Remote control and monitoring in smart homes using voice commands

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Abstract. With the development of modern technology, smartphones have become a necessity for most people. Among other uses, mobile phones are increasingly being used in smart home systems. In smart homes, mobile phones are used to remotely control and monitor various systems such as simply turning on/off lights and household appliances, various monitoring systems, etc. Nowadays, sending coded messages or pressing application buttons is increasingly being avoided in the process of developing smart systems. More and more frequently is used voice commands. The system which uses voice commands for remote control and monitoring smart home is described in this paper. In the implemented system, the user is able, using specific voice commands to remotely control the operation of various appliances in his home. An Android application was designed to control the implemented system. Using the designed Android application, the user controls the desired home devices with specific voice commands. Also, on the designed Android application are buttons that the user can use, in case the user's voice is not recognized in the implemented system. For experimental work analysis, the model of the home is made with lights and different home appliances inside. The results of the experimental work analysis of the implemented system show this system is very simple to use and very efficient. Also, the latest technology for remote control and monitor smart systems is applied in the proposed smart home system.

1. Introduction
Home automation is the automatic or semi-automatic control and monitoring of household appliances and home features like doors, gates, windows, and etc. [1]. Home automation is used to provide convenience for users to remotely control and monitor the appliances and provides better use of electricity. The increased use of PCs, smart devices, and wireless technology makes it easy for a user to remotely control and monitor automated systems. A lot of research has been done for smart homes. Some of the solutions are using the Internet, wireless technology, others are using Bluetooth and GSM technology for controlling the home appliances [2]. Controlling the device or home appliances through the voice command represents the smart, modern and user-friendly system [3]. There are various home automation solutions based on voice control on the market today, which to a greater or lesser extent suit the end-user. The most known voice command systems are Amazon’s Alexa and Apple’s Siri, Google Home, Home Assistant, HAL, OpenHAB, Crestron, Amazon Echo, Castle OS, etc. These systems are becoming more popular way of voice control and monitor different systems. Voice-control home automation systems offer people a more comfortable lifestyle and simplify ordinary tasks [4]. According to the major companies involved in voice recognition research, the voice will be the main interface between humans and machines in the near future [2]. Such systems are especially suitable for
people with disabilities and the elderly. Therefore, a home automation system with voice control has been designed so that users can perform certain tasks using voice over their smartphones. The entire system is controlled via smartphone application. In this paper is designed and implemented the smart home system which uses voice commands for remote control and monitor smart home. This smart home system enables the user to use his voice to remotely control the operation of different appliances in his home. For voice recognition of specific commands is created the android application. Using the created android application, the user controls the desired home devices with specific voice commands. Also, on the created android application are buttons that the user can use, in case the user's voice is not recognized. For experimental work analysis, the model of the home is made with indoor and outdoor lights and different home appliances placed inside.

2. Smart homes using voice commands

Home automation is becoming popular due to its numerous benefits. Home automation refers to the control of home appliances by local networking or by remote control [3]. A voice-controlled home automation system is a specific automation system. Using Natural Language Processing and the accessible hardware in most smartphones enables to use for controlling electrical equipment [4].

The first speech recognition system, named Audrey, was created by Bell Laboratories in 1952. That system was understanding only ten digits spoken by particular people. Ten years later, IBM developed and demonstrated their Shoebox Machine. The device recognized and responded to 16 different spoken words, including all ten digits “0” to “9” as well as calculating commands such as “plus” or “minus”.

In the 1970s is developed the Hidden Markov model. In this model, speech recognition started using a statistical method measuring the probability of unknown sounds. Now, the potential to recognize an unlimited number of words became imminent due to the method allowing the number of understandable words to go up to a few thousand. These choices of observation distribution in each state of the model allow accurate modeling of virtually unlimited types of data. The first mass accessible voice command system was launched by Apple Inc. as they released the virtual assistant named Siri in 2011 [4].

There are several commercial and research projects on smart homes and voice recognition systems. One of them is an integrated platform for home security, monitoring, and automation SMA from uControl. This system is a 7-inch touchscreen that can wirelessly be connected to security alarms and other home appliances. The home automation through this system requires holding and interacting with a large panel which constraints the physical movements of the user.

Another popular commercially available system for home automation is Home Automated Living HAL. This software uses the power of an existing PC to control the home. It provides a speech command interface. A big advantage of this system is it can send commands all over the house using the existing highway of electrical wires inside the walls of the house. No new wires mean HAL is easy and inexpensive to install. However, most of these products sold in the market are heavily priced and often require a significant home makeover [5].

