Design of IOS smart Home System Based on MQTT Protocol and Speech Recognition

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Abstract. With the rapid development of Internet of Things technology in recent years, speech recognition technology based on artificial intelligence and Internet of Things has gradually penetrated into various fields. In the traditional field of smart home systems, users generally need to manually set function scenes, which are time-consuming and labor-intensive and inconvenient for human-machine system interaction. In order to better meet the needs of people's intelligent life, to provide users with better control experience on smart home appliances, improve the quality of intelligent home life. This article designed a smart home control system that uses iOS as the core, voice recognition module as the interactive means, and MQTT communication protocol as data transfer. The system uses speech recognition technology based on artificial intelligence and deep learning to improve the recognition rate of speech input, achieve perfect interaction between humans and computers, and enable users to truly experience the intelligent and humanized characteristics of smart home systems.

1. Introduction

With the continuous development of artificial intelligence technology, the speech recognition technology based on artificial intelligence has also made remarkable progress. It began to gradually move into various fields, and gave birth to the speech recognition industry. The so-called speech recognition is to enable the machine to transform the speech signal into the corresponding text or command through the recognition and understanding process of the machine [1]. The speech recognition technology can be traced back to the Baer laboratory in 1950s. The initial speech recognition can only identify simple English numbers. With the rise of artificial intelligence and the support industry, speech recognition technology has developed rapidly. This is the development of the information society and the improvement of people's living standards. It has a profound meaning. Smart home is the use of advanced computer technology, embedded system and network communication technology, the various devices in the system (such as lighting systems, environmental control, security system, network appliances) through the family network to join together[2]. Since the emergence of intelligent buildings in the United States in 1984, there have been nearly 30 years of research history abroad, and the development of mobile Internet and Internet of things technology in our country is lagging behind the developed countries such as Europe, America, Japan and South Korea. Smart home systems have the advantages of convenience, efficiency, intelligence, and environmental protection compared to traditional homes[3]. This article uses the MQTT communication protocol and voice recognition and other related technologies to complete the design of a new type of smart home system. The system overcomes the problems of slow communication and
poor interaction in traditional systems. Through a large number of repeated tests and experiments, it can be proved that the system can complete reliable data interaction and terminal control in complex situations.

2. Development Environment and Mode

2.1. IOS Operating System
The underlying services of the iOS system mainly provide the most basic interactive services, which mainly include four layers: the Core OS layer, the Core Services layer, the Media layer, and the Core Touch layer [4-7]. The lower layer in iOS four-tier architecture provides basic calling services for the upper layer. This system uses the efficient and stable service in the iOS system's four-tier architecture to complete the client design. It can solve the problem that clients send signals on the market are unstable and not timely.

2.2. MVC Design Pattern
The advantages of the MVC architectural model are the coupling between code reuse and the reduction of application data representation and processing. The system uses this advantage to reduce the redundancy of the system code, optimize the data transmission method in the communication interaction process, and enable the system to operate efficiently and stably with high concurrent data volume [8-9].

3. System Function Design
The system communication module consists of mobile client, intelligent gateway, middleware and terminal equipment. The main function of the mobile client is that the user sends the converted information to the middleware through the form of mobile communication after sending the command by voice or sends the signal command directly to the intelligent gateway through the connection of WiFi. iOS smart terminals and home gateways subscribe to the MQTT topic and start processing the signaling after executing publish/subscribe messages. The middleware is responsible for sending the received control commands to the home gateway via the Internet route. After the home gateway connects to the MQTT server to obtain related topics, the network signal is parsed and sent to the smart gateway for processing. Ultimately, smart gateway converts received WiFi/Internet signals into ZigBee signals that can be recognized by the smart home devices and transmits it to each smart device. In addition, the terminal equipment can be converted to serve as a signal route and transmit signal data, so as to realize the signal transmission between the ZigBee equipment. [10]. System communication signal controls function flow is shown in Figure 1:

Figure 1. Smart home signal control implementation process
This system function is mainly composed of several major functional modules such as system management, switch control, scene control, dimming control, timing control, and security control. The system management is the core of the entire system control section, that is, the relatively independent functional modules such as switches, dimming, and security can be managed through scenarios and timing control, and these relatively independent functional modules can also be directly controlled. The design of the scene module and the timing module is all designed to implement the user's personalized control. The main function of personalized customization is that the user can set different home equipment execution behaviors according to their own actual control requirements. The system supports the user-friendly and easy-to-use personalized customized scene module. For example, the user wishes to automatically light the living room lamp when the home door is opened, the television is turned on, the sports channel is automatically selected, and a scene triggered by the door magnetism needs to be set. Scene behavior includes gradually lit sub-scene such as a living room, and several executive actions such as turning on the TV and adjusting to a sports channel.

