

Interactive Smart Home Design Based on Internet of Things

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Abstract—This article focuses on interactive and holistic smart home design for two-bedroom architectural pattern based on Internet of Things. Integrated system over home devices and information exchange among human, machine and things can be realized by connecting the home devices together with ZigBee agreement. Moreover, information on the environment, devices and the family members in the home can be transferred with the ZigBee network. The feasibility and interactivity of the proposed smart home design is demonstrated through experiment results.

Index Terms—smart home, sensor, Internet of Things, ZigBee technology

I. INTRODUCTION

Internet of Things, a brand-new field of technology, realizes the connection between things and internet under agreement with the aid of information sensors such as radio frequency identification, infrared sensor, GPS and laser scanner to exchange information and communicate, thus positioning, tracking, monitoring and managing intelligently [1]. With sensors, the application of Internet of Things can achieve the intelligence in human-computer interaction. With the aid of Internet of Things, human-computer interaction as well as information exchange and communication among things can be realized[2].

Smart home embodies the specific application of the Internet of Things, where network communication, automation and control technology and artificial intelligence technology are integrated on the platform of homes[3]. Compared with common homes, the smart ones, in addition to their traditional functions of homes for living, are also equipped with all-round information interactivity and the advantage of saving energy with the combination of network communication, information domestic appliance and equipment automation in them. All the devices in the smart homes are connected through the Internet of Things, enabling varied functions and means such as information home appliances control, lighting system, telephone remote control, indoor and outdoor remote control, anti-theft alarm, environmental monitoring and heating and ventilation control and so on[4-7].

In-depth researches have been conducted on smart home in America, Germany and Singapore, leading others in the world. The concept of smart home originated in 1970s. In 1984, the first smart building came into being in America, marking the realization of the concept of smart home. Now, smart homes

have been under batched construction in America and other countries. We Chinese got to know the concept of smart home at the beginning of 1990s and researches on the smart home system was conducted at the end of the 1990s. Now, the generation and popularization of Internet of Things help smart home turn to a new page. As wireless communication technology of Internet of Things takes place of complicated wiring technology and cheap sensors reduce the costs of smart homes greatly, development of smart homes has been promoted in China[8].

Currently, a variety of intelligent products for smart home can be found in domestic appliance market and the concept of smart homes has been well accepted. Based on the biometric technology, [9] proposed a smart intelligent security system by using face detection. Wire/wireless communication and multimedia were used in the development of the smart home security system. Su B. et al. designed a somatosensory interaction smart home system by introducing the Kinect depth sensor[10,11]. The system could achieve the intelligent control by user-defined gesture manipulation and speech recognition. Through bone tracking and voice recognition technology, the smart home interaction system was realized by experiment. [9-11] are targeted at a certain product or single system other than the overall home design. In addition, Shen B. et al. did a research on the design and accomplishment of smart home based on Internet of Things[12], which just made analysis from the perspective of smart home system design and left space for demonstration of the ways of interactivity.

In this article, with the aid of Internet of Things, all the home devices are connected to each other with ZigBee agreement with low energy consumption, forming a ZigBee network, where holistic system is designed, enabling multipath connection of smart home devices and human-computer interactivity. The design enables owners to interact with home services in many ways. The feasibility and interactivity of the smart home plan have been verified through experiment.

II. SMART HOME DESIGN

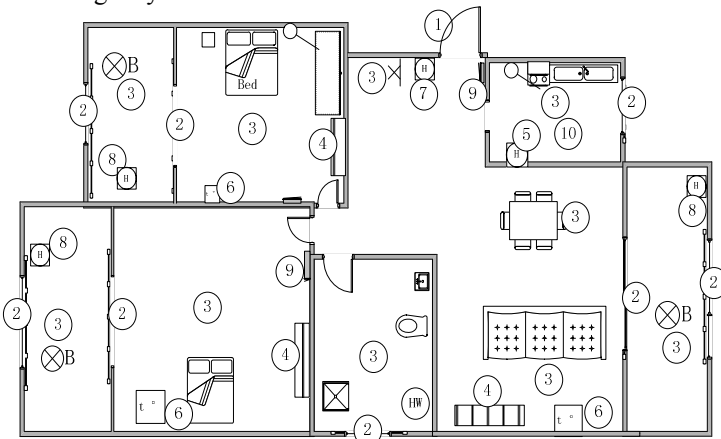
A. Comprehensive Design

With the aid of the Internet of Things, smart home integration design is conducted over architecture patterns with two bedrooms and two living rooms. The smart home design is as shown in Fig.1, in which, the Internet of Things can be

found in the following five aspects:

