

**PERSONAL ASSISTANT ROBOT**

**SOFTWARE ENGINEERING PRINCIPLE**



**EMBEDDED SYSTEM DEVELOPMENT**

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Connect Life and Learning

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## **1. INTRODUCTION**

This SRS report is been created for a particular embedded system (“Personal Assistant Robot”). All the details and explanations discussed in the reset of the document will be based on the above-mentioned system only. The main intention of this document is to make others understand the working of the system and also some detailed description to recreate the system independently. In this section, the users can find the basic information or the guidance to read the contents to be into the document.

### **1.1 PURPOSE**

The main purpose of the system is, the system which is been developed and discussed in this document is the system which has unique features itself and could be used in many applications real time. Creating such a personal assistant robot is to pursue physical assistance to the users in the real world to make their work easy. So, the main intention of this document being created is to make a documentation of the developed system and could be made in practise to the real world, and in the future, someone can read this document to make some development on the crated system.

This document is for the users of the developed system and for the developers to recreates the system and make some developments in the future. This will also be a helpful document for the system at the business side, to show off this proposal to some investors to make it possible in the commercial sale in the real-world market.

### **1.2 SCOPE**

The system which is been developed and being discussed in this document is a “Personal Assistant Robot”. So, as it was developed for the first time and as a dedication to my family member, the robot is named as “Chitti” and now on the robot will be mentioned as “Chitti”.

On seeing of features and capabilities of Chitti, the total control of it is in the hands of the controller or the commander. The user’s personal phone will be acting as a control device of Chitti. With the phone and the phone application which is developed for it will have all the command instructions to control Chitti. The motion of Chitti can be controlled, it has a robotic arm attached on top of it, which can be controlled as well. To make it simple, if the user tells Chitti to go to a pre fixed destination, it will go there autonomously with no control and performs the physical task when it reaches the desired destination. It could be operated both manually and autonomously. It can not go to the destination other than the pre fixed ones.

The software developed for this system is totally modifiable on the developer side only. And once the software is loaded it will react according to it.

### **1.3 DEFINITIONS, ACRONYMS AND ABBREVIATIONS**

DC – Direct Current

AC – Alternative Current

RF – Radio Frequency

RPM – Rotation Per Minute

GB – Giga Bytes

MHz – Mega Hertz

BPS – Bits Per Second

MAH – Milli Ampere per hour

### **1.4 REFERENCES**

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## **1.5 OVERVIEW**

Every single section after this is going to have a detailed description of each part of the system developed. So, in case of the developer the person should look after all the sections in the overall description to know more about the working and functionalities of the system. And the that the section discussed will be the specific requirements which is more important for the developer point of view, but as the users or business people can skip that section where they will not get a clear idea of it.

The organisation of the document is created in such a way that it will talk about the general working structure of the system in the section 2 and the creation of the system of such a kind in section 3.

## **2. OVERALL DESCRIPTION**

The overall description of the system is, since it works on the real time, first it looks for the obstacle around itself. Whenever it sees an obstacle around the working region of the system, it will stop moving further. Until the obstacle is in the phase of the sensor the motion stops. The users should also remember about the control range of the system. When it goes outside the range of the system, then the user will lose the communication with the system. And it cannot be brought back to its range. The users should also keep an eye on the power of the system, as mentioned earlier when the system runs out of the power less than the minimum required power to operate which will be 300mAH.

If there are any dust or intervene in any of the cameras available in the system, then the system will never fulfill the required operation of it.

Reset of the factors that affect the product and its requirements will be described on the following headings,

