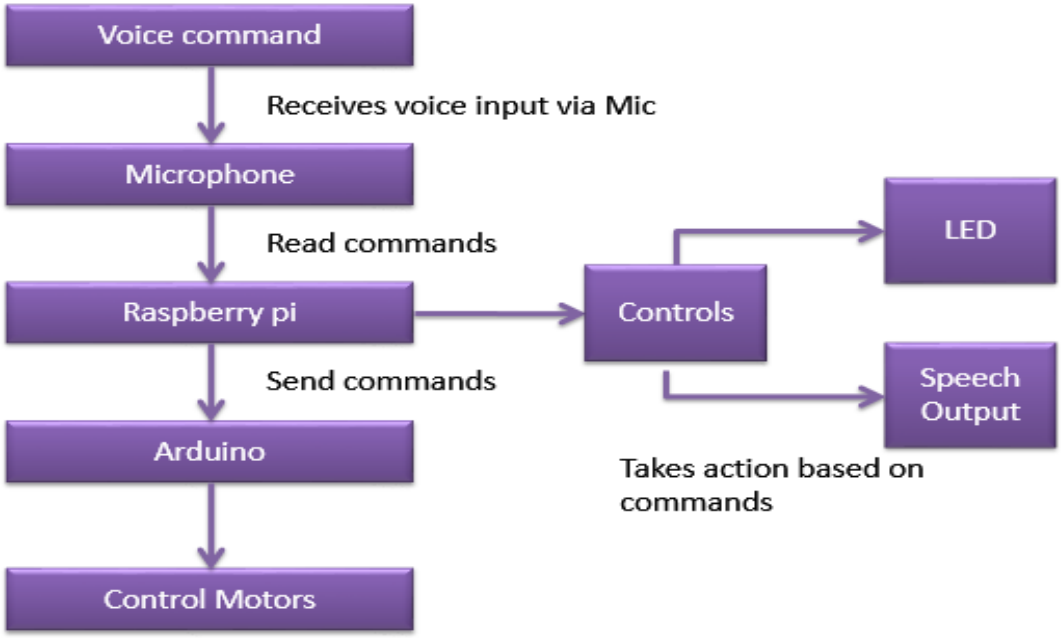


Figure 31. Raspberry Pi Program Sequence

3.6.2 Arduino Sequence

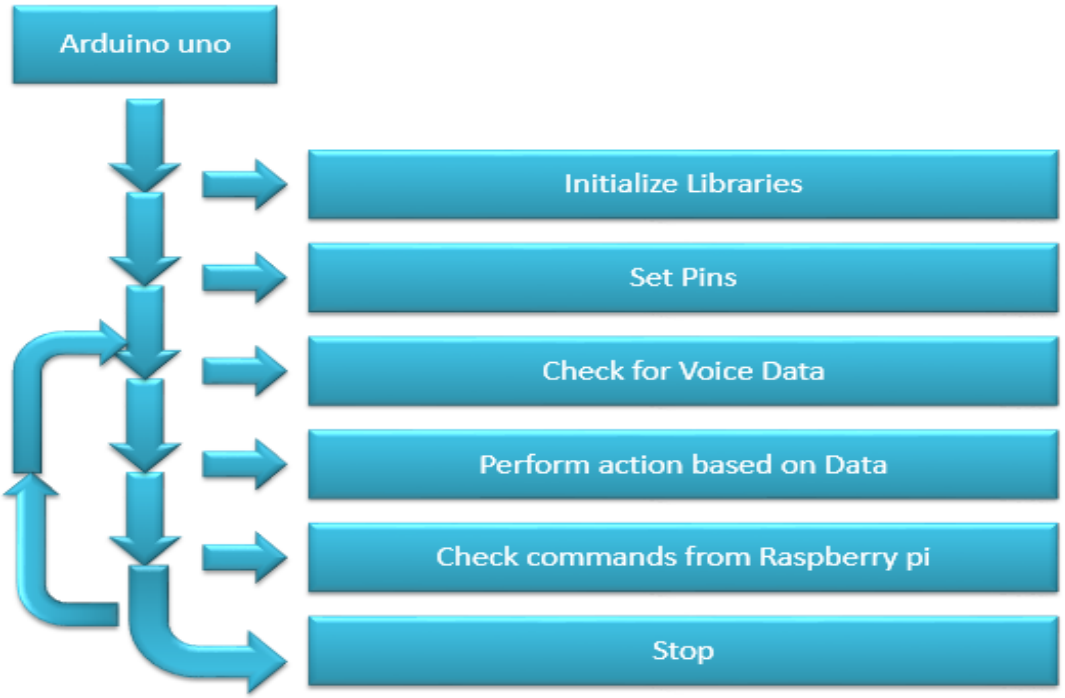


Figure 32. Arduino Program Sequence

3.6.3 Autonomous Drive Sequence

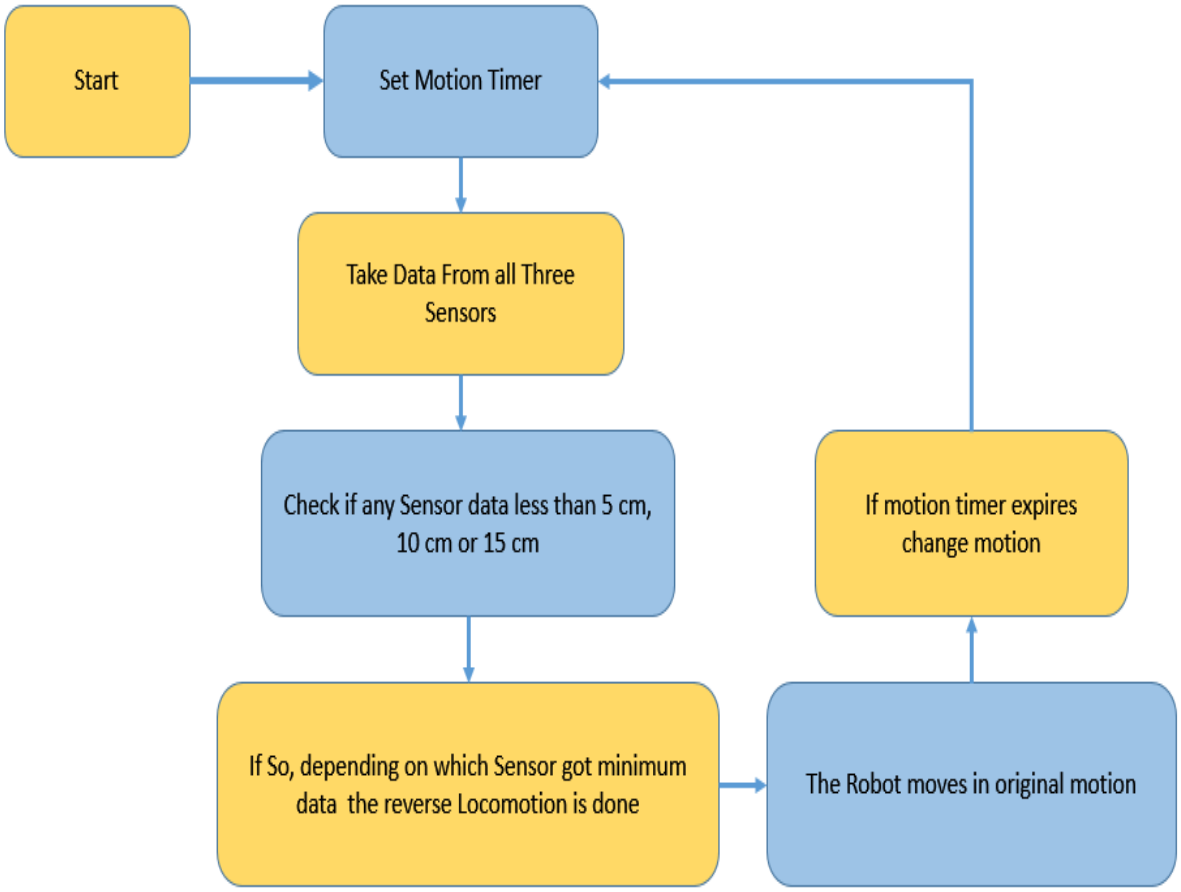


Figure 33. Automatic Drive Algorithm

The Robot uses three Ultrasonic sensors to detect its environment. The data from all three sensors is taken simultaneously. The sensor with a least distance value i.e either 5 cm, 10 cm, 15 cm is chosen randomly. Once any sensor gets a least value the approapriate locomotion takes place. For example, if front sensor gets a value 0f 10 cm then, the robot would stop and then it would go reverse for 500 ms. After that it would rotate in any direction for 500 ms and then continue its motion. This way the robot is able to avoid obstacles.

A motion timer has also been set at the beginning of the sequence. Once the robot starts it moves in forward direction continuously. A motion timeer of 10 to 20 seconds is set randomly. If the timer expires the motion changes to some other random motion for a time of 2 seconds. For example, when timer expires left, right , left rotate, right rotate or some other motion would be continued for a time of 2 seconds.