4. Communication Analysis and Design

4.1. Speech Recognition Technology
Speech recognition technology is the computer's speech semantic training, the establishment of a speech recognition model, so that the computer itself can identify and understand people's voice signals, and convert the recognized voice signals into corresponding information[11-12]. In general, a complete speech recognition system is composed of five parts: pre-processing of speech, feature extraction of speech signals, training speech recognition model, pattern matching and post-processing. The most important one is the extraction of speech feature parameters and model training. It matches two phases of patterns and combines all common features to form a training model. Pattern matching is to compare the speech feature parameters extracted from the test sample with the template of the training phase mark. The reference model with the highest degree of similarity between Germany and Germany is identified. The speech recognition framework is shown in Figure 2 below.

![Speech Recognition Framework](image)

**Figure 2.** Frame diagram for speech recognition

4.2. ZigBee Network Communication Technology
ZigBee communication technology is a very popular short-distance, low-power, low-rate, mature and stable wireless communication technology with flexible networking [13]. ZigBee is a short-range wireless technology standard developed based on the IEEE 802.15.4 standard. It is mainly used in areas such as automatic control and remote control, and has the advantages of ad hoc networks, over-the-horizon range, low-cost, and low-power consumption. The ZigBee Alliance standardized the network layer protocols and APIs and developed the ZigBee security layer based on IEEE 802.15.4. The complete ZigBee protocol mainly includes physical layer, medium access control layer (MAC layer), link control layer, network layer, application convergence layer and application layer [14-15]. The system embeds the ZigBee chip-based wireless network transceiver module into various home electronic devices that need to be controlled. Each network sub-node communicates data through these network transceiver modules. Thus realizing the device linkage control of the home electronic devices. Using ZigBee networking flexibility to easily achieve wireless connectivity of the home network transceiver nodes, the home gateway can achieve the connection between the home network and the external network to achieve the ability to remotely control various electronic equipment modules.
4.3. **MQTT Communication Interaction Technology**

MQTT (Message Queuing Telemetry Transport) is an important communication technology in Internet of Things applications. It is a message protocol based on binary message-based publish/subscribe programming model developed by IBM. It complies with the OASIS specification and is applicable to Low-power and network bandwidth limited IoT scenario.

MQTT is a proxy-based publish/subscribe messaging model that differs from the traditional request/response synchronization model. The publish/subscribe model decouples the relationship between the client (client) that issued the message and the client (subscriber) who subscribed to the message\[16\]. By decoupling the relationship between the subscriber and the publisher does not need to establish direct contact. A publisher can correspond to multiple subscribers. When the publisher changes, it can notify all subscribers of the message. This mode provides greater network scalability and more dynamic network topology.

MQTT services are running between the smart home gateway and the iOS terminal in this system. The smart home equipment sends the data that it reports to the MQTT server of the intelligent gateway, and the MQTT server will publish the subscribers to the subscribers with the same theme (iOS terminal) according to the subject directory specified in the background. When the iOS terminal needs to obtain the relevant equipment information, access to the smart home gateway in the form of WIFI/GPRS, subscribe to the MQTT theme message that is consistent with the information and the request to complete the whole data by publishing this control command message.

In the MQTT protocol, a MQTT packet consists of three parts: Fixed header, Variable header and message body (Payload)\[17\]-\[18\]. The fixed header represents the packet type and the packet class identifier of the packet, the existence of the variable header domain and the specific content of the packet is determined by the packet, and the message body indicates the specific content received by the client. The message format of the MQTT packet is shown in Table 1 as follows:

| Table 1. Message format for MQTT protocol |
|------------------------------------------|
| Fixed Header | Variable Header | Payload |
| Necessary | Messages can be omitted |