1. Entrance guarding system is positioned at 1 as shown in Fig. 1. The entrance guard is taken into smart home system in interactive smart home integration design. The door will be unlocked with fingerprints or entrance guard of the smart home system.

2. Curtain controlling system is positioned at 2 as shown in Fig. 1. The curtain will be pulled or drawn in accordance with light intensity with the aid of the sensor. Silicon photovoltaic detector with high luminous sensitivity even to dim light is adopted for the light intensity sensor. Under the thermoelectric effect, the hot junctions are on the active face while the cold junctions put inside. Thus thermoelectric voltage generates between the junctions. The light intensity sensor will collect environmental information to decide to draw or pull the curtain intelligently.



Notes: 1-Entrance guard; 2-Curtain; 3-Light; 4-Air conditioning and ventilating system; 5-Gas leakage sensor; 6-Temperature and humidity sensor; 7-Infrared sensor; 8-Light intensity sensor; 9-Control panel; 10-Smoke sensor

Fig.1. Smart home design

3. Lighting controlling system is positioned at 3 as shown in Fig. 1. Four modes have been set under the system, namely, harmony, study, recreation, visiting. The mode can be selected by cell phone or control panel with one simple touch. Meanwhile, infrared detector is installed at the door. When someone comes to the door, the light will be turned on by the infrared sensor which sensed the human body and the intelligent services will be provided automatically.

4. Air conditioning and ventilating system is positioned at 6 as shown in Fig. 1. Air-conditioning vents and temperature and humidity sensor are installed for each room. The sensors will send information collected to the smart home system, which will regulate the home environment automatically for comfort of the families in aspect of heating, cooling, ventilating and dehumidifying and so on.

5. Environment system is positioned at 5 as shown in Fig. 1. Gas leakage sensor and smoke sensor are installed in the kitchen. The gas leakage sensor will sense gas leakage and automatically close the valve. The smoke sensor will sense the fire or high-intensified smoke inside and send alarms, giving warning on the danger in the home for immediate measures taken.

B. Interactivity System in Smart Home Based on the Internet of Things

Smart homes based on the Internet of Things use technology of the Internet of Things to create and change the owners' home environment. With the interactivity more specific and flexible, the speed of response improved, the residence and home affairs management system constructed, interactive means between the owner and their homes intelligentized, the home services and intelligent home communication are also intelligentized. The interactivity home system, as a new interactivity system, allows direct intelligent interactivity among men, computers and things.

The subject of human-computer interactivity in smart homes based on the Internet of Things includes human and intelligent devices. In such homes, curtain controlling system, entrance guarding system, lighting controlling system, air conditioning and ventilating system, environment system, and security system are intergraded. Also, the multipath of interactivity can also be embedded into intelligent products and articles for daily use. Figure 2 illustrates the specific mechanism of human-computer interactivity in the entrance guarding system.