3.7 CHITTI ROBOT PHOTOS

Figure 34. 3WD Omni Directional Chassis

Figure 35. Motor Mounting with Chassis

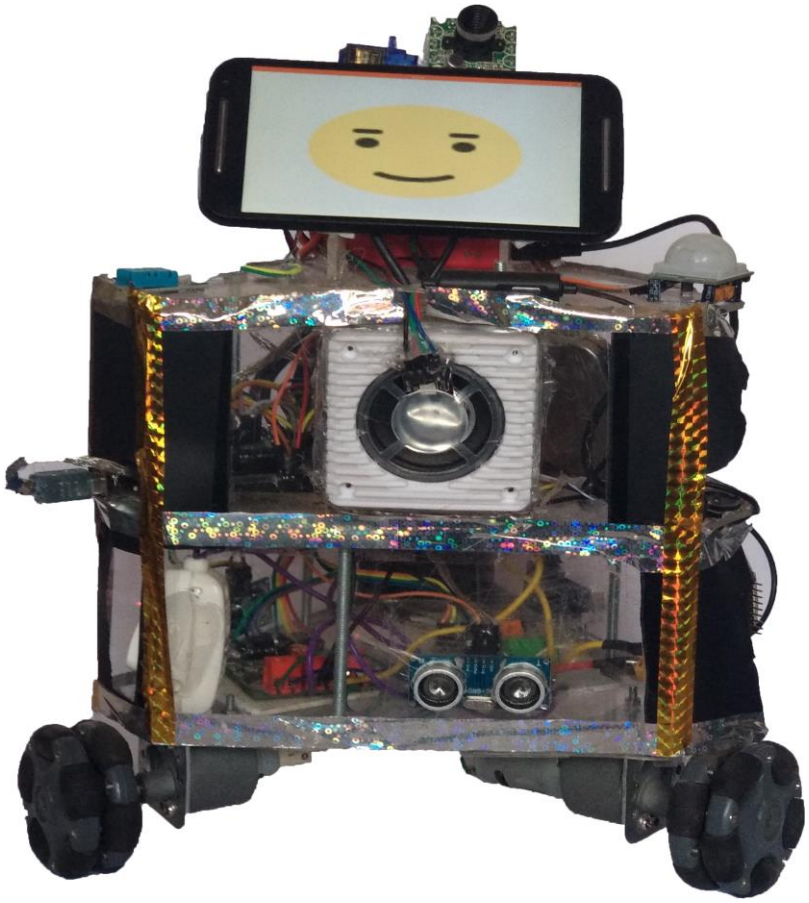


Figure 36. Chitti Robot Front Side

Figure 38. Chitti Robot Right Side

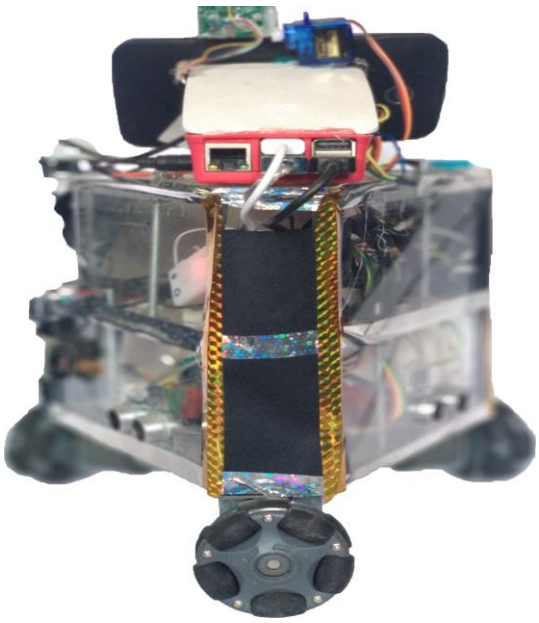


Figure 37. Chitti Robot Back Side

4. PERFORMANCE ANALYSIS

4.1 CHITTI ROBOT INTERFACE

At beginning Smart Home Robot "Chitti" analyses the data from PIR Sensor to detect if a Human i.e the User is present nearby. If it does find a user then the Robot enters Command mode in which it moves stabily in a single location and listens for any audio input. If the sensor detects no human motion it goes into Autonomous drive mode. In this mode the robot drives autonomously around the House using the data from three Ultrasonic sensors mounted across the robots chasis.