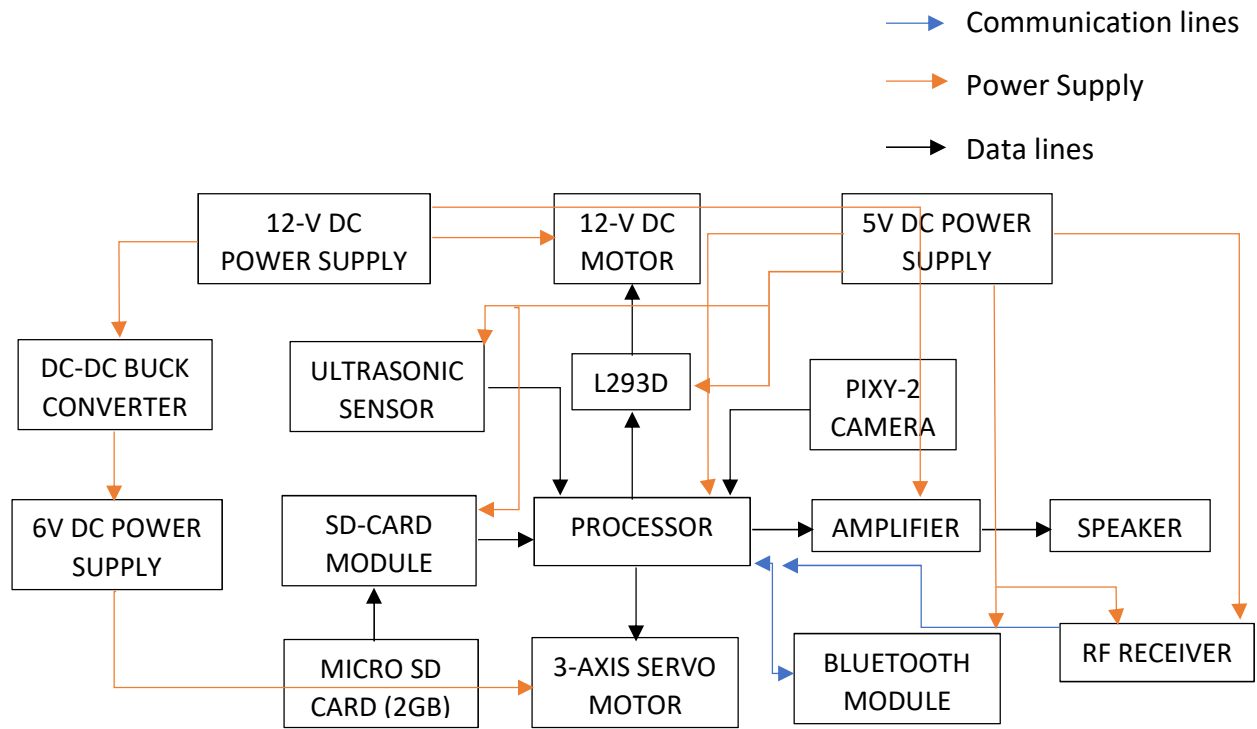
### **2.1 PRODUCT PERSPECTIVE**

The system being developed here in this case is totally a collection of software benches which is been collected from different sources as mentioned in the reference section. All the reference links mentioned in the reference section is the resource for this system. And also, there was a journal paper published in International Journal of Research in Advanced Technology (IJORAT) "ISSN Online 2456-2769" this document was the basic level and complete references were acquired from there.

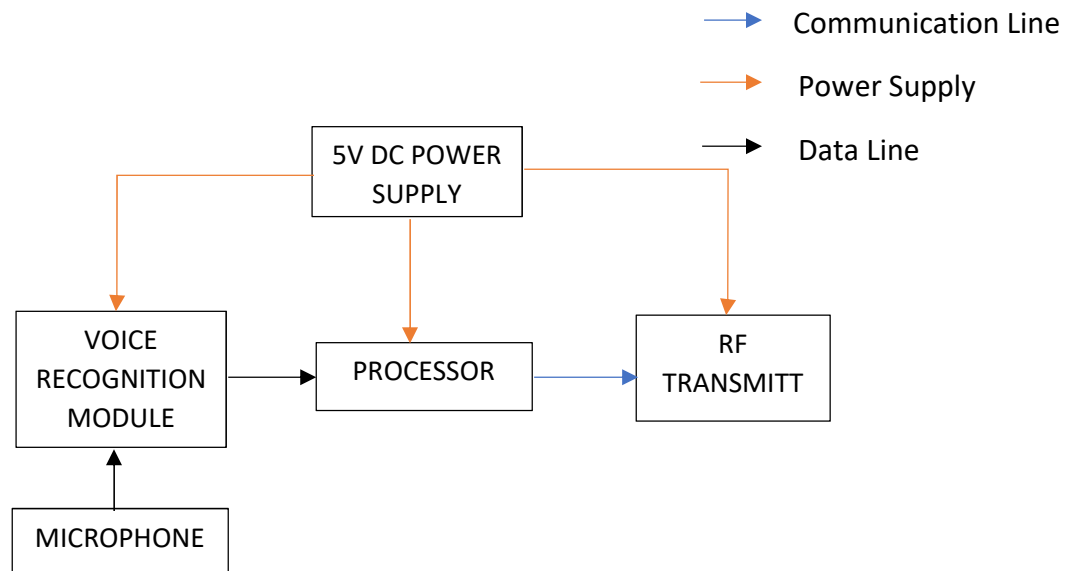
In this project there are going to be lot of components used to perform the tasks, major parts of the project were tried to covered in the below showed block diagram as follows,

