

## Designing of Service Robot for Home Automation - Implementation

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*Abstract— "Home Automation" industry is growing rapidly. Home Automation is a way to have things around your home happen automatically. The first thing that comes to mind when folks think of home automation are robots, flashing lights, complicated electronics and a general feeling that their home is less of a warm home and more of a cold science experiment. Home automation systems must comply with the household standards and convenience of usage. The term 'Home Automation' today applies to the next level of automating home electronics. The home automation system is intended to control all lights and electrical appliances in a home or office using voice commands.*

*A Robot is a reprogrammable, multi-functional manipulator designed to move material, parts, tools, or a specialized devices through variable programmed motions for the performance of variety of tasks. In order to make a robot do anything it has to have a program or a set of programs that tell it to do certain tasks. Robots come in all different shapes and sizes. Some robots have been used to try and look and behave physically like a human being. Other robots are used for home entertainments. In this paper, many appliances of Home are followed and automated by Service Robot.*

**Keywords— Service Robot, Home Automation, ZigBee, EasyVR, AVR AT Mega 16.**

### I. HOME AUTOMATION

Home automation is a method of controlling home appliances automatically for the convenience of users. This technology makes life easier for the user, and saves energy by utilizing devices according to strict requirements. Controls can be as basic as dimming lights with a remote or as complex as setting up a network of items in the home that can be programmed using a main controller or even via cell phone from anywhere in the world.

A home automation system can involve switching off electrical appliances like air-conditioners or refrigerators when a desired temperature has been reached, then switching on again when the temperature has crossed a certain value. A home automation system can also be used to secure a house from burglars by sending alerts to the nearest police station and the homeowner in case a trespasser is sensed.

Apart from algorithmic automation, devices can be controlled by the user to suit personal requirements using direct buttons, cell phones, the internet, or infrared remotes. A network of

appliances and sensors can interact with each other and make decisions for operation.

The different Tasks of Home Automations are as follows :

#### 1. HVAC

Heating, Ventilation and Air Conditioning (HVAC) solutions include temperature and humidity control. This is generally one of the most important aspects to a homeowner. An Internet-controlled thermostat, for example, can both save money and help the environment, by allowing the homeowner to control the building's heating and air conditioning systems remotely [7].

#### 2. Lighting

Lighting control systems can be used to control household electric lights in a variety of ways: [7].

- Extinguish all the lights of the house
- Replace manual switching with Automation of on and off signals for any or all lights
- Regulation of electric illumination levels according to the level of ambient light available
- Change the ambient color of lighting via control of LEDs or electronic dimmers.

#### 3. Audio

This category includes audio switching and distribution. Audio switching determines the selection of an audio source. Audio distribution allows an audio source to be heard in one or more rooms. This feature is often referred to as 'multi-zone' audio [7].

#### 4. Video

This includes video switching and distribution, allowing a video source to be viewed on multiple TVs. This feature is often referred to as 'multi-zone' video. Integration of the intercom to the telephone or of the video door entry system to the television set, allowing the residents to view the door camera automatically [7].

#### 5. Security

With Home Automation, the consumer can select and watch cameras live from an Internet source to their home or business. Security cameras can be controlled, allowing the user to observe activity around a house or business right from a Monitor or touch panel. Security systems can include motion sensors that will detect any kind of unauthorized movement and notify the user through the security system or via cell phone [7].

6. Intercoms

An intercom system allows communication via a microphone and speakers between multiple rooms [7].

- Ubiquity in the external control as much as internal, remote control from the Internet, PC, wireless controls (e.g. PDA with Wi-Fi), electrical equipment.
- Transmission of alarms.
- Intercommunications.

II. ROBOT

A robot can be defined as a programmable, self-controlled device consisting of electronic, electrical, or mechanical units. Robots are especially desirable for certain work functions because, unlike humans, they never get tired; they can endure physical conditions that are uncomfortable or even dangerous; they can operate in airless conditions; they do not get bored by repetition; and they cannot be distracted from the task at hand.