The fixed header in the MQTT protocol is two bytes long, where bits7-4 in Byte1 represent the type of the data packet and bits3-0 represent the identification bit. In the message type that does not use the identification bit; the identification bit is used as a reserved bit. Receiver must close network connection if invalid identifier is received. There are four types of QoS (Quality of Service) in the identification bits, and the number of QoS indicates the number of guaranteed message delivery time. Byte 2 represents the total length of the variable-length header and message body, but it is not directly saved. This byte is expandable. The first 7 bits are used to store the length, and the last bit is used to indicate the ID. The structure of the fixed header is shown in Table 2:

| Table 2. Structure of fixed header structure |
|---------------------------------------------|
| bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Byte1 | Message Type | DUP flag | QoS level | RETAIN |
| Byte2 | Remaining Length |

When the publisher publishes a message, QoS = 0 means that a fast transfer is used. Insecure, there is no feedback. QoS=1 indicates that there is a possibility of repetition at least once. It is ensured that the message is sent to the client at least once, but it can also be sent multiple times. The client needs to return a confirmation message (ACK packet) when receiving the data packet. This method is often used to deliver information that ensures delivery. QoS=2 means only once to ensure that the message only arrives once. This method requires the exchange of four data packets, and also reduces the performance of the message broker. In this mode, the client needs to send PUBLISH to the server first,
and the server will reply to the PUBREC. Then, the client sends a PUBREL message, the server then sends the required topic to the subscriber, and finally the client returns a PUBCOMP confirmation message.

5. Network access and Scene Functions

System management is the core of the entire software section. Designing the system management module is to facilitate the unified management and control of terminal equipment and make the system more efficient, convenient and intelligent.

The implementation part of the system master control module includes the system's network connection, system management, and status information of the devices in the read gateway. In order to realize that the client can access the intelligent gateway and ensure the stability of the control and avoid the control confusion, the system adopts a broadcast UDP packet to obtain the relevant information of the intelligent gateway [19]. In practical applications, when the first time the system networking is successful, the client and the smart gateway are in a LAN. Before the client connects to the smart gateway, it sends a broadcast UDP packet that contains the identification information. After the smart gateway receives the broadcast packet, Returns the reply information that contains its own network information to the client, and the client saves this information locally. When the client and the smart gateway are not in a LAN mode, remote connection can be used to initiate connections based on the local saved smart gateway addresses.

6. Software Testing and Results Analysis

After completing the overall design of the smart home system, a systemic test and analysis was conducted for the memory overflow problem of the system software and the stability of the interactive communication. In the testing process, several key modules such as iOS system smart phone terminals, intelligent routing gateways, and smart home terminal devices equipped with ZigBee modules were used to perform device and scenario control tests under LAN and remote network control conditions. The initial stage of the test is mainly for the software layer test, the main test software in the iOS system running compatibility and memory leaks and other issues. For the test problem of the software layer, use the Instruments tool under the Xcode compiler to analyze the resource consumption of the software running. Through Instruments can detect software leaks and other issues, and can easily find the corresponding leaked code block location [20]. After repeated testing and running, the overall system software is maintained in a stable state without any memory leaks.

On the other hand, after the functional test mainly establishes the connection between the terminal and the gateway through the MQTT protocol, the linkage between test equipment control and context triggering. After establishing a scenario between devices that need to be interacted with each other, the external trigger is used to complete the triggering of the scenario, so that the interaction control between the linkage devices is performed. Through multiple test and analyze experiments, the created scenario can implement the interactive control between devices. The experimental results are in line with expectations. Finally, after repeated tests and verifications, the system has good compatibility, stable operation, sensitive operation of the equipment, low power consumption, and can support long-term and large-scale use.

7. Conclusion

This article first analyzes the research status and development trends of smart homes at home and abroad, and expounds the development environment and mode of iOS-based smart home terminal control system. From the analysis of the system communication networking process to the final description of the function control operation module. The entire system design process. The system overcomes the shortcomings of the current smart home system in the market that is not easy to control and lack of multi-device scene control linkage. Using iOS development platform to apply MQTT communication transmission protocol and ZigBee communication technology to achieve a multi-level, multi-device, multi-task, a full range of smart home control system. The system design process covers iOS application software development, MQTT communication protocol introduction, and core key technologies based on ZigBee smart home networking interaction, and has certain reference and
reference value for in-depth research on smart home related technologies. At the same time, this article adopts the current mainstream MVC design pattern, multi-functional equipment communication control, and rapid human-computer interaction operation experience. It is practical and easy to promote, can effectively improve the quality of home life, and it can effectively improve the quality of home life and has important practical significance for the construction of human intelligent life.

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