## 2.1.1 BLOCK DIAGRAM

### RECEIVING PART



### TRANSMITTER PART



### **2.1.2 HARDWARE INTERFACES**

The above shown block diagram clearly explains what are all the components been interfaced in the project. We should have close look on the components because each of the component has different voltage levels and each of them are used for different purposes. Generally, the components used all over the project is for the communication, image processing, obstacle detection, actuation of some motors to make the robot move and perform some lifting of the objects. Voice recognition module is used for the voice command recognition and some of the SD card module with the speakers to make it speak back some of the instructions to give to the users with audio level control.

### **2.1.3 SOFTWARE INTERFACES**

All the hardware used in the system has some of the pre programmed code in it where it is taught what, when and how to do. Totally the software contained in this system has two parts in it, one is the software for the transmitter part which takes the input from the microphone with one of those voice recognition modules, which will recognise the commands which were already taught to it. It gives back some of the data as output to the software with some of the useful data which will help the developer to process accordingly to activate something else in the receiver part. It is also activated with the RF transmitter which will transmit the data to the receiver to make something useful from the transmitter.

The next part of the system is receiver part, which contains rest of the parts in the block diagram. Actually, the receiver part of the system is been activated two ways, one is through the RF receiver and the next one is through the Bluetooth module. With the help of the Bluetooth module, it allows the users to control the motion of the system, control of the 3-axis robotic arm on it. With the help of the RF transmitter it is actually getting the data from the voice recognition module, so this part will be the answers for those questions raised from the users through the voice recognition module. Those answers by the system will come from the SD module which has the SD card dumped with some of the pre recorded speech instructions. All the parts of the system used here should be programmed accordingly with the protocols accumulated with those modules.

### **2.1.4 COMMUNICATION INTERFACES**

The communication interfaces in the system here are RF transmitter and receiver and Bluetooth module. With the help of these two modules, the system will allow us to control the system wirelessly. One thing to keep in mind is that the RF transmitter receiver part will not work well when both of those modules are triggered at the same point of time. The developers should make sure to turn on the transmitter first and

then we have to turn on the receiving part of the system by that way it starts communication each other. One more complication with the Bluetooth module is that it will not allow the developers to talk to the processor when the module is connected with the processor during the time of development. But apart from these conditions, everything else will be working fine on the first go while developing the wireless communication.

### **2.1.5 MEMORY CONSTRAINTS**

There are some of the memory constraints in the system. The first memory constraint is on the voice recognition module. The module used here at this system will allow the developers to save 15 commands and on the other side of the system since the system hold a micro SD card to store the speech back commands, it is limited to 2 GB (Giga Bytes).

## **2.2 PRODUCT FUNCTIONS**

The software sections of the system contain three parts mainly all over the part of the software. First when the software has to compile with any of the module, it has to be initialised and make some setup with the module and the processor with some of the available functions. When the initialisation part is good, we need to do the setup which means the pin connection of the module with the processors should be given in detail at this part of the software. On the top view of the software it generally comprises of the two functions. One is the setup files inclusion and the next one is the loop function which will run continuously over the time forever when the power supply is given to it. This part of the software is the main part where the real processing of the data from the real world comes to the action.

