The Eurasia Proceedings of Science,
Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 2018

Volume 2, Pages 225-232

ICRES 2018: International Conference on Research in Education and Science

Voice Controlled Home Automation Design

Ahmet VATANSEVER
Trakya University

Hilmi KUSCU
Trakya University

Gurkan TUNA
Trakya University

Abstract: In recent years, in parallel with the advances in technology, home automation systems have started to offer more functions and been more sophisticated. Compared to the past, remotely controllable home automation systems have become much cheaper and are not luxurious anymore; hence more and more people nowadays use home automation systems to make their lives easier. Home automation systems especially play a key role for the elderly and disabled and offer convenient and flexible solutions for them. Since home automation systems allow the elderly and physically disabled to maintain their lives in a comfortable and secure environment, the aim of this study is to design a voice controlled home automation system. To design the proposed home automation system, firstly a prototype home has been built and then some devices have been placed in it. Then, by using a throat microphone, a set of voice commands has been defined in the voice recognition module. The designed home automation system works as follows. Basically the voice recognition module converts voice commands into digital signals, and then these digital signals are transmitted to the home automation system via a ZigBee-based communications module. The receiver of the ZigBee communications module receives the commands given by the transmitter and sends them to the microcontroller. Finally, the microcontroller analyzes the commands and performs the expected operations. Arduino Uno has been used as the microcontroller and EasyVR module has been used for voice recognition. The software of the home automation system has been developed in C using Arduino IDE.

Keywords: Home automation system, Voice recognition, Microcontroller, EasyVR, Arduino

Introduction

The elderly population has increased rapidly as a result of both developments in health services and rise in people's lifespan in Turkey and worldwide. As the elderly lead a long life, they need some help to live happily in their houses. Home automation is one of the major growing and progressing industries thanks to developing technology, which could be helpful for those people. Home automation systems make people's life easier, safer, more comfortable and more economical. Some of the home automation systems serve people who like luxury and sophisticated home automation platforms, on the other hand, others generally target elderly and handicapped people who only need some help. For example, old people or people with special needs who live alone at home may have troubles in using household appliances. Voice command system may help those people to open and close them.

Speech Recognition is a key component of novel home automation solutions. Basically, it is a kind of technology that provides the system to understand the words (not the meanings) given by speech (Bharambe, & Kodgire, 2016). Controlling an electronic device by voice provides both easy use and increase in efficiency and productivity. Voice recognition systems also help users do two or more tasks simultaneously while working on computers or other devices (Bharambe, & Kodgire, 2015).

This study aims to design a home automation system that responds to voice commands and allows controlling the on/off status of electrical devices like lamp, air conditioner, television and door in a house. The system allows controlling various devices using the following commands: “open the door”, “close the door”, “turn on the air conditioner”, turn off the air conditioner”, “switch on the lights”, “switch off the lights”, “turn on the television”, “turn off the television”, “power on all the devices” and “power off all the devices”.

Method

The Structure of the System

A pair of Arduino Uno boards controls the implemented system. The XBee RF modules are used for wireless communications. One of them is a transmitter for transferring the signals and the other one is a receiver for getting the signals; and both are connected to the Arduino Uno card. The EasyVR module is used as the voice recognition card and EasyVR Commander which is graphical interface software of EasyVR module defines voice commands.

Figure 1 shows the flow diagram of the voice controlled home automation system. As can be seen from this flow chart, the voice command is firstly told by the user and these voice commands are transmitted to EasyVR module via throat microphone. Then, EasyVR module receives these voice commands and transforms them into digital signals using Analog Digital Converter (ADC). The next step is to compare voice commands to the ones recognized before, i.e. open the door, close the door, turn on TV, turn off TV etc… If they match, it transmits each letter value which is corresponding for commands as binary. This binary information is later received by ATmega328 microcontroller. After matching and comparison is finished here, transmitter sends information signals to XBee. These digital signals are taken by receiver XBee and binary values are sent to ATmega328 microcontroller. Microcontroller compares value serials to values here. Last, according to value serials, servo engines and leds accomplish the task here.

