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Design and Implementation of Home Care and Intelligent Control System for Empty Nest Based on Internet of Things

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Abstract: This paper introduces the design background of the home care and intelligent control system for empty nesters. With the development of economy and the increasing cost of living, the pressure of young people is increasing, and they have to leave the elderly to work in the field. We must realize that there are serious security problems and mental health problems in the long-term leaving the elderly at home alone. Therefore, this paper designs an empty nest elderly home care system based on WiFi communication and embedded technology according to the Internet of Things architecture. The system can provide remote care and real-time monitoring of danger for the children of the elderly, and can effectively prevent the elderly from having an emergency situation at home alone without timely treatment. The main functions of the system include real-time video surveillance, fire warning and harmful gas monitoring, temperature and humidity monitoring, light intensity monitoring, indoor lighting intelligent control, etc.

1. Design Background of the System

According to relevant statistics, the number of people over the age of 65 in China is showing a surge, and the trend of population aging is increasing. In 2018, the number of people over the age of 65 in China has reached 16.658 million, accounting for 11.9 % of the total population in China. There are more and more elderly people, and the number of empty nesters is not a small number. Therefore, it is difficult to guarantee the home safety of these elderly people when their children are not around. Every year, there are not a small number of family accidents caused by the lack of care for the elderly at home[1]. Nowadays, although there are many elderly care equipment in the market, such as emergency callers for the elderly, human body sensors and other related products, but they have a single function, low monitoring accuracy, real-time care for the elderly is not high enough, some abnormal behavior of the elderly is not sensitive enough to identify, early warning of harmful gases or combustible gases and response measures are not flexible enough, and the corresponding pension institutions, nursing workers and other resources are also very scarce, and expensive, many families can not afford[2].

So this paper aims to provide real-time monitoring and risk warning for the elderly who are not around their children, try to share the pressure of their children, and prevent the occurrence of family accidents. We can use embedded technology to realize remote care and danger alarm for the elderly living alone through the application of sensors, and carry out some intelligent control when necessary.

2. Overall Design and Technical Introduction

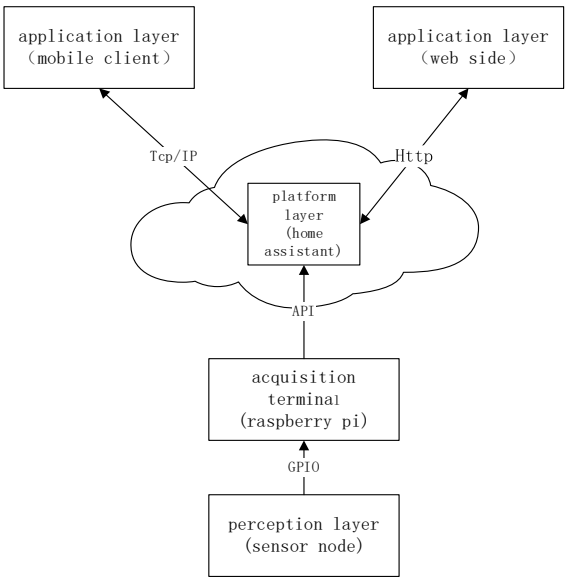

Figure 1: Overall system architecture

According to the overall structure diagram of Figure 1 system, the function of the system is mainly divided into two parts, including hardware part (perception layer) and software part (network layer, platform layer, application layer). The sensing layer is mainly a variety of sensor nodes ; the network layer and platform layer (back end) mainly refer to the construction of internal network server and external network access service through raspberry pie ; application layer is the so-called user can directly access the webpage or APP.

The secondary design mainly uses embedded technology, API application interface technology, intranet penetration technology and so on. Among them, embedded technology occupies a pivotal position in hardware development. In the application technology of the Internet of Things, embedded technology is crucial. The home care and intelligent control system of empty nesters is based on the embedded development of raspberry pie, which has strong computing performance, comprehensive software support, and the ease of use of open source hardware[3].System perception layer sensor data uploaded to the server built by raspberry pie requires an API interface to complete[4].Since the server built by the raspberry pie can only be accessed through the local area network (intranet), the system needs to map the IP of the raspberry pie to the external network (public network) by using the method of intranet penetration to achieve remote access[5].

3. Detail Design

In this chapter, we will mainly introduce a detailed design of the system and the detailed design and actual stage of several key modules in the system.

3.1 Hardware Design

3.1.1 Video Monitoring Module

The real-time video surveillance module for the elderly mainly uses the camera of the official CSI interface of raspberry pie, and is completed by calling the open source motion component under Linux. The video monitoring function of this system can clearly obtain the real-time status of the elderly.

3.1.2 Fire Warning and Harmful Gas Detection Module

The function of the module is mainly to collect the environmental data of the elderly through the MQ2 sensor of the perception layer. If harmful gases and combustible gases are detected, alarm notifications will be sent at the software side. The fire warning and harmful gas detection module of the system can detect the current environmental information more sensitively and send alarm notification to the software side.