3. Design and implementation of the remote control and monitoring in smart homes using voice commands

In this part of the paper, a system for remote control and monitoring in smart homes using voice commands is designed. For experimental work analysis, the system is implemented in a home model. For control and monitoring the smart home, the android application is created. MIT App Inventor is used to create the android application. MIT App Inventor is a software environment that allows the creation of fully functional applications for smartphones [6]. First is created a graphical appearance for the android application and enabled communication with the smart home system. After that is programmed the created application for recognize voice commands. It is also programmed that the system can return information to the user when it performs a given task. The SpeechRecognizer and TextToSpeech blocks are used for that. The SpeechRecognizer component is used to listen, recognize voices and convert them to text. The TextToSpeech component pronounces the default text aloud and confirms to the user that it will perform the given task. The voice color and pitch of the pronunciation
can be adjusted. In case of not recognizing voice commands, the user is enabled to press the button next to the command on the android application to perform desired tasks. The appearance of the created android application is shown in Figure 1.

![Figure 1. The appearance of the created android application](image)

The android application sends the recognized voice command converted to text wirelessly (WiFi network) to the nodeMcu ESP8266 module. This module performs the tasks based on the received voice command. In the proposed smart home system, the user, using voice commands, is able to control: heating, indoor and outdoor lighting, open and close doors and windows. Expansion of this system can be done in a simple way by adding desired elements to control. Figure 2 shows a functional block diagram for remote control and monitoring in smart homes using voice commands system.

![Figure 2. The functional block diagram of the remote control and monitoring in smart homes using voice commands system](image)

4 Relay Module contains EL817 optocoupler for signal isolation and amplification with NodeMCU and four relays. Working voltage is 5 V, maximum load AC 250 V / 10 A, and DC 30 V /
From Figure 2 can see that NodeMCU esp8266 acts on individual elements of the smart home based on the received voice commands. Servo motors are used as actuators for opening and closing doors and windows. The relays are used for switching on and off individual elements of the smart home model. For the experimental work analysis of the remote control and monitoring in smart homes using voice commands the model of the home is made. The made home model is size 80x60 cm, and is shown in Figure 3.

Figure 3. The model of the smart home (a) appearance of the smart home model, (b) the hardware part of the smart home model

4. Experimental work analysis of the remote control and monitoring in smart homes using voice commands

For the first experimental work analysis it tested the voice command for turning the heater on and off (see Figure 4).

Figure 4. The experimental work analysis of the heater

The required data of the remote control and monitoring system of the heating control subsystem is the value of the current room temperature from the temperature measuring sensor. The exact value of the temperature given by the sensor inside the smart home can be read on the LCD display, and thus determine whether it is necessary to turn the heating on or off. The voice command "HEAT ON" is used on the mobile phone. When the voice command is spoken to the android application, after one second we can notice that the heating has been turned on in the model of the home. When we want to turn off the heating, we do it with the voice command "HEAT OFF". In case the system does not recognize the voice, the user can turn on / off the heating manually on the Android application. For the
second experimental work analysis we tested the voice command for turning the fen on and off (see Figure 5).

![Figure 5. The experimental work analysis of the fen](image)

Voice commands for controlling the fen are 'FAN ON' and 'FAN OFF'. Also, on the Android application are buttons for manually controlling the fan. For the third experimental work analysis we tested the voice command for turning the outdoor lights on and off (see Figure 6).

![Figure 6. The experimental work analysis of the indoor lighting](image)

Voice commands for controlling the indoor lighting are 'LIGHT ON' and 'LIGHT OFF'. Also, on the Android application are buttons for manually controlling the indoor lights. Also, the outdoor lights are able to control this way using voice commands' OUTDOOR LIGHT ON' and 'OUTDOOR LIGHT OFF' (see Figure 7).
Figure 7. The experimental work analysis of the outdoor lighting

After experimental analysis and detailed testing of the smart home system which is controlled using voice commands, we can conclude that the system is harmonized, functional, and user-friendly. Also, according to the needs of different users, this system has the possibility of connecting additional subsystems for voice controlling, without ruining the operation of the implemented ones.

5. Conclusion
In this paper, the system for remote control and monitoring of smart homes using voice commands is designed. The designed system uses smartphones that have become irreplaceable in the modern world, and voice commands that represent the future for human-machine communication. An android application is created. The use of the created android application is very simple. It is enough to open the android application and press the button "Speech text" and say the desired command. In case of not recognizing the voice command or staying in places where it is not appropriate to speak, the user can press the button on the application. These buttons are placed on the android application, so the user can perform desired tasks if not able to use his voice. The smart home model is made for experimental proof of the proper work of the designed smart home system. Application in the real smart home does not require any additional system upgrades because relays and higher power servomotors are used at the output. Experimental work analysis of the designed smart home system is performed. Based on the results of the performed experimental work analysis can be concluded that the designed smart home system works correctly. Of the 100 random voice commands, all were recognized and tasks were performed correctly. Based on the above, can be concluded that the designed smart home system works well and can be used for voice control of desired elements in a real smart homes.

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