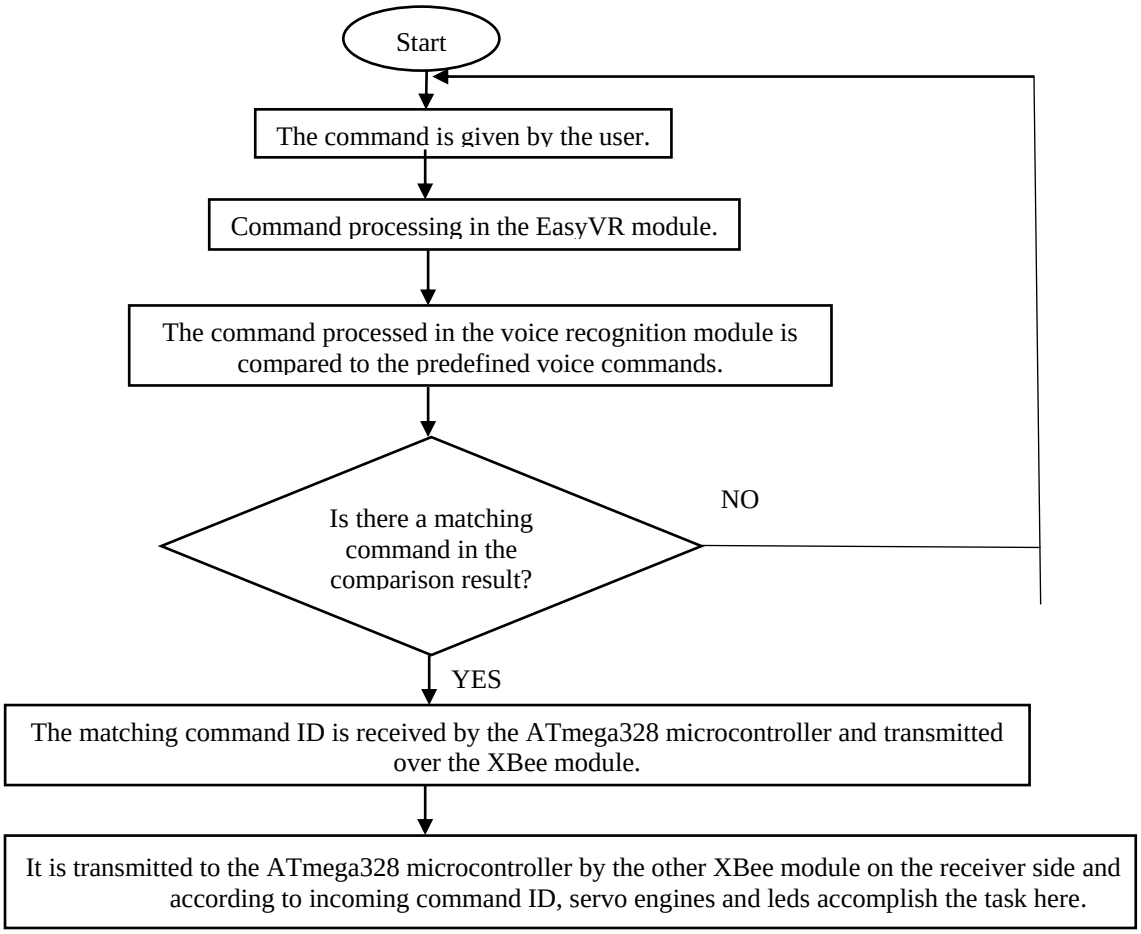

Figure 1. Flow chart of controlling the home automation system by voice

When the command "open the door" is issued by the user, servo engine placed under the door turns around with 90^{o} angle, which enables the door to open. If the command "close the door" is given, servo engine moves to the starting point so the door closes. If "turn on the air conditioner", "switch on the lights" and "turn on the television" commands are issued, the leds in the model which represents the appliances in the house are turned on. If "turn off the air conditioner", "switch off the lights" and "turn off the television" commands are given, the leds are turned off. When "power on all the devices" command is given, television, air conditioner, and lamp is activated. If "power off all the devices" command is issued, television, air conditioner, and lamp is turned off.