This part of the software mainly holds some of the comparison and decision-making statements which will all be pre programmed as stated in the above parts.

Both the transmitter and the receiving part of the system will be mainly of these two parts with the setup and the looping part.



## **2.3 USER CHARECTERISTICS**

When the user wants to use the system, they got to remember some points before they got to use it. The entire control of the system is through the Bluetooth module and it gives the direct communication with the personal mobile phone of the users. Through the third-party software which is open source available in the android phones, the user has to download that software called (HC05) control on their phones with which they have to control it. After that the user will have to sync it with the module available on the system itself. After that it allows the users to control the motion and the robotic arm of the system. These commands to control the actions of the robot are customisable. There is also one more option that the user has is that they can switch the system to an automatic mode, by that the robot will start working autonomously.

The transmitter which comes as a package which has some processor, voice recogniser will be a portable package and it will be on the hands of the users. If they want to talk to the system directly at any time of the other operations of the robot they can talk to them at any time and the robot will give some speech back recorded voice and will be heard on the robot. It does both the operations simultaneously.

## **2.4 CONSTRAINTS**

As all other system has some of the limitations, this system has some of the constraints to be taken care of. The main and important one is that the system should be driven within the range and the range should be the range that can the communication module will able to communicate with the processor and the module itself. When the communication with the system gets cut off then the communication back will take some time and mainly at this time the system goes out of control which is really dangerous in the real time systems. So, the users should keep this point on their mind when they are intending to move the robot to the further positions or locations.

And in the autonomous mode of the system, the system will go to the ed destination and the user has to operate the robotic arm to lift or make some actions on it. It does not have the power to identify the object and pick it up for the users. Once when the process is done, the users has to drive the robot back to their place manually by clicking one command. Other than these limitations, all other constrains are common that the work area of the system should be wide and easy to move around. The cameras used on the system should be made clear view on the lenses. The battery

power supply should be properly taken care of. When it runs out of the battery, it will be stuck at its current process and will not complete it if it stops in between.

## **2.5 ASSUMPTIONS AND DEPENDENCIES**

All the software used in this system are independently linked. It will be using some of the library file which are all open source as well. Maybe in the near future there might be some of the updates available on the libraries which is completely not dependent to each other. So, this system will not be creating any problems. This will be working well over the time. All the sources included in the system are customisable, erasable and re writable. Which means it can be changed to any means in the future and for the development as well.

## **2.6 APPORTIONING OF REQUIREMENTS**

Maybe in the future, on the development point of view, if some one intended to make the robot completely autonomous, this document will be inspiration version for those and they can start from here. Because in our case there some of the parts where the robot will be driven pragmatically. Which is not the good practise to do. As for as now, these are all the few changes which will be made in the future and this gives them a good start for it.

## **3. SPECIFIC REQUIREMENTS**

This section is going to talk more about the system in detail technically. So, if any common people who has less knowledge in the field of technology will not be understanding much about the topics which will be discussed further in this document. It is better for them to skip this part, and continue reading rest of the sections. If a person on the mood of development, research and some technical person wondering for some ideas or thoughts to work for their own projects and commercial system buildings, this will be the right section or part for them to read through.

As told before, this section discusses more about designing the system itself and more about testing each of the parts and how to make more test fields to make it work nice in the real world when it is made to work on the real time.

This will also talk more about the interfaces that are coming from the external environment and make it work with the processor and to manipulate the actuators that will be initiated from the processor to make it work in the real world.

### 3.1 EXTERNAL INTERFACES

As there is block diagram on the top section 2.1.1 shows the inputs to the processor and the outputs from the processor, those are the interfaces which will really be happening in the system. The processor that is been used in this system is basically a multi IO port holding processor with which the developers are allowed to connect many IOs on it. As a default part, all the inputs and the outputs used in the system is going to have the power supply on it and the power supply circuit are made in one separate section where all the IO's power supply along with the processor's power are sorted together in to one circuit with considering all the circuit analysis.

