NFC INSTITUTE OF ENGINEERING & FERTILIZER RESEARCH
NFC-IEFR Journal of Engineering and Scientific Research
(NIJESR)
http://nijesr.com/
E-mail: editor.jesr@iefr.edu.pk

Speech Recognition Based Home Automation System using Raspberry Pi and Zigbee

Saad Ali Younis[1], Umer Ijaz[2*], Ijaz Ahmad Randhawa[3], Abubaker Ijaz[1]

[1]*School of Electronic & Electrical Engineering, University of Leeds, Leeds, United Kingdom*
[2]*Department of Electrical Engineering, Government College University, Faisalabad, Pakistan*
[3]*Department of Agricultural Engineering, University of Agriculture Faisalabad, Pakistan*

ARTICLE INFO

***Corresponding Author:**
drui.nfc@gmail.com
DOI:
10.24081/nijesr.2017.2.0008

Keywords:
Speech Recognition, Home Automation System, Raspberry Pi, Zigbee

ABSTRACT

In this era, there is a great revolution in the home automation industry. Considerable development in speech recognition software and wireless communication modules has given home automation a new edge. This system is very helpful for medical patients, disabled and elder people, especially those who live all alone without any helping hand. The home automation system is separated in two major sections, base station and remote station. The base station and remote station are wirelessly connected through low powered RF ZIGBEE wireless communication module, which is an IEEE 802.15.4 standard. For speech recognition purposes, one of the finest credit card sized computers, Raspberry pi, is used within the base station. All along with this a simple microcontroller is used to control the switching of electrical appliances and lights of home within remote station, which works according to the command generated from base station. The aim of this paper work is to design a speech recognition based home automation system which is most efficient, user friendly, low in cost, compact in size, easy to install and latest in technology.

I. Introduction

Speech Recognition based Home Automation System is designed to ease the life of aged and immobilized people. With a user friendly home automation system that is totally based on speech commands and wireless communication, all the electrical appliances can be controlled from any point of home [1]. The system can be designed according to the users' demands which is easy to set up, organize, run, retain, low in cost and is mobile within the range of the wireless device [1].

A usual home automation system enables the user to manage all the electrical appliances of home from a centralized control unit, which is interfaced with a wireless module [1]. All the appliances that are being controlled from a centralized control unit have to be designed in such a way that they are compatible with each other [1].

The project proposed demonstrates a system design that is divided into two system units; a base station unit and a remote station unit. All the speech recognition process will be done in the base station, which is integrated as a single moveable unit and will issue a control command to the remote station through a wireless module [1]. This would enable the automation of different home appliances [2] such as lights, fans, televisions, security cameras, water motor, computers, audio sets etc. Sensors are placed for knowing status that either the appliances are on or off. The overall system is based on two major devices, which are Raspberry Pi and Zigbee Wireless module [3]. The speech is made through a microphone, which is processed in Raspberry Pi by using a speech recognition software and relevant controlling command are generated in binary sequence. These Binary sequences are sent to the other microcontroller placed in remote station through Zigbee and regarding appliance is turned on or off. This system provides a cost effective solution for speech recognition based home automation compared to previous technologies used for the said purpose. Moreover, it uses Raspberry Pi, which is easily programmable chip and can be integrated with any wireless technology with ease. The Zigbee wireless technology used provide the said data rate at reasonable distances, which is ideal for this purpose.

II. Speech Recognition

Speech recognition is a technology, which converts the human speech into Text. Speech recognition is also identified as Automatic Speech Recognition (ASR) [4]. The research behind speech recognition techniques and software's is not the story of this era but it has been more than 40 years. Speech recognition software's are used to interact with computers and machines to provide and execute commands. After the advent of Siri and Google Software Recognition API, there has been tremendous development in Speech Recognition technology. However, it should be noted that the initial attempts at speech recognition were hardware-based whereas all of the aforementioned modern techniques use a software-based

NFC INSTITUTE OF ENGINEERING & FERTILIZER RESEARCH
NFC-IEFR Journal of Engineering and Scientific Research
(NIJESR)
http://nijesr.com/
E-mail: editor.jesr@iefr.edu.pk

approach [4].

A. Methodology behind Speech Recognition

The speech recognition process takes place in four steps, which is shown in Figure 1.