Arduino Uno Microcontroller Card

Arduino, a ready-to-use electronic card, has a main microcontroller, pins to connect control units, and communication ports (Delebe, 2014). The Arduino Uno is a microcontroller board based on the ATmega328. There are 14 digital input/output pins, and 6 of them can be used as PWM output. Also, it has 6 analog input pins, 16 MHz crystal oscillator, a USB input, a power input, and reset button. The card consists of the necessary things to support microprocessor (Arduino Uno Datasheet, 2015). Figure 2 describes the front and back surface of Arduino Uno:

Figure 2. Arduino Uno microprocessor card

EasyVR Shield 2.0 Voice Recognition Card

EasyVR Shield 2.0 is a voice recognition shield developed for Arduino. It was designed to provide versatile, robust and cost effective solutions for various voice recognition applications. It is commonly used for voice controlled light switches, locks, curtains or kitchen appliances in home automation solutions (EasyVR User Manual, 2015). Figure 3 shows an EasyVR Shield 2.0 module.

Figure 3. EasyVR Shield 2.0

EasyVR Shield 2.0 Features

An EasyVR module consists of a set of built-in Speaker Independent (SI) commands for ready-to-run basic control functions. In addition, besides voice passwords, it supports 32 user-defined Speaker Dependent (SD) triggers or commands. An EasyVR 2.0 module contains SonicNet technology for wireless interactions between modules and other voice sources. In addition, it has both DTMF tone generation and simple and user friendly graphical user interface. It can be used on any host with standard UART interface powered with 3.3V-5V. There is serial communication protocol in order to program on host card. Headphone jack and microphone input are also available in addition to programmable LED to indicate feedback during recognition tasks (EasyVR User Manual, 2015).

ZigBee Technology

ZigBee, a new standard for wireless communications, enables low cost, low power, short range and low-data-rate wireless multi-hop networking technology standard (Masica, 2007). It forms a suitable baseline for sensors and control network based upon IEEE 802.15.4 (Kızılırmak, 2012). It is widely accepted because of minimum power use, low-cost, secure, easy-to-install in implementations that are relatively low throughput size data transmitting like distant monitoring, control and distributed processing (Masica, 2007). Due to its advantages over competitive technologies, ZigBee is a very nice option for wireless voice applications (Öztaş, Belen, Kaya, & Kaya, 2011).

Digi XBee 2 Serial XBee-PRO ZigBee Modules

In this study, two XBee-PRO 63mW PCB antennas are used. These modules are wireless communications modules which enable to form low-power and high-cost sensor connections by using 802.15.4 and ZigBee communication protocols that work on 2.4 GHz ISM frequency band (Xbee Pro63mw Datasheet, 2016). In Table 1, technical features of XBee-PRO ZigBee (XBee PRO ZigBee Product Datasheet, 2016) modules are indicated.

Table 1.Technical specifications of Xbee-PRO ZigBee modules

Feature	**Value**
Indoor Range	90m
Outdoor Range	1600m
Transmit Power	63mW
Receiver Sensitivity (%1per)	-101dBm
Serial Data Interface	UART, SPI
Configuration Method	API VEYA AT commands
Frequency Band	ISM 2.4 GHz
Data Rate	250kbps
Digital Input/Output	15
Supply Voltage	2.7-3.6V
IDS	PAN ID and addresses, cluster IDs and endpoints (optional)
Operating Temperature	-40 ^{0}C- +85 ^{0}C

Servo Motor

The servo motor is used to open or close the door. Tower Pro SG90 is a plastic and geared mini servo engine. It has small, light and high output power. Servo can be turned to 180^0 (each way is 90^0). Table 2 shows tower pro sg90 mini servo motor features.