3.1.3 Temperature and Humidity Detection Module

The function of this module is mainly to collect the current ambient temperature and humidity of the elderly through the DHT11 sensor in the sensing layer, and upload it to the server database built by the terminal raspberry pie, and synchronize the data to the software side through the API interface[6].The temperature and humidity detection module of this system can accurately detect the current temperature and humidity, and real-time display in the software side.

3.1.4 Lighting Intelligent Control Module

The module is mainly through the perception layer of human infrared sensors[7]、Sound sensors and photosensitive sensors cooperate to control indoor lights. When the light intensity is low, people and sound are detected, the indoor lights will be opened.

3.2 Software Design

3.2.1 Server Selection and Construction

This system needs to connect to the Internet through WiFi module to realize the function, must have the server to store data. There are two solutions: one is to build the server itself, and the other is to directly use the Internet of Things platform services provided by other companies on the market. Here, we choose to build our own data cloud server. The raspberry pie installs HA (Home assistant), and builds the raspberry pie as the server of the system. The sensor data are synchronized to the sensor of the HA platform component in real time through the API interface of HA. All the data synchronized to the sensor component are automatically stored in the database. The HA Internet of Things platform server uses the Sqlite3 database[8].

3.2.2 Web Page Module

Because HA can only run in the local area network, users want to remote access, you need to build services on the public network, the local area network port mapping in the public network, here I use Natapp, Natapp services can be bound by the domain name for your local page applications outside the network access.

This system through the HA Internet of Things platform to build a Web terminal, users through

PC browser or mobile browser can realize remote real-time monitoring of the elderly and real-time view of all kinds of sensor data.

3.2.3 Mobile module

The HA service built by the mobile terminal and Raspberry Pi is communicated through TCP / IP, the TCP / IP transmission protocol, the transmission control / network protocol, also known as the network communication protocol[9]. The system has two ways of mobile communication, the first is through the installation of mobile phone APP (HA mobile client) through the APP can view the system status in real time (mobile terminal and raspberry pie in the same LAN); another is to access the front-end interface of the HA platform through a mobile browser to view the system status in real time.

4. System test

The purpose of system testing is to detect whether the home care and intelligent control system of empty nesters based on the Internet of Things meets the expected goals. Whether the elderly can timely monitor the abnormal environment and make corresponding actions. Firstly, it is necessary to test whether the function of the system is complete and the system is stable. Secondly, it is necessary to test whether the system collects and uploads HA platform data accurately. Finally, you need to test whether the system can complete the expected functionality. After the test, if the system reaches the expected goal, it will pass the test. Otherwise, it is necessary to analyze and adjust the problems until the expected goal is achieved.

4.1 Testing Environment

In order to test the system function modules properly, the test environment should be based on the local computer and the corresponding software environment. Test environment table 1 shows.

Table 1: Test Environment

Testing item	Testing hardware	Testing software
Sensor modules	DHT11, PCH8591, gas sensor, Body infrared sensor, sound sensor	Thonny Python IDE
alarm notification module	Gas sensor	Home assistant
Vlient	PC client, Mobile client	PC, phone

4.2 Functional Test

4.2.1 Sensor Function Module Test

The home care and intelligent control system for empty nesters based on the Internet of Things is divided into sensors for real-time data display and automatic sensors for testing. Functions for testing as shown in table 2.

Table 2: Test results

Sensor	Testing content	Number of test data	Number of effective data forwarding	effective rate
Temperature and humidity sensor	Temperature	25	25	100%
Temperature and humidity sensor	Humidity	25	25	100%
Light intensity (PCH8591)	Light intensity	25	24	96%
Sound sensor	Is there a sound	25	23	92%
Gas sensor	Gas strength	25	23	92%

4.2.2 Test of Alarm Notification Module

When a gas concentration data reaches a threshold, it is sent in the HA platform notification bar. Test table for alarm notification module as shown in table 3.

Table 3: Alarm Module Test Table

Testing content	Number of test data	Success times	Success rate
Is notification sent	25	24	96%

4.2.3 Client Test

This test is mainly to test whether the HA Internet of Things platform can normally receive each sensor data and real-time screen. As shown in table 4, the software test table.

Table 4 shows the test table for real-time data acquired by the HA Internet of Things platform.

Table 4: Software test table

Testing item	Test control times	Control of successes	Success rate
PC client	25	23	92%
Mobile client	25	24	96%

5. Conclusion

This paper studies the home care and intelligent control system of empty nesters based on Internet of Things. The system for empty nesters environmental parameters acquisition and real-time video surveillance, can realize the real-time care and remote monitoring of the elderly, has high application value. This system has many shortcomings, such as the need to access WiFi with the use of WiFi signal problems, the system will not be able to use, in the future can use NB-IoT[10]; there are few home intelligent devices connected to the system. In the later period, the HA (homeassistant) Internet of Things platform can be used to add specific functions to the home intelligent devices. I will continue to strive to improve the function and update the system technology so that it can reach a higher application level.

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