The main part of the system is to make it move front, back, left and right and stop whenever necessary. For making these operations possible, two DC motors are used for the system along with the balancing wheels on the either sides of it. The DC motor used in this case is 200RPM. Since we are using two DC motors, two pins should be connected with the processor along with the two-motor driver to make the power supply to 12V dc where the processor is only capable of supplying 5V.

For making the robotic arm operation work which already has 3-axis for different postures, this will be taken care by the three pins connected with the processor and an external power supply is needed in this case as it requires high power because of the holding torque.

An ultrasonic sensor is used in the system to avoid the obstacles on the way of the motion when it is performing some motion operation. And some motion on the hard code is done to make some turns and stops at the point of obstacle detection.

Pixy-2 camera is used for the object detection by which it will see the real world and does some operations based on the detection of the objects on its sight. The SPI protocol on the processor is used for the communication with the module and the processor.

The UART protocol of the processor is used for the voice recognition system which will basically having a microphone connected to the module which will be running on the third-party software to save the data and to read it when the commands are said on the microphone.

Radio frequency transmitter and the receiver modules are respectively used for the wireless communication of the system. Where one of those modules will be placed on the system itself and the other will be given as a separate device on the hands of the users with which they can talk to the system directly.

As the response to the commands been thrown via microphone to the system, there is separate part of the system acting where it is used for the speech back operation. By making this useful feature to the embedded system devices, it makes more sense to

understand what actually happening inside the system and it will let the users know in a comfortable way.

All the controls are over ruled with one special module called Bluetooth interface, which became nowadays a widely used technology and becomes more reliable to the users to use. All the users in the current world will be having a mobile with them by that it could be controlled on the hand and this feature of the system becomes handier.

### **3.2 FUNCTIONS**

This system is developed fifty percentage with the help of the hardware's and the reset of the system is been developed on the basis of the software only. There are lots of other software been used inside the system for the simpler operations. The first software used is the mobile application which is open source and should be installed in the hand device of the users to take the control of the system on their hands. The name of this software is "Bluetooth HC05". By installing this it asks for the parity and the access to communicate with the system.

The hardware modules which are been used in the system already are run by the library file available as open source. With the help of the library files like Pixy2.h, Servo.h, SD.h, most of the hardware were made to interface with the processor with less firmware works. The module for the voice recognition is run by the third-party software called voicer, with which it allows the developer to store some of the commands on the module for the future comparisons with the live commands.

The main portion of the software was developed in the Embedded C, C++ and some python code to make the entire system work in the real world.

All the variables used in the system development were unique with the camel cases and the different sizes and the names of the variables been used in the system were really helpful for the debugging.

Mostly the structure of the system will be comparing the data with the previous known data and most of the cases the switch case statements are been used for the decision making and performing some operations. The top-level structure of the system will be comprising if the functions which will be more efficient in the memory point of view. The major functions will be the initialisation or setup functions and the loops to perform the task for ever when it is powered.

All the standards of the software were been covered and it is written traceable for someone who are willing to develop the system again from the scratch.

### 3.3 PERFORMANCE REQUIREMENTS

This part of the document, we are going to discuss about the actual number of users to use the system, number of inputs given to the system at a time, number of devices connected to the system and the reaction time of the system to the inputs.

The main theme of the system is to connect the system with the user's personal mobile phone to control the system to make the smooth operation. To make this possible, the user of the system will have a secret code which will be used to pair with the system, and then the users are good to use with it, which means the system will be connected with one operator at once. As we are dealing with the micro controllers, the reaction time of the system with any sort of inputs will be in micro seconds.

The system is protected to its surroundings by the help of the obstacle detection sensors with which it measures the real distance between its own structure and the obstacle around it, and the measurement range for this system is set as 20 centimeter which is not a huge nor the less. Its is calculated based on the system chassis and the motion of the motors connected with the wheels to make a smooth rotation to avoid the smash.

The robotic arm used in the system to lift or grab objects are set to the angle motion of  $1^\circ$  in 15 milli second so that the operation of the motor will not strain too much and the power consumption will be efficient. Along with that the servo operations are fixed to certain values so that it cannot be operated when it reaches the set limit. The set limit for each of the motors are  $0^\circ$  to  $45^\circ$ ,  $45^\circ$  to  $90^\circ$  and  $90^\circ$  to  $180^\circ$  to the corresponding 3 axis motors.