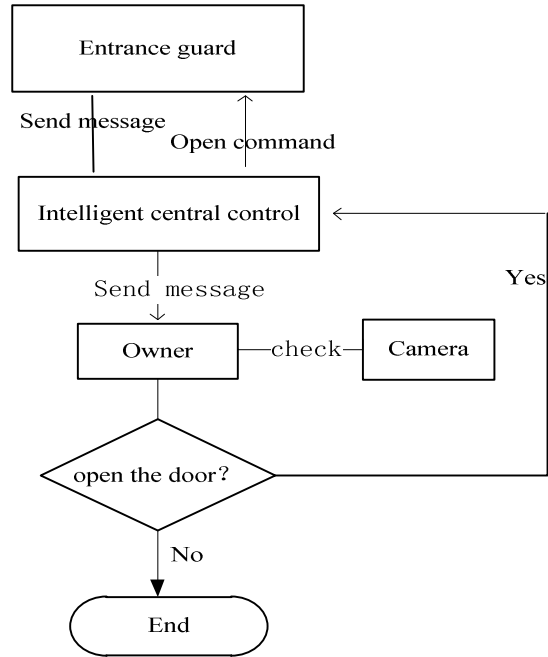


Fig.2. Mechanism of human-computer interactivity in the entrance guarding system

In the interactive design for the entrance guarding system, the visitors are allowed to leave text or voice messages via the system, which will then be sent to the owners by the central control unit. The owners, upon receipt of such message, can turn on the camera via the central control unit. In case the visitor is a friend, the owner can order the central control unit to open the door while the owner can make no response in case of a stranger. This is a scene where human-computer interactivity is realized.

In the interactive design for the curtain controlling system, the light intensity information is collected by the light intensity

sensor and then sent to the central control unit before the owner finally receives such information. The owner can determine whether and which part of the curtain shall be closed.

In the interactive design for the lighting controlling system, infrared detector is installed at the door. When the infrared sensor senses that someone opens the door, the light will be turned on by the infrared sensor and the intelligent services will be provided automatically. The owner can select a mode for different periods where the brightness of the lights will be set with one simple touch. For example, harmonious and romantic light can be set for meals, soft and eye-caring light can be set for study or work and bright and pleasing light can be set for meeting.

In the interactive design for the air conditioning and ventilating system, the temperature and humidity sensor will constantly collect data on the temperature and humidity around and send such to the central control unit, which will then turn on the air conditioning and ventilating system automatically or hand such choice over to the owner with message sent.

In the interactive design for the environment system, the gas leakage sensor and smoke sensor are installed and sense the environment around. In case of gas leakage sensed, the owner will be informed and the valve will be closed automatically. When the smoke is too heavy, message will also be sent to the owner for immediate measures taken in fear of grave accidents.

III.COMPONENTS OF INTERACTIVE SMART HOME

The central control unit is the control center of the whole smart home. The proposed system can be brought under remote control with computers, telephones or panels and other intelligent terminals which are connected with the network at home. Control over the whole home device can be gained by registering with the intelligent central control system. The control panel or intelligent terminal can also be used at home. By designed system, intelligent human-computer interactivity can be realized in favor of the owners.

A. Hardware Design

The central control unit is the core of the system, which communicates with ZigBee nodes under ZigBee communication agreement[13,14]. Connection among ZigBee nodes, switches, sensors and intelligent sockets of smart home system is shown in Fig. 3. In the plan, features of different types of domestic appliances are taken into accounts integrally and two kinds of major networking technology are adopted. The temperature and humidity sensor, light intensity sensor, infrared sensor, voice alarm, curtain controller and light controllers are connected with ZigBee networking technology and the chip of model CC2530F256 is adopted for ZigBee nodes. The entrance guarding system and the control panel are connected to the central control unit with WiFi[15].

B. Software Design

SQLite is adopted to establish the data management system under the plan. SQLite is a light relational database management system with minimal resources occupied, and

thus it has been adopted into many embedded products. QT is applied into platform development under the design. QT, a multi-platform application program framework with C++ graphics owner interface, generates extensions and some macro with special codes, easy in extending and tolerant for programming. In addition, the software IAR for 8051 is adopted for the smart home system development, which serves as the inevitable software in developing TI Z-Stack protocol stack application program and it is indispensable in program compiling, simulation and debugging.