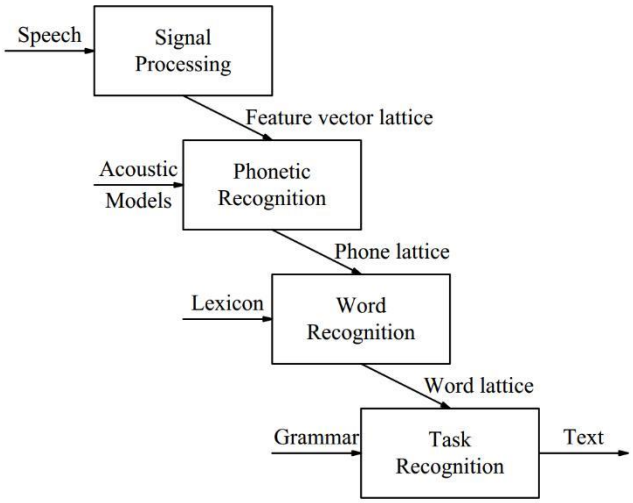

Figure 1: Speech Recognition Process [5]

The user speaks the first step after the speech; which is processed into feature vectors. In this step speech signal is broken into smaller blocks and acoustic information of the original sound is kept. Every sound has a specific pattern and is represented with a sound wave; this pattern information is the acoustic information [4]. Feature Vector represents this acoustic information.

Right after that feature vector is interpreted with acoustic model. Acoustic Property of each individual sound is present in acoustic model and phonetic representation of that particular sound [4]. In this step the lattice of the feature vector is mapped by using acoustic model that is correspondent to phonetic representation [4].

In the third step word is recognized that has been generated by phonetic lattice, which is corresponding to the phonetic combinations [4]. For this purpose lexicon dictionary is used. The output of this step is the corresponding word lattice.

In the final step the word lattice is processed and grammar is checked. After that final text is represented.

III. System Design Overview

The system design is divided into two major stations, which are [1]:

I. Base Station

II. Remote Station

A. Base Station

The base station is the station where all the speech will be recognized and the controlling codes will be issued to remote station. The microphone is used to receive speech input, which will be transferred to the Raspberry Pi. The Raspberry Pi will process the audio signal with the help of speech recognition software. It will then check that the current speech is correct or not. If it is correct it will automate the appliance according to the speech command else it will display an error and will request to give command again. For Displaying purpose a LCD is interfaced with the Raspberry Pi which not only indicates that the speech command is accepted or rejected but also the status of the appliance that is being turned on or off with the speech command. The status check is more useful for troubleshooting. At the UART port of Raspberry Pi, Zigbee is interfaced which sends the controlling codes to the Remote Station as well as receives the input of the sensors, which is processed in Raspberry Pi, and display either the appliance is activated or de-activated.

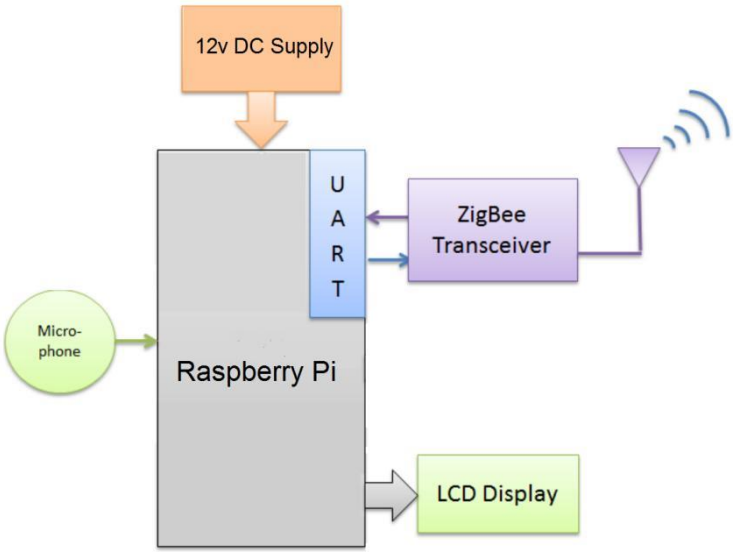

Figure 2: Base Station Block Diagram [1]

NFC INSTITUTE OF ENGINEERING & FERTILIZER RESEARCH
NFC-IEFR Journal of Engineering and Scientific Research
(NIJESR)
http://nijesr.com/
E-mail: editor.jesr@iefr.edu.pk

The 12 Volts DC power supply is given directly to Raspberry Pi, apart from this Zigbee is operated at 3.3 Volts ad LCD Display at 5 Volts. These voltages are supplied directly from Raspberry Pi.