The speed of the DC motor used in the system for the motion of the robot is 200 RPM, but during the operation of the system the speed of the motors are manipulated to the 50% and lesser especially during the turns and cuts for the high torque purpose which is easy to make the motion of the robot smoother.

Since the system consists of a transmitter and the receiver part, the receiver part should be reset after turning on the transmitter once, to make the communication more comfortable. The total range of all the communication devices involved in the system will be 433MHZ and the distance will be up to 300feet.

The voice recognition module used in the system contains a microphone to take the commands of the users into the transmitter and the suggested distance between the microphone and the mouth should be at least 4 centimeters, so that the receiver in the module will receive commands precisely.

As the main commander of the system is going to be the personal mobile phone. There some set commands to control the robot's motion and some other operations like

grabbing and movement. The mobile application installed in the user's mobile phone will carry a code feeder followed by the keyboard to enter something else. This part is all we needed to key in the commands. The command that we got to feed in is the mode selection initially to switch between the automatic and the manual mode. The manual mode is nothing but the entire operation of the robot will be based on the user's commands. They have to move it to different directions and the movement of the arm including the grabber expect the obstacle detection part which will be detected all the time by default. Next the automatic mode as the name of the command says the entire operation of this kind is going to be automatic, when the commander decides to feed the automatic mode, they have to key in the destination point followed by the mode selection by that the robot will know where it should go and decides the path and reaches the destination. Afterwards it does the arm operation to lift an object with the pre fixed motion and comes back to the home position which is also a fixed point to end the command.

Apart from all these command changes and the feeding details, the robot will give the voice over to let the users and the people around it what is happening and it also creates live surroundings to make it easier.

### **3.4 LOGICAL DATABASE REQUIREMENTS**

As the system only deals with the real world and live environment around, this will be processing the live data around it, so this system does not contain any pre decided data feed into the database. So this system does not need any database required. But there is processing of data involved in many parts of the system mainly in the automatic mode which was mainly on the image processing techniques.

When the automatic mode in the system is selected by the commander at any point will use the camera fit in the front of the system to see the real world and make the processing with the data fed into the system during the creation of the system. There are some of the distance, size of the image along with the width and x, y co ordinates of the image it is seeing will be processed with the real data coming in to the system via camera.

Most of the parts of the system will carry some of the pre defined or data into the firmware to make the comparison so that the system will know what and when to do the things. But all these sorts if information or data given to the system does not mean it involves the logical database.

### **3.5 DESIGN CONSTRAINS**

The design is made completely based on the C programming. The software which is written in any other language will not be supported in this system. The chassis and the physical design of the system is developed in such a way that the weight of the system should also be considered before the development, the weight of the system is already in the maximum level of its capacity so the other components or extra wire added to the system will also count and make the operation worse.

The system should be operated in the range of 300 meters because of the wireless communication devices installed in the system.

The voice commands given by the robot back is played using a micro SD card and the memory of the card is 2GB. The speed of the processor or the response time of the system will be in micro seconds.

The power of the entire system comes from two parts, one is for the processor and all the sensors and modules that needs the 5V supply and the other one is the main source for the DC motor for the motion, the arm movement, the audio amplifier will be supplied 12V and the 6V from the 12V source using a 12V to 6V DC to DC buck converter. For these supplies the portable power bank is used which is of 5V and 10Am and for the main source a 12V 3Am batteries are used correspondingly. The good thing in this battery is both are rechargeable so that it can be charged then and there frequently whenever needed.

Only one command will be passed to the system at a time and only one device is allowed for the system to communicate with and the commands can be given by one person only.

The grabbing power of the robotic arm included in the system will be of a paper weight because of the power used in the system and the motor specification along with the budget of the project brings to the constrain of the paper weight for the grabber of the robotic arm.

Because of the physical design and structure of the system along with the motor installment and the chassis power of the system, the system may be made to move freely in the front, back, left. The right motion of the system struggles a lot to make a smooth operation because the DC motor to move the system is not placed both on the back either side of the system. Instead one is placed on the front and the other is placed on the back, which results in bad right motion.