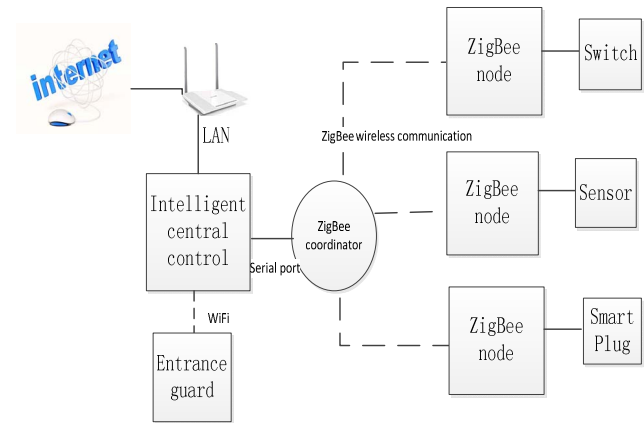


Fig.3. Structure of smart home system

Remark 1. The article focuses on the research on designing smart home with integration of the Internet of Things and wireless networking technology to realize human-computer interactivity and the verification of such design. Given that the object targeted in the design is the single home, where data are limited, no discussion is made on data storage. Future research can be conducted on data storage and analysis in smart homes. The system can conduct concentrated analysis over the data collected to conclude the preferences of the owners for better intelligent response other than a single choice made by the owners repeatedly.

IV.INTERACTIVE VERIFICATION OF SMART HOME SYSTEM

To inspect the feasibility of the interactive smart home design, information domestic development and research platform (IDDRP) is employed. The interactive information is captured from the experiment. IDDRP was developed in Jiangsu Modernized Circulation and Sensor Network Engineering Technology R&D Center. The state-of-art technologies such as intelligent terminal development technology, wireless communication technology, sensor technology and embedding technology are adopted in the platform; enabling verification of smart home design. Fig.4 shows the information domestic appliance R&D center. The hardware needed in smart home design, including infrared sensor, smoke sensor, temperature and humidity sensor, the gas leakage sensor, the light intensity sensor as well as domestic facilities are also shown in Fig. 4.

To access the holistic and interactive results of the smart home design, nodes are allocated in accordance with five

majors systems of the smart home designed in the second part of the article. After node allocation, the effectiveness of holistic smart home design can be obtained in Fig. 5, from which, it is clear that with the smart home design, the indoor temperature keeps 24.4 °C, humidity 54.2% and the light intensity 105lm, accomplishing smart home integration design.



Fig.4. Information domestic appliance R&D center



Fig.5. The holistic control interface of proposed smart home system

To further access the interactive effect of the design, on-site inspection has been conducted over the interactive technology adopted in the entrance guarding system. The entrance guard under the smart home system is installed and debugged. The system interface display can be viewed in Fig. 6, where there are two buttons on the homepage of the entrance guarding system, namely, message and fingerprint.

The switch can be controlled via finger recognition or the button "Door open" on the central control interface.



Fig.6. Entrance guarding system interface

The scene where a visitor came to an absent owner was simulated. Then, the visitor chose "voice message" on the interface to leave a message to the owner. The owner, upon receipt of the message, through remote registration with the smart home system, opened the camera to identify the visitor and decide whether to open the door or not. Fig. 7 shows the interface of door opening by remote login, which indicates the success in setting human-computer interactivity in the entrance guarding system.

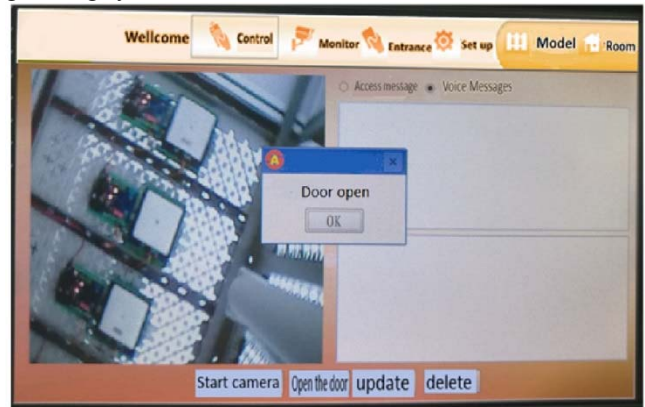


Fig.7. The interactivity in door opening control interface

Remark 2. Currently, preliminary interface design has been finished without consideration on look or convenience taken. In-depth development is about to be conducted over the system along with deep-going research carried out over humanized design of the human-computer interactivity interface.

V.CONCLUSIONS

In this article, technologies of the Internet of Things are employed into varied domestic facilities and smart home integration is designed. In the design, sensor technology under the Internet of Things and wireless ZigBee networking technology are applied to ensure all-round information exchange among human, computer and things to realize home intelligence. The integration and interactivity of smart home

design have been verified via IDDRP and the feasibility of the design is indicated by experiment results.

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