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Design and Implementation of Intelligent Home Environment Monitoring System

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***Abstract*—Monitoring the home environment is conducive to improving the comfort and convenience of the home environment and improving the quality of life of the family. Through the design of the indoor home environment monitoring, the monitoring system architecture of the smart home environment is deeply analyzed and studied. In addition, raspberry is used as the embedded processor of the smart home environment monitoring system. raspberry is equipped with sensors to collect and process environmental parameters in real time, and uploaded to the OneNET platform for real-time monitoring of the smart home environment. The experiment and test prove that the system can meet the basic needs of home environment intelligent monitoring, and complete the function test of smart home monitoring system.**

Keywords-Environmental monitoring; raspberry; Embedded Internet of Things; OneNET platform

I. INTRODUCTION

With the continuous improvement of people's living standards and the rapid progress of Internet of Things technology, the demand for home intelligence in modern society is also gradually increasing. People's demand for home environment not only needs to meet the comfort, but also pay more attention to the complete intelligence [1]. Embedded Internet of Things technology has been widely welcomed and applied at present, the use of embedded Internet of Things can not only reduce the manufacturing cost of household products, but also help promote the continuous progress of smart home systems to the direction of embedded technology, but also provide people with a more comfortable place to live. At present, raspberry has the advantages of low power consumption, miniaturization and stability compared to the market controller. Therefore, this paper uses raspberry as the central controller, combines temperature and humidity, light intensity, $CO_2$and other environmental data sensors to interact with the OneNET cloud platform, and uses the mobile cloud APP and PC OneNET view cloud platform to remotely control and monitor the home environment and monitor each function module in real time. Through smart home environment monitoring, the life of residents is more convenient, which is conducive to providing residents with a more comfortable indoor living environment, ensuring the health and comfort of the family environment, improving people's quality of life, and meeting the needs of modernization.

II. OVERALL DESIGN OF INTELLIGENT FURNITURE ENVIRONMENTAL MONITORING SYSTEM

At present, smart home has been widely used, Majdi Rawashdeh et al. [2] used Activity Recognition (AR) to study sensors assign activity labels and event sequences, making the identification of home activities more efficient, flexible, and accurate and has brought great convenience to everyone's daily life. The requirements for the smart home environment monitoring system generally include three links, as shown in Figure 1. It mainly realizes three functions, the first is to become aware of the data collection of the layer of the smart home network, the second is to realize the whole house coverage design of the smart home network layer, the third is to realize the use of the smart home network cloud platform, and the data is visualized [3].

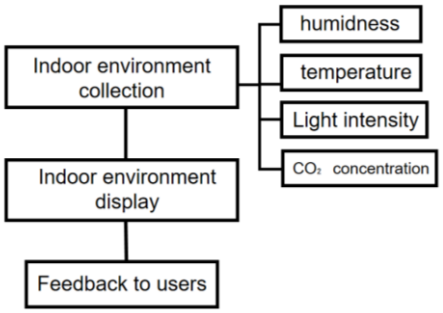

Figure 1. Home environment intelligent monitoring system link

Smart home environment monitoring system needs to be constantly updated and improved to more efficient equipment control and data processing, while the information needs to be converted into a visual interface, in order to provide good interpersonal collaboration functions, so that residents can carry out more comfortable indoor environment integrated management through intelligent home environment monitoring. From the standpoint of residents to think about the problem and optimize the system, is primarily seen in the aspects that follow:

First, the four basic environmental factors of indoor household are collected, which are temperature, humidity, light intensity and CO_2 concentration [4]. Temperature sensors, humidity sensors, light intensity sensors, CO_2 concentration sensors are used to monitor the environment and collect related environmental parameters.