Table 2. Tower pro SG90 mini servo motor features

Feature	**Value**
Operating Voltage	4.8 V - 6 V
Stall Torque	1.2kg / 42.3oz (4.8V) , 1.6 kg / 56.4oz (6.0V)
Operating Speed	0.1 s / 60º
Weight	9 g
Size	22 mm x 11,5 mm x 27 mm
Gear Box	Plastic

Throat Microphone

Throat microphone transmits voice with throat vibration. Therefore, the voice can be transferred clearly even in noisy environments. In order to convey voice commands into EasyVR voice recognition module, throat microphone with two sensors (shown in Figure 4) are used (Throat microphone two sensors datasheet, 2016).

Figure 4. Throat microphone with two sensors

Features of Microphone

- Sensitivity: 37.5+/-2dB &1kHZ 2.2Kω 3V 0dB=1v/pa
- Impedance: Max. 2.20kω &1kHZ
- Directivity: Omni-directional frequency: 100Hz - 16000Hz
- Max. Operation Voltage: 10V
- Standard Operation Voltage: 3V
- Current Consumption: max. 0.5 mA
- S/N Ratio: Min. -56dB &1.1Khz

Hardware Implementation

Figure 5 shows the design of voice controlled home automation.

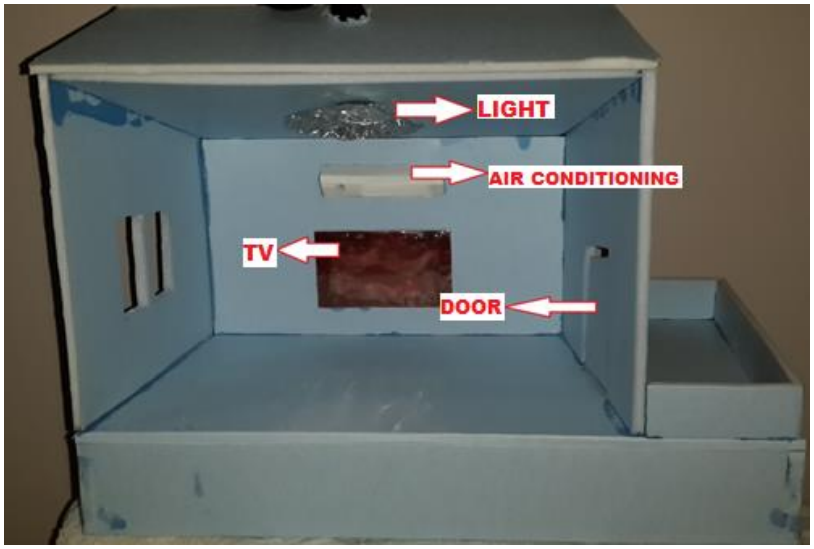

Figure 5. Design of the voice controlled home automation

Results and Discussion

Although home automation systems can be controlled using different methods, in this study, voice commands are used to control the designed home automation system. Because the system has been designed to help the elderly and physically disabled. 10 commands are used to control the devices connected to the home automation system. Commands can be given via throat microphone in both normal and noisy environments. Therefore, each command has been tested 10 times in both normal and noisy environments.

The results show that 95% of success rate has been reached in a normal environment and 94% of success rate has been reached in a noisy environment. It is clear from the results that the environment does not have such importance as throat microphone transmits the voice with throat vibration.

Table 3. The results of tests with throat microphone in normal environment

No	Commands	Number of tests	Accuracy
1	Turn on the air conditioner	10	10
2	Turn off the air conditioner	10	10
3	Switch on the lights	10	9
4	Switch off the lights	10	10
5	Turn on the television	10	9
6	Turn off the television	10	10
7	Open the door	10	10
8	Close the door	10	9
9	Power on all the devices	10	9
10	Power off all the devices	10	9

Table 4. The results of tests with throat microphone in noisy environment

No	Commands	Number of tests	Accuracy
1	Turn on the air conditioner	10	9
2	Turn off the air conditioner	10	10
3	Switch on the lights	10	9
4	Switch off the lights	10	10
5	Turn on the television	10	10
6	Turn off the television	10	9
7	Open the door	10	9
8	Close the door	10	10
9	Power on all the devices	10	9
10	Power off all the devices	10	9

In this research, the system responds to commands of only the researcher whose commands have been introduced before. It is not possible for unauthorized person to use the system. This system is speaker-dependent; however, it can also be developed as speaker-independent system.