But for this application, we will not be concentrating more on the right turn, so all these constrains are totally fine for the prototyping. But is not okay for the commercial purpose.

### 3.6 SOFTWARE SYSTEM ATTRIBUTES

Since the total weight of the system will be light and carriable, the system is mainly focused on the portability with some constrains and it was made possible. It can be carried to any place with some extra fittings and could be made run at any place.

The system itself prevents it from the external offenses so that we could say that the system contains the security for the system itself by obeying Isaac Asimov laws.

The system only needs the power which can be recharged on the go, so it is less maintenance device with one demands that the motors used in the system for the motion of the system and the arm of the robot will be under a special care because there will be some wear and tear for the motors since it's a mechanical device. It should be changed at certain point but not frequently.

There is nothing else in the user's side to install separately as everything in the robot will be installed at the time of purchase with the clear instructions for the installation. So, it is highly installable.

As the application section says the detail usage of the system, it is a highly usable product in the real world. It creates a big revolution in the technology market as it has many competitors and the user's as well.

It is also developed in such a way that it is easy to read through for all level knowledge people. When the code written for the development of the system is been read by some one will easily understand the concept and gets a good clarity of the concepts and the system.

These are the main software system attributes.



## 4. USE CASES

### OBSTACLE DETECTION

Actors: Robot, Obstacle in the real world

Description: This section tells the structure of obstacle detection

Frequency: This case will be triggered all the time whenever the system is on.

Main Course: When the obstacle is detected, it stops and gives voice command and tries to make the robot escape from the obstacle by making a left turn and continue the operation.

Alternative Course: When none of the obstacle is detected, the system should continue its user's command performance and repeat the same when it meets any obstacle.

Extension: The obstacle measurement can be improved by replacing the module.

### MANUAL OPERATION

Actors: Robot, Commander to send some commands to the system to react.

Description: Depending on the inputs given to the system by the user the system will react to it by performing some motion and movement.

Frequency: This part will happen whenever the mode is switched to the manual operation mode.

Main Course: This is a reaction to the inputs type part, where the system will move front if the user says so. And movements depending on the given commands.

Alternative Course: If this mode is not selected and or nothing given even after selecting this mode, nothing will happen to the system. The system waits for the commander to get the commands or performs the previous action of the operation.

### AUTOMATIC OPERATION

Actors: Robot, Commander and real objects to the system to react.

Description: Depending on the input data received to the system by the sensors and camera the system will react to it by performing some motion and movement.

Frequency: This part will happen whenever the mode is switched to the autonomous operation mode.

Main Course: This is a reaction to the inputs type part, where the system will move front if the system sees particular objects through the camera with some specifications in the frame of it. Depending on the data processed and set with some hard values, the system will react to reach the destination point.

Alternative Course: If the system reads some bogus data, it will also react to it to reach to the destination point as it will work on the trial and error method.

Extension: High resolution cameras can be used for the better image processing.

## VOICE COMMANDS

Actors: Robot, Commander, transmitter, receiver, micro phone and the speaker.

Description: When the input command is said into the microphone connected with the transmitter, the command will be received in the robot and speech will be sounded in the speaker.

Frequency: This process will happen whenever the speech command is sounded in the microphone.

Main Course: When the command is given into the microphone by the commander, the system will transmit the data into the transmitter and the receiver attached with the speaker on the robot will react to it by performing some motion or voice back in the speaker.

Alternative Course: When none of the command is given to the system, no reaction will happen to the system till that time the system will respond to its previous commands.

Extensions: High memory voice recognizers can be used to store more commands or there should be some facility to connect to the network to recognize the voice using the google and process the audio from the users.

## 5. APPENDICES

The supporting document of this system or the inspiration of the system is based on the document which was published in the International Journal of Research in Advanced Technology IJORAT (ISSN Online – 2456-2769) Vol 2, Issue 5, May 2017. That was the inspiration of this system, all the reference and some of the concept of the system was taken from the journal paper which was published in the year of 2017. And all the concepts and the usage of the documents were referenced with the proper notations.