There are a multiple features the Robot can possess, but for our project limits below is the list of tasks that the robot can perform:

- Say "Hi" to Chitti
  When a user says 'Hi' chitti responds with "Hello Sir" and presents a gentle smile
- Say "Describe yourself Chitti"
  This will define Chitti to describe itself, which it does by using the popular dialog in the Robot film which goes like this: "Hello I am Chitti, speed 1 GH,z memory 1 GB and storage memory 16 GB, Nice to meet you"
- Say "Chitti Please demonstrate your locomotion"
  This will command Chitti to showcase its 10-directional omni drive locomotion
- Say "Chitti play my favourite song"
  Chitti will play your favourite song (predefined ofcourse), and may also dance for you depending on its mood
- Say "Chitti take a photo"
  Takes a photo like a boss, plays a nice song to really make you smile for the photograph
- Say "Chitti go play"
  Commands Chitti to go into Autonomous mode and Play around for a while
- Say "Chitti stop"
  Stops and shuts down the Robot. Chitti is upset ofcourse but it presents itself with a smile and sleeps to dollow the command

4.2 TESTING

Smart Home Robot is a combination of Hardware and Software. The testing phase has been kept with this in mind.

1. Test name: Raspberry Pi Display displays remotely on VNC App
   Description: To check if the display comes properly on the Remote Android mobile app

   Expected result: see Raspberry Pi desktop on Android mobile

   Actual result: Shows desktop

   Status: Pass

2. Test name: Check if Voice commands are recognized properly
   Description: To check if the Voice input is processed correctly and proper Speech to Text conversion is done by Google Voice API

   Expected result: input voice and output text match correctly

   Actual result: gives expected Text result

   Status: Pass

3. Test name: Check if Emoji's are displayed are correctly
   Description: To check if the Facial expressions that is the emoji's image file used in this case displays full screen and with proper visible brightness

   Expected result: see Emoji's fullscreen

   Actual result: Shows Facial expressions

   Status: Pass

4. Test name: ESpeak Speech sysnthesis

   Description: To check if the ESpeak speech sysnthesis speaks the given text properly. Adjust the Speech tone, speed and voice so that it is clearly heard by the user.

   Expected result: hear Speech by robot properly

   Actual result: proper Text to Speech synthesis

   Status: Pass

5. Test name: Check if LED's are working

   Description: To check if the RGB SMD RGB LED Module is working properly

   Expected result: see various colors bright up at the center of the Robot at startup. If it does not then maybe the connections have broken or the module has been damaged

   Actual result: Shows various colors at startup and colors based on mood of the robot

   Status: Pass

6. Test name: PIR Sensor working properly

   Description: The PIR Sensor gives signal if a Human user is active near it at a range of 3 meters.

   Expected result: If PIR does not give signal even if a user is present then their may be a fault in wiring or the setting of the sensor. The RGB LED Module is set to Green to show that a Human user has been detected nearby, and it shows Red color otherwise.

   Actual result: Green color displayed by LED

   Status: Pass

7. Test name: Check data from DHT 11 Temperature and Humidity Sensor

   Description: view data from the DHT 11 sensor. The sensor gives a float value of the Humidity and Temperature values. Humidity value is given in percentage, while Temperature is presented in Degree Celsius. A error in Sensors values can be guessed

if values are too high such as Humidity = 80.90% or Temperature = 120.10 C. If so, there is a possible problem in the wiring or DHT11 Sensor has been damaged.

Expected result: Displays proper Temperature values

Actual result: Sometimes gives uneven values, the sensor is not a reliable one

Status: Both Pass and Fail, depending on environment conditions

8. Test name: Check if Servo motor is working
   Description: To check Servo motor is working properly or not. At the beginning of the program the Servo is moved from 0 degree to 90 degree and from 90 degrees back to 0 degree. The motion of motor is observed at the beginning, if it moves properly as desired then it working properly. If not, there may be a possible problem of wiring, power supply, shaft weight or hardware fault.

   Expected result: Servo motor moves vertial up and down at the beginning of program

   Actual result: Motor moves each time progam is started

   Status: Pass

9. Test name: Is Camera Module working
   Description: The camera functionality has not been used extensively in the project. But the Robot can capture video and photo when commanded to do so. It displays the photo after capturing.

   Expected result: If successful capture of image takes place then the Phot taken is displayed correctly over the Mobile display.

   Actual result: Shows Photo

   Status: Pass

10. Test name: See if Raspberry Cooling fan is working properly

    Description: The cooling fan is used to cool down the High temperatures exhausted by the Raspberry Pi's processor. If the cooling fan is not working then the processor would heat up alot and this could damag the main component that is the mind of the robot.