**A robot can include any of the following components:**

- effectors - "arms", "legs", "hands", "feet"
- sensors - parts that act like senses and can detect objects or things like heat and light and convert the object information into symbols that computers understand
- computer - the brain that contains instructions called algorithms to control the robot
- equipment - this includes tools and mechanical fixtures

The different Types of Robots are as follows :

1. Industrial Robots

Industrial robots are robots used in an industrial manufacturing environment. Usually these are articulated arms specifically developed for such applications as welding, material handling, painting and others. If we judge purely by application this type could also include some automated guided vehicles and other robots.

2. Domestic or Household Robots

Robots used at home. This type of robots includes many quite different devices such as robotic vacuum cleaners, robotic pool cleaners, sweepers, gutter cleaners and other robots that can do different chores. Also, some surveillance and telepresence robots could be regarded as household robots if used in that environment.

3. Medical Robots

Robots used in medicine and medical institutions. First and foremost - surgery robots. Also, some automated guided vehicles and maybe lifting aides.

4. Service Robots

Robots that don't fall into other types by usage. These could be different data gathering robots, robots made to show off technologies, robots used for research etc. Service Robot is also called as Line Follower Robot.

5. Military Robots

Robots used in military. This type of robots includes bomb disposal robots, different transportation robots, reconnaissance drones. Often robots initially created for military purposes can be used in law enforcement, search and rescue and other related fields.

6. Entertainment Robots

These are robots used for entertainment. This is a very broad category. It starts with toy robots such as the running alarm clock and ends with real heavyweights such as articulated robot arms used as motion simulators.

7. Space Robots

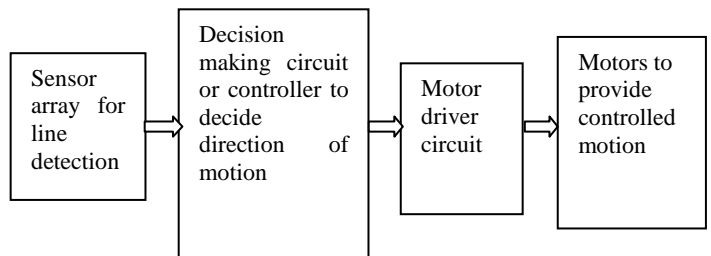
I'd like to single out robots used in space as a separate type. This type would include robots used on the International Space Station, Canadarm that was used in Shuttles, as well as Mars rovers and other robots used in space.

8. Hobby and competition Robots

Robots that you create. Line followers, sumo-bots, robots made just for fun and robots made for competition.

III. SERVICE ROBOT

Service Robot is also called as Line Follower Robot. Let us see how the Line Follower Robot works. First see the block diagrams.



**Fig 1 : Service Robot - Block Diagram**

An array of sensor is used to detect the line. Based on the status of sensors, special circuit or controller decides the position of line and also the required direction of motion required to follow the line. Motor driver circuit is used to ON/OFF the LEFT/RIGHT motors of the robot to provide desired motion.

i Sensors

Sensors are required to detect position of the line to be followed with respect to the robot's position. Most widely used sensors for the Line Follower robot are PHOTSENSORS. They are based on the base observation that "the white surface reflects the light and black surface absorbs it". Sensor circuit contains emitter , detector and comparator assembly.

IR or VISIBLE light is emitted from the emitter. This emitted light strikes the surface and gets reflected back. If the

surface is white, more intensity of light gets reflected and for black surface very less intensity of light is reflected. Photo detector is used to detect the intensity of light reflected. The corresponding analog voltage is induced based on the intensity of reflected light. This voltage is compared with the fixed reference voltage comparator circuit and hence it is converted into logic 0 or logic 1 which can be used by the controller.

The comparator circuit may be designed in two ways.

Case-1

Black area = 1

White area = 0

Case-2

Black area = 0

White area = 1

Here, Case - 1 is used.

### 3.1 Service Robot Applications

Menu driven systems such as e-mail readers, household appliances like washing machines, microwave ovens, and pagers and mobiles etc. will become voice controlled in future.

- The robot is useful in places where humans find difficult to reach but human voice reaches. E.g. in a small pipeline, in a fire-situations, in highly toxic areas.
- The robot can be used as a toy.
- It can be used to bring and place small objects.
- It is the one of the important stage of Humanoid robots.
- Command and control of appliances and equipment
- Telephone assistance systems
- Data entry
- Speech and voice recognition security systems
- Clear-Up the Kitchen Table - All objects on top the kitchen table will be moved to where they belong.
- Fill the Dish Washer - The dirty dishes will be sorted correctly into the dish washer.
- Clear-Up this room - All objects that are not at their place will be moved to where they belong.