Second, the development of intelligence and automation of indoor home facilities enables users to monitor and manage these devices in real time. Based on intelligent technology, sensor acquisition and wireless transmission are used to realize remote monitoring and management of home system. Through wireless data transmission technology, these data are sent to the remote control center to realize the monitoring and management of the entire indoor environment. At the same time, the collected data information is carefully sorted and

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collected, and then a fuzzy neural network model is constructed. Through the in-depth study and continuous learning of these data, a comprehensive smart home database system is established, so as to evaluate the indoor environment in real time, in order to improve the comfort of the home environment.

Third, the use of affordable and reliable materials and systems to save the cost of home intelligent systems, so as to design cost-effective products. In the detection system of the smart home environment, various types of hardware are indispensable, therefore, on the basis of ensuring the quality of the hardware, it is also necessary to attach great importance to the total cost of the smart home environment monitoring system. Choose cost-effective sensors, transmitters or controllers and other related equipment to reduce the cost of the entire smart home system. In addition to hardware costs, software issues are also what we need to consider, and the function of the software system needs to pay attention to stability and reliability to better adapt to the development of the system.

Fourth, the intelligent monitoring system of the home environment needs to have excellent adaptability to adapt to different types of households, and its wiring should be simple, without large-scale line transformation of the houses that have been renovated. Given the need to simplify the wiring of smart home monitoring systems, we can choose to use raspberry's wireless transmission technology and combine it with the terminal monitoring network to transmit information. This method can not only significantly reduce the complexity of wiring, but also make the home environment look more beautiful.

Fifth, the system is equipped with a visual operation interface, which allows users to easily and intuitively understand the home environment information. Through the OneNET platform [5], users can operate instructions on this interface to accomplish the system's human-computer interaction, and make corresponding adjustments and improvements to the structure and function of the indoor environment monitoring and control system on this basis. In this way, users can more easily and quickly query the indoor environmental information, but also more efficiently give instructions, so that users can realize the interaction and comprehensive management of information through the home intelligent environment window.

III. ARCHITECTURE AND FUNCTION DESIGN OF SMART HOME ENVIRONMENT MONITORING SYSTEM

A. Overall system architecture

Clarify the work level of the system to ensure the needs of intelligent detection of the Internet of Things home environment. In practical applications, the intelligent detection system of the Internet of Things home needs to be designed in layers, and the intelligent detection system of the Internet of Things home environment can be mainly divided into three levels: user service layer, data transmission layer and data acquisition layer.

In the intelligent monitoring system of the smart home environment, the main responsibility of the user service layer is to further collect the information of the indoor environment, and interpret the information in depth through specific programs, complete the analysis and processing of the corresponding data according to the actual needs, and finally backup and manage the collected data, so as to achieve the purpose of intelligent control of the operation of home indoor equipment. In the data transmission layer, Raspberry-mounted sensors are mainly used to transmit information, collecting data from the lower sensor devices to ensure that information can be exchanged efficiently. On the data acquisition layer, it is necessary to use some intelligent terminals to carry out information processing and control, so as to complete the home environment monitoring and alarm function. Obtain comprehensive information about the indoor environment by utilizing a variety of sensors, such as temperature sensors, humidity sensors, light sensors and carbon dioxide concentration sensors. At the same time, we connect the data measured by the data acquisition module to the OneNET iot cloud platform through WIFI, and realize the visual display of environmental information.

B. Function Design

The functions of the home environment intelligent detection system need to be scientific, rational and efficient. In order to better meet people's needs for intelligent monitoring and management of home environment in daily life. It is also necessary to design a home environment monitoring system that integrates data collection and analysis from the perspective of user needs, and conduct more in-depth research and optimization of the entire smart home environment monitoring system. From the perspective of software architecture, this application system is mainly composed of the following modules: central management system module, temperature monitoring system module, humidity monitoring system module, CO_2 concentration monitoring system module and illumination monitoring system module. With raspberry as the central processing unit, various parameters of home living environment are collected in real time.

First, central management system module. This module plays a global management function in the central management system module, and can perform multiple tasks such as data maintenance, collection and analysis of indoor environment resources, equipment maintenance, data query and database storage and maintenance.