One factor affecting voice recognition systems is noise or another voice in the environment. Other factors are the quality of the microphone used in the study and the distance between the microphone and the user. Voice recognition systems work effectively only when the user and the microphone is close to each other. For that reason, throat microphone with two sensors is preferred in this study. According to the tests, it is understood that even in noisy environment throat microphone can transmit the commands clearly. However, there is a drawback of throat microphone. It may cause sweating and itching on throat.

Conclusion

Considering the important role of home automation systems for the elderly and physically disabled, in this study a voice controlled home automation system has been designed. To implement the common functions of a typical home automation system, firstly a prototype home has been built and then some devices have been placed in it. Then the design of the voice recognition and communications modules has been realized using off-the-shelf components. Finally the software of the designed home automation system has been developed. Although in this study we have focused on controlling only four appliances, the overall functions of the designed system provided by the voice recognition system can be used for different purposes such as controlling wheelchairs and directing vehicles and mobile robots. Since the designed home automation system allows the elderly and disabled to control some devices remotely via voice, it can make their lives easier and more comfortable. The future work of this study consists of increasing the number of functions the designed system provides, and improving the voice recognition capabilities.

References

Arduino Uno Datasheet (2015, June, 15). Retrieved form http://arduino.cc/en/Main/ArduinoBoardUno.

Bharambe, D.V. & Kodgire, S.P. (2015). PSoC based isolated speech recognition system for voice controlled appliances. *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), 4*(11), 4270-4272.

Bharambe, D. & Kodgire, S.P. (2016). Speech recognition system for voice controlled devices. *International Journal of Latest Trends in Engineering and Technology 6*(3), 455-459.

Delebe, E. (2014). *Projeler ile Arduino.* İstanbul: Kodlab Yayın Dağ.

EasyVR User Manual (2015, June, 15) Retrieved form http://www.veear.eu/files/easyvr_user_manual_3.6.7.pdf.

Kızılırmak, E. Y. (2012). *ZigBee İle Endüstriyel Vinç Kontrolü*. (Unpublished master dissertation). University of Hacettepe, Ankara, Turkey.

Masica, K. (2007). Recommended practices guide for securing zigbee wireless networks in process control system environments. Retrieved from http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/Securing_ZigBee_Wireless_Networks.pdf.

Öztaş, Ş., Belen, M. A., Kaya, İ., & Kaya, A. (2011). Zigbee teknolojisi kullanılarak kablosuz kafe otomasyon sistemi tasarımı. Symposium of Elektrik-Elektronik ve Bilgisayar, University of Fırat, Elazığ.

Throat microphone two sensors datasheet (2016, June, 12) Retrieved from http://tr.aliexpress.com/item/Clear-Transmission-Throat-Microphone-Air-Tube-Headset-with-2-Sensors-for-Yaesu-Portable-Radio-FT-10R/32276708707.html#extend

Xbee Pro63mw Datasheet (2016, June, 21). Retrieved form http://www.robotistan.com/xbee-pro-63mw-pcb-anten-seri-2b-xbp24-bz7pit-004.

XBee-PRO ZigBee Product Datasheet (2016, June, 16). Retrieved form http://www.digi.com/pdf/ds_xbee_zigbee.pdf.

Author Information

Ahmet Vatansever
Trakya University
Edirne, Turkey
Contact e-mail: *ahmetvatansever@trakya.edu.tr*

Hilmi Kuscu
Trakya University
Edirne, Turkey

Gurkan Tuna
Trakya University
Edirne, Turkey