B. Remote Station

The remote station is the station where all the automation of the electric appliances is controlled. But the control commands are received digital code from the base station. The digital signal at the remote station is received through Zigbee, which is interfaced with microcontroller at UART port. On the basis of the digital command received from the base station, will help in determining the microcontroller to either turn on and off the appliance as well as of which room. The sensors placed will help in determining the status of the appliance that has been automated by updating the both the LCD's.

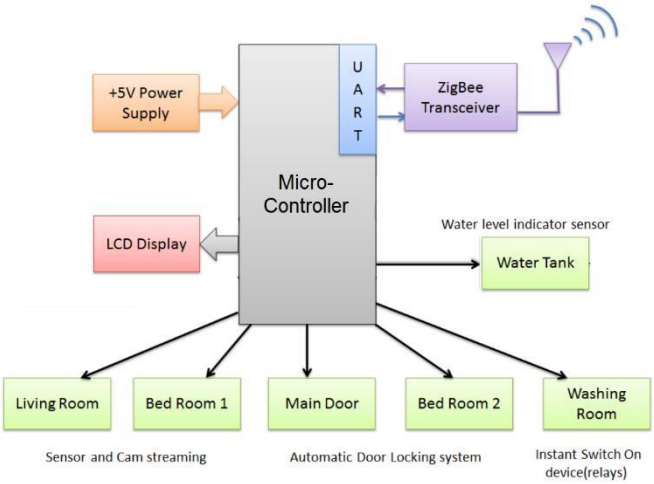

Figure 3: Remote Station Block Diagram [1]

IV. Raspberry Pi

Raspberry Pi has brought innovation in the field of embedded system. This credit card sized computer can be plugged into any monitor, TV or any LCD screen [6]. It is able of doing everything that a desktop computer does. It requires 12 Volts power supply and standard mouse and keyboard is used. In this proposed design raspberry pi is used as speech recognizer. For this purpose many software's are introduced in Raspberry Pi provides both online and offline mode for speech recognizing. But the most suitable tool is Sphinx-4 for speech recognition purpose [7]. There are certain models introduced for Raspberry Pi but for the proposed design above Raspberry Pi Model B is suitable by keeping present and future aspects and changes in mind.

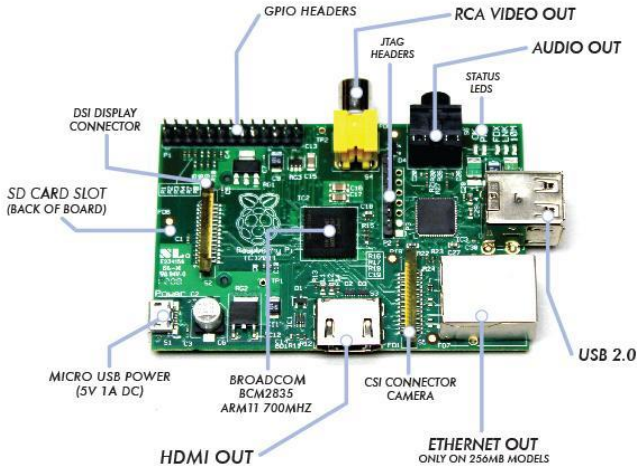

Figure 4: Raspberry Pi Model B Labeled Diagram [6]

Table 1: Raspberry Pi Model B Specifications [6]

Parameter	Description
Operating System	Linux
Chip	Broadcom BCM2835 SoC
CPU	700 MHz Low Power ARM1176JZ-F
GPU	Dual Core Video Core IV, Multimedia Coprocessor
Memory	512 MB
Ethernet	10/100 Ethernet RJ45 jack
USB 2.0	Dual USB port
Video Output	HDMI or Composite RCA
Audio Output	HDMI or 3.5mm jack
Onboard Storage	Depend upon SD card
Dimensions	8.6cm * 5.4 cm * 1.7cm

A. Sphinx-4 Speech Recognition

Sphinx-4 is considered to be the one of the best tools for the speech recognition purpose on Raspberry Pi. It provides an offline mode facility for speech recognition purposes. The Framework behind the speech recognition process of Sphinx-4 is shown in Figure 5.

