Design of Intelligent Home Control System Based on Speech Recognition

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Abstract. With the improvement of People's living quality, the demand for convenience, comfort and intelligence of smart home is more and more high, so the speech recognition and control technology is very important in smart home. The system adopts ZigBee module to collect and transmit terminal information, and SNR8016 is used as speech recognition module. Its main control center and each module for data exchange, to achieve indoor LED lights, curtains, air conditioning, dehumidifiers and other electrical control. After testing and verification, the system can realize the speaker-independent intelligent control of household electrical switches and voice broadcast. The system has the advantages of low cost, low power consumption, easy operation, safety and reliability. It can bring users a better sense of experience and comfort.

Keywords: Smart Home, voice recognition, Zigbee, SNR8016

1   Introduction

Smart Home is a home-based, combined with the Internet of things, artificial intelligence, Edge Computing, 5G and other technologies, home devices to achieve remote control, centralized management, connectivity and other functions, provide comfortable and convenient living environment for users. The speech recognition intelligent home control system has better controllability and convenience, it breaks through the traditional control method to the distance limit, simultaneously also satisfied the user to the intelligent home demand.

Through the analysis of the development of smart home and speech recognition technology[1-2], this paper makes a comparative study of the common wireless communication technology, a low-cost, low-power, simple operation of voice recognition intelligent home control system is designed. The system can switch home appliances according to User's voice instructions, and can monitor indoor temperature and humidity in real time, analyze temperature and humidity data, adjust air conditioner and dehumidifier in time.

2　　Overall design of the system

2.1　Functional Requirement Analysis

The overall system block diagram is shown in Fig. 1.
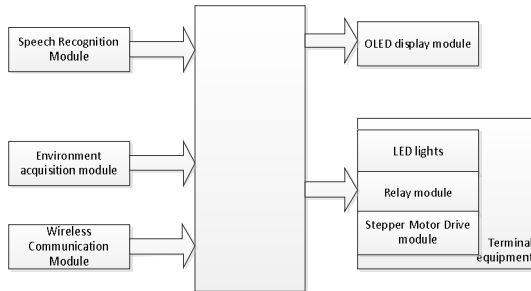

Fig. 1.　　System Block Diagram

The main functions of the system are as follows.

(1) In this system, the voice information is collected by microphone, and recognized by speech recognition module according to certain principle, and the recognition result is transmitted to the main control.

(2) After receiving the control instructions of the speech recognition module, the master controller sends the control instructions to realize the switch control of the household electric lamp, curtain, air conditioner, dehumidifier and so on.

(3) Household appliances in accordance with the instructions to complete a series of actions in the feedback to the main control, the main control received information through the speaker voice broadcast.

(4) The system can use ZigBee to collect the temperature and humidity data of the temperature and humidity sensor in real time, then send the data to the main controller, display the data in the display module, and when the temperature and humidity reach the set value, the system automatically activates the air conditioner and dehumidifier.

2.2　Function module design

(1) Speech Recognition Module

The speech recognition module mainly completes the speech collection, the speech recognition, the speech broadcast and so on. The module uses microphone to collect the user's voice in real time. It realizes the conversion of voice data and digital signal, and converts data into control commands. The command transmits the control command to the host through the serial port, and the terminal device carries on a series of control operations after receiving the command. After the terminal device completes the corresponding control operation, the final feedback to the speech recognition module, and the Speaker of the speech recognition module broadcast the control result to the user.

(2) wireless communication module

Compared with wireless communication, wired communication has less interference, better security and security, but its disadvantages are high cost, complex circuit, difficult maintenance of equipment, etc. , so it has been gradually replaced by wireless data transmission. Wireless communication is characterized by low cost, stable performance, flexible networking, good scalability and low maintenance cost.Considering the problems of transmission distance, transmission power consumption and data reliability, ZigBee wireless transmission technology is more suitable for the communication requirements of smart home[3]. It can better ensure the communication requirements between each node in the smart home.