## IV. LITERATURE REVIEW

Many researchers have expressed their views and technical parameters which have been proved useful for development of Home Automation and Service Robot.

A study made by Gomez C, Paradells J [1] surveys the different architectures and technologies used in Wireless Home Automation Networks. Wireless home automation networks comprise wireless embedded sensors and actuators

that enable monitoring and control applications for home user comfort and efficient home management. This article surveys the main current and emerging solutions that are suitable for WHANs, including ZigBee, INSTEON, Z-Wave, and IP-based technology.

Ali Ziya Alkar, John Roach, Dilek Baysal [2] presents an IP Based Home Automation System in which designed a low cost hardware/software framework based on a unit IPAcBox which allows home/industrial automation systems to be accessed and controlled through a direct internet connection right out of the box even in dynamic IP configurations.

Fei Lu, Guohui Tian\*, Fengyu Zhou, Yinghua Xue, Baoye Song [3] also presents Building an Intelligent Home Space for Service Robot Based on Multi-Pattern Information Model and Wireless Sensor Networks which concerned with constructing a prototype intelligent home environment for home service robot. In that environment, multi-pattern information can be represented by some intelligent artificial marks. Light-packs service robots can provide reliable and intelligent service by interacting with the environment through the wireless sensor networks.

Wang Huiyong, Wang Jingyang, Huang Min [4] presents an Building a Smart Home System with WSN and Service Robot where they described the architecture and implementation of a smart environment with WSN and service robot, in which the home server acts as an intelligent collaborator between our mobile service robot and the environment. To demonstrate the practicability of a WSN and service robot assisted smart home environment, they came up with devices required to provide reliable services, developed them, and implemented software for management and control.

M. S. Islam & M. A. Rahman [5] presents a paper on Design and Fabrication of Line Follower Robot in which they described about designing and fabrication of a Line Follower Robot.

Vaishali Wagh, Prof. Manisha Wasnik [6] presents a paper on Different Technologies Used in Home Automation - A Review and Comparison in which they covered the review of different Technologies which strongly support the Home Automation systems in Reliable way.

## V. SYSTEM ARCHITECTURE

This project comprises of two sub-parts. The front end involves designing an Embedded C application to communicate with remote microcontrollers ARM7. The back end involves building a network of microcontroller based prototypes to emulate devices used at residential locations for the purpose of Home Automation such as temperature sensors, motors, occupancy (proximity) sensors, lighting control etc. Micro-Controllers communicate with Service Robot via

ZigBee-a low power ,low cost wireless communication protocol.

The architecture of the system is depicted in following figures. Five main blocks are involved: The Server, ZigBee Module, Smart Devices, Easy VR Module, and the Service Robot. The home server is the information center and the control center of the whole smart home system. It provides means to store information, monitor the smart devices, send tasks of the user, prepare plans in a centralized way, and monitor the tasks execution by the service robot.

The Service Robot used in this project is also called as Voice Controlled Robot (VCR) whose motions can be controlled by the user by giving specific voice commands. After processing the speech, the necessary motion instructions are given to Robot via ZigBee Module.

5.1 Voice Node

The master unit part is developed using ARM7 LPC2138 development board is as shown in Fig. The LPC2138 microcontrollers are based on a 16/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support.

EasyVR is a multi-purpose speech recognition module designed to add versatile, robust and cost effective speech and voice recognition capabilities to virtually any application. EasyVR is the second generation version of the successful VRbot module and builds on the features and functionality of its predecessor. Along with features like 32 user-defined Speaker Dependent (SD) triggers and a host of built-in speaker independent (SI) commands, the EasyVR adds convenient features such as firmware update capability, 8ohm speaker output and additional SI languages.