NFC INSTITUTE OF ENGINEERING & FERTILIZER RESEARCH
NFC-IEFR Journal of Engineering and Scientific Research
(NIJESR)
http://nijesr.com/
E-mail: editor.jesr@iefr.edu.pk

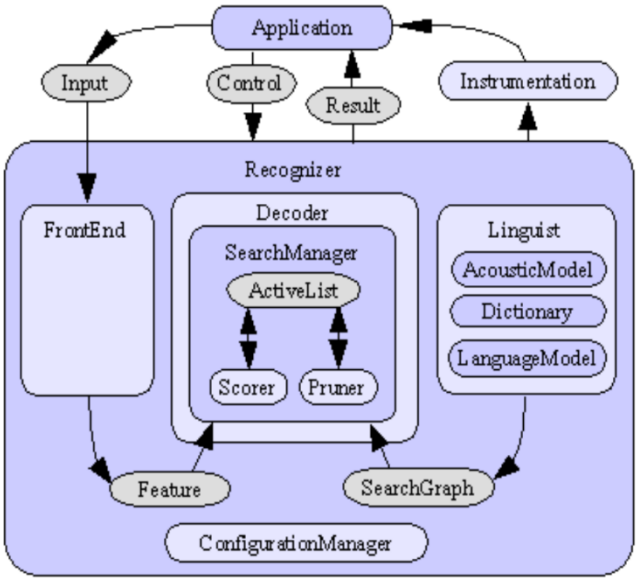

Figure 5: Sphinx-4 Speech to Text Decoder Framework [9]

V. ZIGBEE

The IEEE 802.15.4 protocol standard Low RF (Radio frequency) device Zigbee is used in this design for the wireless communication purpose [10]. The Zigbee module is low in cost, low powered device and easy to interface. Due to its efficient and reliable performance, Zigbee is used in many applications where wireless communication is required.

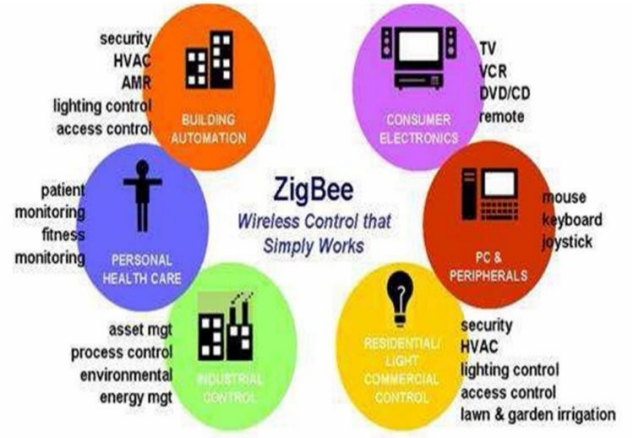

Figure 6: Zigbee Based Applications [9]

The Zigbee has a maximum data rate of 250Kbps for transmitting and receiving the data [10]. The Zigbee is easily interface able with microcontroller and Raspberry Pi at UART port and their source and destination address can be configured by using software named 'X CTU' [10].

Figure 7: XCTU icon [1]

The baud rate can be set through programming as well as it is also configured using X-CTU. It has a maximum baud rate of 115200 bps that can be configured but for the each byte that is transmitted has a start and stop bit [10]. So the actual baud rate is calculated as [10]:

Actual Baud Rate = Configured Baud Rate x 8/10

Zigbee's are classified into four types that can be used depending upon the user requirement. These four types of Zigbee varies in distance of coverage area, apart from this almost all the specs are same and also the pin specification is same.

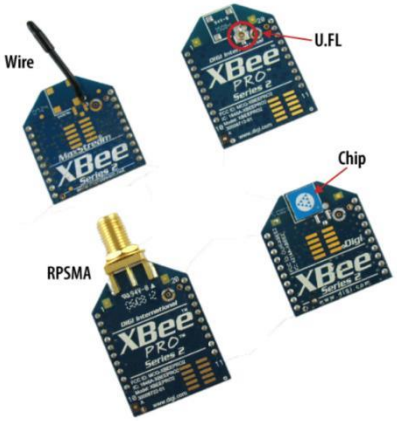

Figure 8: Antenna Types of Zigbee [8]

NFC INSTITUTE OF ENGINEERING & FERTILIZER RESEARCH
NFC-IEFR Journal of Engineering and Scientific Research
(NIJESR)
http://nijesr.com/
E-mail: editor.jesr@iefr.edu.pk

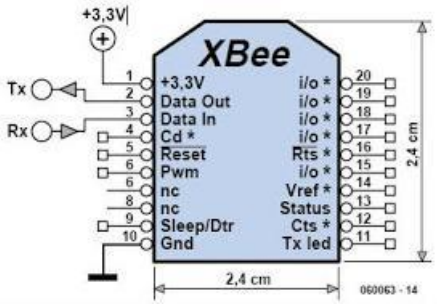

Figure 9: Zigbee General Pin Diagram [1]

There are different ways of developing network for communicating between Zigbee to Zigbee. Either it's between two Zigbee's or the network is between one Zigbee to other through more than one Zigbees which is also called Mesh Network of Zigbee. For the home automation system design, mesh network is suitable as it extends the range as well as mesh network is reliable for such systems.