    Expected result: Fan should be working properly

    Actual result: Fan cools the Raspberry Pi

    Status: Pass

11. Test name: Arduino Uno Working correctly

    Description: Arduino Uno has been used as middleware between the Raspberry Pi and the rugged hardware components. If it fails then a multitude of operations would fail such as Locomotion, Automotive drive and Power Supply. To check if Arduino is working properly the robot is programmed such that it lights up an the inbiult led two times when the Arduino is supplied with power.

    Expected result: The Inbuilt LED should blink two times

    Actual result: LED blinks thus the Arduino microcontroller is working correctly

    Status: Pass

12. Test name: Driving Motors are working correctly

    Description: Locomotion is a very important part of the Robot. If any of the Three motors are not working as desired that would fail the entire locomotion. So the startup sequence of Arduino consists of a loop that rotates the robot left and right. By observing the robot's locomotion at beginning of the sequence we can guess out exact which motor is failing to work correctly.

    Expected result: Robot must rotate left and right correctly at startup

    Actual result: It rotates correctly

    Status: Pass

5. CONCLUSION

5.1 CONCLUSION

Use of personal, domestic, home robots are beginning to get attention in this era of advancing technologies. The 2012 movie Robot & Frank featured a domestic robot, the story of the movie centred on an elderly man and his relationship with a caretaker robot. In the Star Wars film series, robots of all shapes and sizes can be found assisting the humans with several tasks. C-3PO is a robot designed to assist humans in translation, and etiquette, while R2-D2 was created to assist with maintenance. Other robots in the films can be found serving as co-pilots or fighting in battles. In the 2008 film Wall-E humans use sentient robots as trash compactors to clean up the mess they left behind on Earth. Wall-E is a small bulldozer like robot who has claws for hands and spends all his time collecting garbage. Another robot named Eve is small, sleek, and can fly.

Personal Robots are gaining alot of hype and popularity. But our civilization is still not ready for it completely. Several concerns such as cost, maintenance, maneuverability, feasibility and type of apllication to name a few add up to a debate on wheather the society is really ready for this kind of robotics technology.

Some recent developments suggest that they might not be too far away. Processors, sensors, and other components that robots need have gotten much better and cheaper, propelled by advances in smartphone technology. And open-source software is now available for robot simulation, control, vision, and many other functions. Also, rapid-prototyping tools like 3-D printers and laser cutters are lowering the barriers for designing and building new robots.

With this project we aim to learn the exploding set of technologies in this ever evolving field of Robotics. The team was able to successfully build and work out a Home robot that is functional, playful and intuituve. Soon the reality of Autonomous robots will become true, and this team and its experience in developing the robot will surely be a part of it.

5.2 FUTURE SCOPE

- Smart Home Technologies

First off, traditional clay bricks are out. Future houses are likely to be eco-friendly, eschewing CO^2-heavy manufacturing processes. Your home might incorporate building blocks constructed from natural cement churned out by bacteria, or be fashioned from fungi – indeed several companies including MycoWorks and EvocativeDesign are exploring the potential of mushroom-based materials.

- Kitchen

One thing that's certainly on the menu is a spare pair of hands to wield the pans – be that a fully robotic chef. And it's cheers all round as be-splattered recipe books and pastry-flecked screens get the boot in favour of hygienic upgrades. A nifty vertical recipe projector which also uses a canny array of cameras to detect ingredients and offer culinary suggestions accordingly.

- Bathroom

Among those vying to keep an eye on your vital statistics is Withings, whose "Smart Body Analyzer" makes your old nemesis – the bathroom scales – look positively friendly. Claiming to measure your weight, body fat, heart rate and BMI, it will not only terrorise your tiled floor, but take to your phone: an accompanying app tracks your activity and adjusts your calorie budget for the day to meet your health goals

- Living Room

Android helpmates are already being used in hotels around the world to deliver items to guest rooms, such as extra towels or room service items. Such robot helpers are likely to become ever more sophisticated, capable not only of fetching the port, but also having a jolly good natter.

- Bedroom

Technology and sleep are unlikely bedfellows: for years scientists have been wagging their fingers at those who go to bed in the company of the dazzling blue lights of their connected devices. But when it comes to hitting snooze-mode, technology need not be a nightmare.

White noise generators such as those produced by Ectones are already available, offering the chance to drown out frisky foxes, chirpy birds and bickering kids with the comforting sound of a fan or pattering rain. But that's a drop in the ocean compared to what the future could hold.

5.3 APPLICATIONS/UTILITY

- Healthcare
- Care giving
- Companionship
- Entertainment
- Toy
- Pet
- Security
- Teacher
- Research
- Public Assitant

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APPENDIX – I

APPENDIX - II