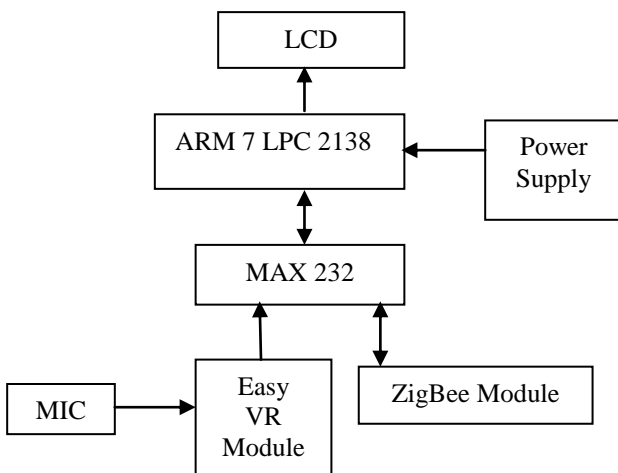


Fig 2 : Voice Node

ZigBee technology works on low data rate. ZigBee provides low cost and low power connectivity for equipment that needs battery life as long as several months to several years but does not require data transfer rates as high as by Bluetooth. ZigBee

can be implement in mesh networks larger than is possible with Bluetooth. ZigBee compliant wireless devices are expected to transmit 10-75 meters, depending on the RF environment and the power output consumption required for a given application.

The Voice Node Flowchart is as shown in following fig.

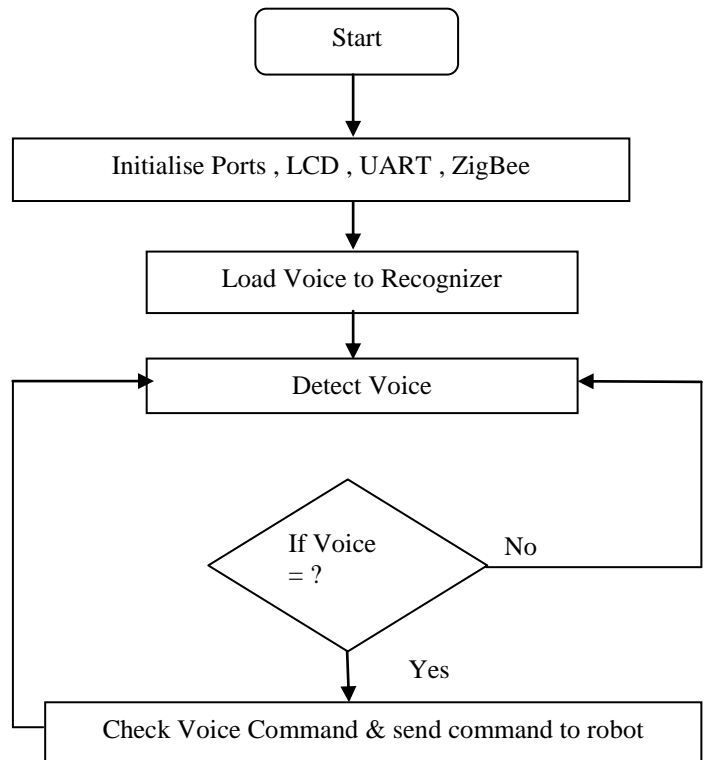


Fig 3 : Voice Node - Flowchart

As per above master unit flowchart it is observed that how the master unit initiates and executes the Voice command. When voice command initiates from speaker’s mouth i.e. turn light On/off, Turn the television on/off, Turn the Fridge on/off etc. then accordingly Master unit gets activated and initialize Easy VR Module.

After EasyVR module initialization the ZigBee network initialized. ZigBee is based on an IEEE 802.15 standard. Its low power consumption limits transmission distances to 10–100 meters. ZigBee devices can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. Also command displays on LCD display which is interfaced with ZigBee network and EasyVR module.

When initialized of EasyVR module and ZigBee network then Activates the voice module, voice recognition is an important asset for a robot, increasing its ability to interact with human beings and above all using their most natural form of communication. With this module, we are controlling service robot by voice. The module recognizes human voice. It receives configuration commands for the respective object but if fails to receive command then again module tries to

recognize the exact human voice and then receives the correct command for the respective object and accordingly send object ID to the respective object through ZigBee network.

5.2 Smart Device ( End ) Node

The Application Node ( Smart Device ) which can be any home appliance like Freeze,TV,Washing Machine etc is as shown in fig 5.8. The AT Mega 16 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the AT Mega 16 achieves throughputs approaching 1 MIPS per MHz and to optimize power consumption versus processing speed. The AT Mega 16 AVR is supported program & system development tools, including C compiler, macro assemblers.