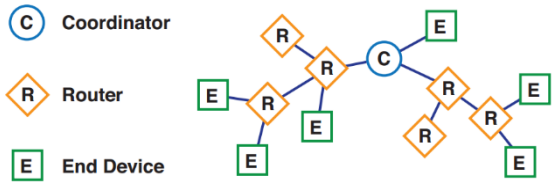

Figure 10: Zigbee Mesh Network [11]

Figure 10 shows the mesh network that can be developed with the help of more than two Zigbee's. There are 3 main nodes in a mesh network. The main is coordinator then its router and at the end the last node is end device [11]. Coordinator is the main node from which data is transmitted where as routers are also the Zigbee device but they can be configured as the Router with the help of software [11]. Configuring the Zigbee with the help of software can set the end node, which represents the end device of the mesh network. Zigbee at coordinator node act as master where as Zigbee at end device act as slave.

In the design proposed, there is one main remote station from where all the connection are carried out so there will be only one Zigbee acting as end device node, one coordinator and number of router can vary.

VI. Future Improvement

The proposed system design is just the beginning of an idea but the future works entail many wide features. Some of them are discussed as follow:

- Adding voice confirmation message after activating or deactivating the appliance.
- Improving software to provide controlling feature for the appliances such as to control speed of fan or control the volume of audio system etc [10].
- Designing of android and IOS app for controlling the appliances through mobile by wireless communication between Bluetooth and Zigbee.
- Designing of online home control panel to provide online automation control.

VII. Conclusion

To conclude, a suitable design is proposed for the home automation system based on speech. With the extensive work in technology, intelligent designs are implementing to make the human life easier. In the same way using all the latest equipment Raspberry Pi and Zigbee, a home automation system is successfully proposed that is low in cost, low power consumption based system, efficient speech recognition and easy to install.

Acknowledgment

The Authors are thankful to Mr. Ameer Haider for his constant support and guidance to conduct this research work.

References

[1] Dhawan S. Thakur and Aditi Sharma; Voice Recognition Wireless Home Automation System Based On Zigbee; IOSR Journal of Electronics and communication Engineering, 2013.

[2] M. Rabiul Alam, Md. Fazlul Kader, Kazi Tanvir Ahmmed, Nur Akter Jahan; A computer control system for home appliances; Global journal of computer science and technology interdisciplinary, Volume 13, Isuue 3, Version 1.0, Year 2013, ISSN: 0975-4172.

[3] Fabio Leccese, Marco Cagnetti, Daniele Trinca; A smart city application: A fully controlled street lightning isle based on raspberry-pi card, a zigbee sensor network and wimax; Sensors, 2014, ISSN: 1424-8220.

[4] Marika Hansson, Emil Johansson, Jacob Lundberg and Markus Otterberg; Voice-operated Home Automation; Chalmers University of Technology, Page 3-5, 2013.

[5] Adam L. Buchsbaum; Algorithmic Aspects in Speech Recognition: An Introduction, 2014; Available: http://adambuchsbaum.com/papers/recog.pdf; Last accessed 19th Feb 2015.

[6] Introduction To Raspberry Pi; Available: http://www.botlanta.org/uploads/pdf/RaspberryPi.pdf; Last accessed 19th Feb 2015.

[7] Prasanna G. and Ramadass N; Low Cost Home Automation Using Offline Speech Recognition; International Journal of Signal Processing Systems, 2014.

[8] Introduction to Zigbee; Available: http://blogspot.tenettech.com/?p=3663; Last accessed 19th Feb 2015.

[9] Sharly Joana Halder, Joon-Goo Park and Wooju Kim; Adaptive Filtering for Indoor Localization using ZIGBEE RSSI and LQI Measurement; Adaptive Filtering Applications, 2011.

[10] S. Benjamin Arul. Wireless Home Automation System Using Zigbee; International Journal of Scientific & Engineering Research, 2014.

[11] Mesh Network. Available: http://www.digi.com/pdf/wp_zigbeevsdigimesh.pdf; Digi. 2014; Last accessed 19th Feb 2015.