(3) temperature and humidity acquisition module

The system uses temperature and humidity sensor to monitor indoor temperature and humidity in real time. Zigbee sends indoor temperature and humidity data to the main controller and displays it on the display. When the temperature and humidity reach a certain value, the system will automatically open the air-conditioning and dehumidifier to provide users with more comfortable and convenient living environment.

(4) control module

The control module is mainly composed of display screen and household appliances. The user can view the indoor temperature and humidity through the display screen in real time. The system can switch between voice mode and manual mode. In automatic mode, when the temperature and humidity reached a set value automatically adjust the state of the air conditioning and dehumidifier. In manual mode, voice control lights[4-5], curtains, air conditioning, dehumidifiers, all electrical switch state, etc. .

3 The hardware design of the system

3.1 System design ideas

In this system, the host module is the main control board to achieve voice control of home appliances function. It wakes up the speech recognition module through the wake-up instruction and issues the corresponding command instruction. After the SNR8016 speech recognition module recognizes the command, it transmits the recognition result to STM32 main control chip through the serial port[6]. The result is analyzed by STM32, and then the result command is sent to the terminal device to control the switch state of each appliance. The slave module uses temperature and humidity sensor to collect indoor temperature and humidity, and sends the data to Zigbee of host through Zigbee. The host Zigbee sends the information to the host for real-time display on the OLED display screen. At the same time, when the temperature and humidity reached the set value of the system will automatically start the air conditioning and dehumidifier.

3.2   STM32 master control chip

The STM32 chip is a series of microcontrollers developed by the STMicroelectronics. This system adopts the STM32F103C8T6 chip in the Enhanced Series STM32F103, which is more compact, has many function-rich interfaces, and has high performance, low cost, low power consumption, fast running speed, high degree of integration features.

3.3   Speech recognition module

The system adopts SNR8016 off-line speech recognition module. This module is a kind of non-specific speech recognition module with high stability and does not need user training, only need to specify the wake-up word and command word[7]. Module can set up up to 160 instructions, using the microphone can achieve 10 meters ultra-long-distance speech recognition, and recognition accuracy of more than 97% . It comes with speakers, with voice broadcast function, maximum support for 3W speaker output, built-in FLASH storage 600 seconds audio data. In addition, it can also receive the data through voice engine feedback, and transmission through UART, can be flexible with MCU applications. It uses the microphone to collect the voice information of the user, and carries on the frequency spectrum analysis, extracts the key words from the sound signal, obtains the corresponding speech characteristic information, finally, it is compared with the information set in the keyword list, and the keyword with the highest coincidence rate is determined and sent to the master control as the recognition result.

3.4   Wireless communication module

The system uses ZigBee short-range wireless communication technology to build an intelligent home communication network and complete the sensor data acquisition and transmission[8-9]. The system uses TI company's CC2530 as the main control chip of Zigbee, which is a kind of real suitable for IEEE802.15.4 and widely used in intelligent home system.

4   System software design

The development of voice recognition intelligent home control system includes voice recognition module, wireless communication module and temperature and humidity acquisition module.

4.1   Software design of speech recognition module

In order to improve the veracity of speech recognition, the system adopts the mode of user's command triggering, that is to say, a command is set in the program design as the trigger command of the user. The system defines "Ash" as the user's first-level

trigger command. The user gives the first-level instruction, if the detection is the correct instruction, then the voice prompt. Next, it opens the receiving and detecting recognition of the secondary instruction, and sends the recognition result to the main control chip, and then sends the control instruction to the terminal through the serial port. Finally, the system realizes the switch of LED, curtain, air conditioner and dehumidifier, so as to complete the electrical control of the voice simulation intelligent home.