MAX232 is an IC that operates on single 5V supply and it is integrated with two drivers and two receivers. All receivers can be used to convert RS232 levels to TTL/CMOS levels and all drivers can be used to convert TTL/CMOS level inputs to RS232 levels.

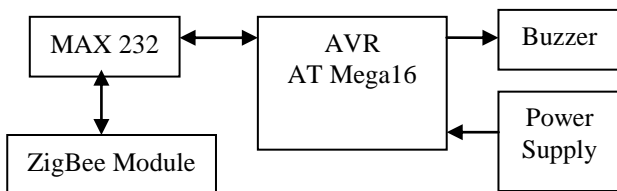


Fig 4 : Smart Device ( End ) Node

The Flowchart for Smart Device ( End ) Node is as shown in fig 5.11.

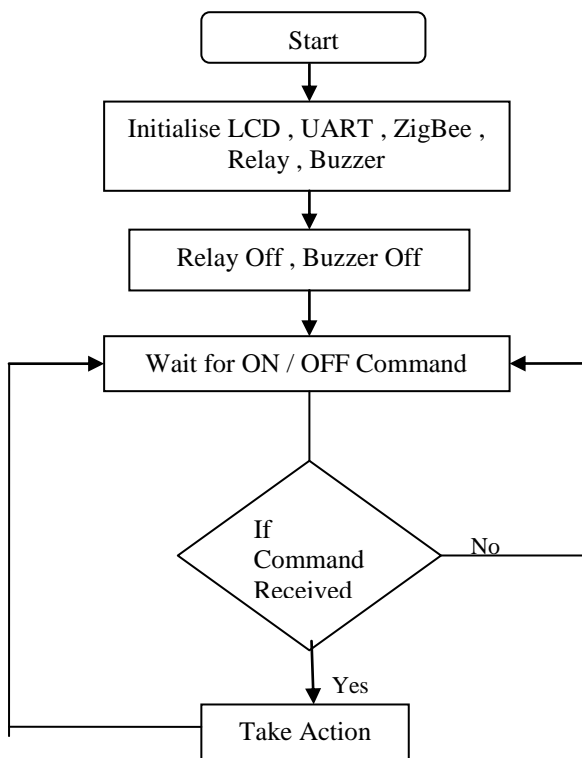


Fig 5 : Flowchart - Smart Device ( End ) Node

The appliance node unit module initialized once the EasyVR module recognition done. The LCD display initializes with ZigBee network and send location request to the respective object ID and accordingly the object wake up from sleep mode and send his location information on ZigBee network and once the information received to the ZigBee network it goes to sleep mode again.

5.3 Service Robot Node

Service robots assist human beings, typically by performing a job that is light On/off; Turn the television on/off, Turn the Fridge on/off etc. And which is operated by a built-in control system .A service robot is a robot which operates semi- or fully autonomously to perform services useful to the well-being of humans and equipment, excluding manufacturing operations. A DC Motor is a device that converts direct current (electrical energy) into mechanical energy.The Architecture of Robot is as shown in fig 5.12.

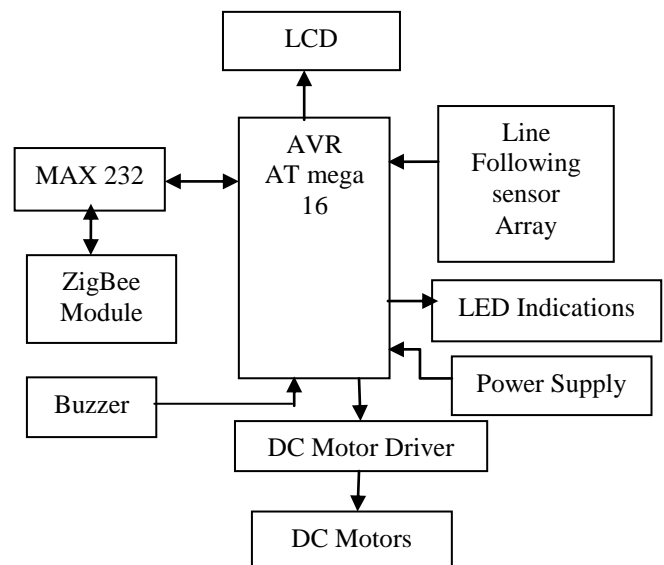


Fig 6 : Service Robot Node

As per above robot unit flowchart it is clearly observed that how the robot act and executes the received Voice command. When command received on the ZigBee network the service robot unit initialize the DC motor which moves the robot forward, backward, left & right. Initialize ID sensor which detect the object ID location and initialize ZigBee network.

Once the appliance location and object ID received from ZigBee network, the robot starts to calculate the path using line following. Line follower is a machine that can follow a path. The path can be visible like a black line on a white surface (or vice-versa) or it can be invisible like a magnetic field. Line follower build for Sensing a line and maneuvering (move skilfully or carefully) the robot to stay on course, while constantly correcting wrong moves using feedback mechanism forms a simple yet effective closed loop system.

If robot finds any obstacle in between the path then again robot starts to calculate the path using line following and once reached the destination, execute the command with respective object ID command.

The Flowchart for Service Robot Node is as shown in Fig 7.

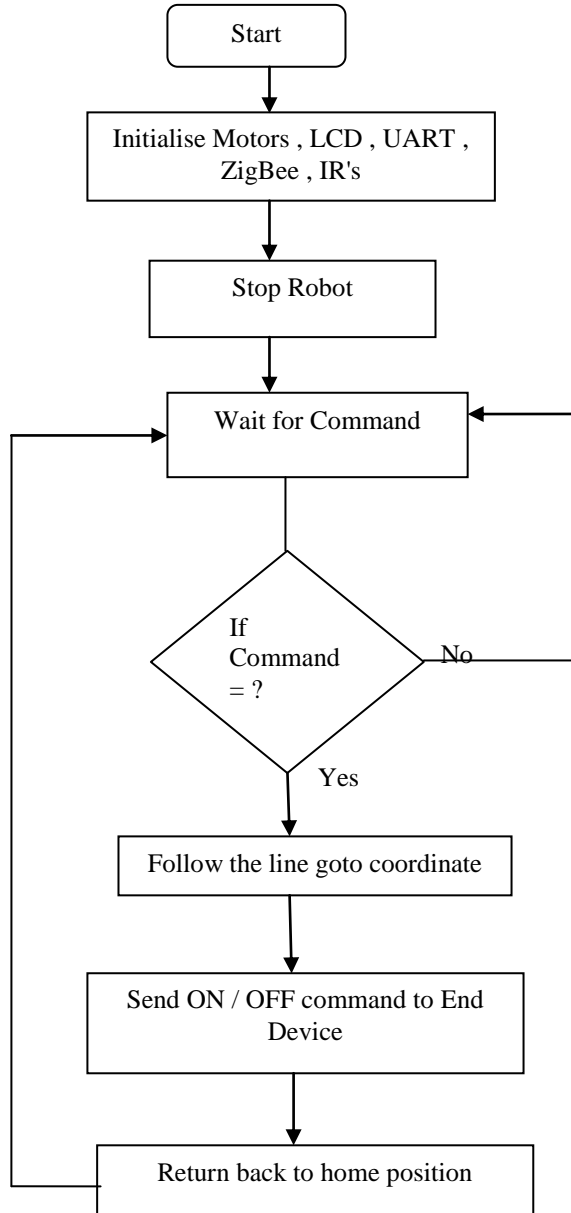


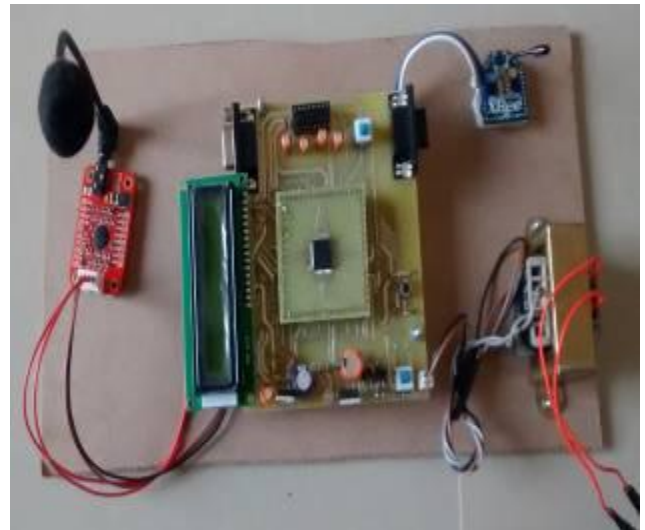
Fig 8 : Flowchart - Service Robot Node

## VI. HARDWARE IMPLEMENTATION

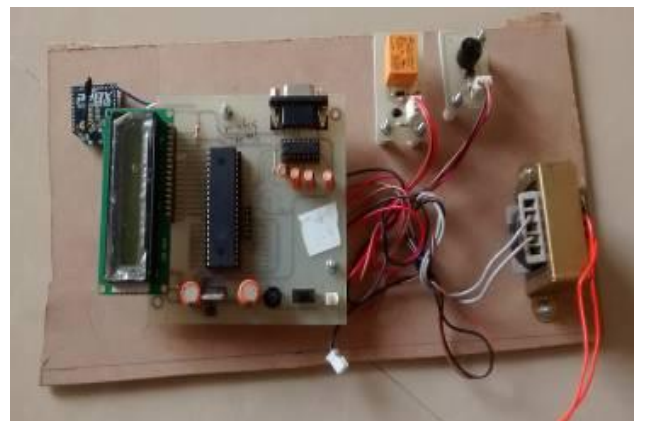
### 1. Service Robot Node



### 2. Voice Node



### 3. Smart Device ( End ) Node



## VI. SOFTWARE USED

- ARM7LPC2138 – Embedded C – Keil Compiler
- AVR AT Mega 16 – Embedded C – AVR Studio

## VII. RESULT

In Voice Node Module the EasyVR Voice Recognition Module is activated and if voice is matched then Object (Appliance ) ID will be sent to ZigBee.

In Service Robot Module the Robot will run over a white surface which has an arbitrary path drawn over it by using black paint. The task of the robot is to run exactly along this painted path. Robot recognises the ID of different home appliances from ZigBee Network and then according to voice command i.e. EasyVR Module the robot will reach at different appliances (destinations) and if any obstacle will found in between then Robot calculate the path again.

The appliance node unit ( Smart Device ) module initialized once the EasyVR module recognition done. The LCD display initializes with ZigBee network and send location request to the respective object ID and accordingly the object wake up from sleep mode and send his location information on ZigBee network and once the information received to the ZigBee network it goes to sleep mode again.