4.2   Wireless communication module software design

The main control STM32F103C8T6 and ZigBee communicate through serial port. The wireless communication module mainly collects the temperature and humidity in this system and uploads it to the main control center. First, the module initializes, connects to the network, and receives the data frame by interrupt callback. After the data frame is checked correctly, the temperature and humidity value is read.

4.3   Software design of temperature and humidity acquisition module

The system uses DHT11 temperature and humidity sensor to detect indoor temperature and humidity. The temperature and humidity sensor is placed in the living room or the bedroom to monitor the temperature and humidity in the room in real time. Then transmit to the host control through ZigBee to determine whether the current environment is suitable for the human body. Finally, the air conditioning, dehumidifier automatic control. Turn on the heating function when the air temperature in the room is less than 10℃, and turn on the air conditioner when the room temperature is more than 30℃. The dehumidifier is adjusted in a manner similar to air conditioning.

5   System function test

5.1   System test

Firstly, the main control chip STM32F103C8T6 of the system is connected with the hardware such as Voice Recognition Module, wireless communication module, temperature and humidity sensor, OLED display screen, relay, step motor, etc. , during the connection process to ensure that the correct circuit connection, no short-circuit open problems, complete the overall construction of the system. Check that there are no abnormal parts of the system after power.

In the speech recognition intelligent home control system, the function test of the speech recognition module is emphasized. The speech signal collected by the microphone is extracted by speech feature extraction, and the result of speech recognition is compared with the commands in the established keyword list, and the accuracy of speech recognition is judged. Because the system uses speaker-independent speech recognition technology, in order to ensure the accuracy of speech recognition, it is necessary to detect the voice of different users. During the test, 10 male and female

students of different ages were randomly selected and asked to say eight voice commands that had been set. Each command was repeated five times to obtain a total of 400 samples. In the quiet indoor environment, the recognition accuracy of the test samples can reach 98% , basically meet the needs of the general family environment of speech recognition.

5.2   Analysis of system test results

After many tests, speech recognition intelligent home control system is relatively stable, environmental temperature and humidity monitoring numerical accuracy, high accuracy of speech recognition, in the case of a single phrase recognition rate can reach 99% , can complete the voice control of household appliances, test results in line with expectations, the system is in good condition.

6   Conclusions

With the rapid development of the Internet of things and big data, the living standard of human beings is constantly improving, the demand for smart home is also increasing, the future of human life will be more dependent on smart devices. Compared with the existing system, the voice recognition intelligent home control system has made some progress in some functions, and can realize voice control of home appliances to a certain extent, however, due to time, funds, their own capacity and other reasons, the whole system still has a lot to be improved and improved.

Acknowledgement

References

1. Liu luping: Research on application of LD3320 speech recognition technology in intelligent waste classification system. China Equipment Engineering 3(23) ,37–39(2021).
2. Xie Zhenyu, Liu Wei: Design of intelligent home voice control system based on MCU. Innovation in science and Technology 23(31) , 83–85(2021).
3. song chaoxia, Shu Ruikang: Design of speech recognition intelligent home control system based on LD3320 . Information and computers (theoretical edition) 32(20) ,105–106(2020).
4. Chen Xixiang, Huang Wu, Li deying: Design of intelligent home control system based on speech recognition . Automation and instrumentation 36(07) ,91–95(2021).
5. Lan Wu, Pan Yang. Multi-modal audio-visual speech recognition in large vocabulary noise environment. Guangxi science 30(01),52-60(2023).
6. Yingying Gao.Intelligent voice recognition function control of the home system.Microcontroller and embedded system applications 22(09),88-91(2022).

7. Qingquan Xiao, Jingcheng Gu. Design of wireless voice control system for smart home. Journal of Guizhou University Science 37(04),65-71(2020).
8. Ting Liu. Design of smart home system based on Internet of things and cloud platform. Wireless interconnection technology 20(09),6(2023).
9. Xi Huang.Research on the development of interactive design of intelligent home from the perspective of human-computer interaction.Footwear technology and design 3(06), 171-173(2023).