## VII.CONCLUSION

In this Project Work I have described about the Designing of Service Robot for Home Automation with ZigBee & ARM7LPC2138 , in which the home server acts as an intelligent collaborator between Service Robot and the environment. To demonstrate the practicability of a ZigBee and Service Robot assisted smart home environment, came up with devices required to provide reliable services, developed them, and implemented algorithm accordingly for management and control.

The goal of this project is to show the usability of the service robots in our daily lives by constructing the smart environment for the service robots. This attempt is expected to enable humans to focus on the important tasks by liberating ourselves from unpleasant daily chores with the help of Service Robots.

## VIII.FUTURE SCOPE

In this project, Designing of Service Robot for Home Automation is introduced. With the interaction with the intelligent space, service robot can obtain more comprehensive environmental information without adding more sensors on service robot. In the intelligent space, robot can work with “light packs” and the service quality can be improved. Future work will entail :

- The optimization set of the artificial land marks.

- In additional, the algorithm of data fusion is an important research topic to improve the accuracy of decision-making.
- Future work will focus on improvement of above proposed work and adding features to make a reliable smart home system.
- To make Home Network more secure , Thumb print can be used instead of EasyVR Voice Module.
- The system can be secured for access from outside through as SSL algorithm protected server where the users are expected to acquire login and password to access to the site.
- An RFID-based localization scheme for mobile robots can be used which uses ultrasonic sensors.
- Intelligent robot motion control system can be done with Image Recognition for Home Automation.
- The System can be done specially for elderly and disabled people.
- Integration of GSM or Mobile server to operate from a distance.
- Design and integration of an online home control panel.
- In this work , many devices can be added as we want to control.

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