Second, system module for monitoring temperature and humidity. The system can also display the temperature and humidity values of each area in the indoor environment according to the needs of users. This module is able to monitor the temperature and humidity of the indoor environment in real time and collect the relevant data, so that the comfort of the indoor space can be quickly assessed. If the detected temperature and humidity exceed the preset limits, the system will prompt the user to adjust the said device manually by mobile phone or other devices.

Third, system module for monitoring CO_2 concentration. This module can monitor the CO_2 concentration in the indoor environment in real time, and once the CO_2 concentration is detected to exceed the health standard, the system will immediately issue an alarm to ensure the health and safety of

the occupants. When the household electrical equipment fails, the module can alarm in time and automatically cut off the power supply. This module helps to reduce the potential safety risks of internal high-power appliances; Through real-time monitoring of CO_2 parameters and comprehensive processing of these measurement data, if the set threshold is exceeded, the system will activate the alarm device and issue a warning to remind the outside world to intervene.

Fourth, system module for monitoring light intensity. The module has the ability to collect indoor light data in real time, so that the indoor light condition can be accurately evaluated.

As the middle level service platform of the whole system, the smart home monitoring platform has good coherence, making the interaction and communication between different modules more smooth. At present, the smart home network has become a very key part of the current social development process. Among many technologies, multi-sensor fusion technology is regarded as an efficient means of information processing, which has been widely used in smart home network system, and can sense and collect complex indoor physical information.

IV. Using the Template

A. *Embedded hardware platform*

Embedded systems are mainly composed of software components and hardware components. According to the functional requirements, the hardware part is mainly composed of temperature and humidity, light intensity and CO_2 concentration acquisition module. The software part is composed of four basic components: main control unit, data memory, display control unit and communication interface. The system is Raspberry-centered processing module, the chip has strong processing power and high reliability, but also has good scalability. Through the practical application of the system, the whole system has strong expansibility, can be applied to different types of equipment, but also has strong reliability, security and anti-interference. We mainly used Broadcom BCM2835 chip and raspberry with Cortex-A53 64-bit architecture as the central processing unit, we used DHT11 temperature and humidity sensor, BH1750 light intensity sensor and TGS4160 carbon dioxide sensor, etc. As a parameter collection unit of the family living environment. Through the real-time detection and control of indoor temperature, the design of smart home control system based on Internet of Things technology is realized. raspberry is equipped with 40 GPIO interfaces to facilitate system construction, and the system hardware structure is shown in Figure 2.

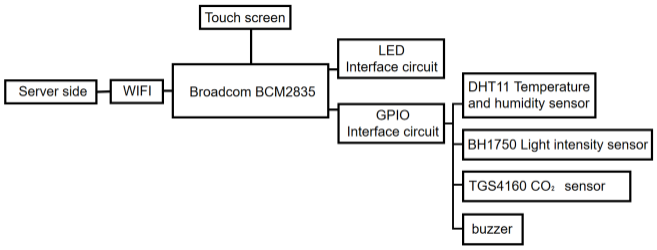

Figure 2. System hardware structure

B. *Data acquisition module*

1) *Temperature and Humidity Measurement Module*

System module for monitoring temperature and humidity. This module mainly includes temperature and humidity detection module and data transmission module. This module is able to monitor the temperature and humidity of the indoor environment in real time and collect the relevant data, so that the comfort of the indoor space can be quickly assessed [6]. The overall function consumption of temperature and humidity data acquisition module is relatively less, and it also has high reliability. By using this module, to enhance the resistance to interference, so as to ensure the stability of its operation. The temperature and humidity of the system are measured by using the DHT11 sensor. DHT11 is connected to raspberry through the I/O interface to achieve simple single-bus communication, and raspberry will process the 40 bit data provided by DHT11 and calculate the current environment temperature and humidity based on it [7]. The specific temperature and humidity sensor measurement circuit diagram is shown in Figure 3.

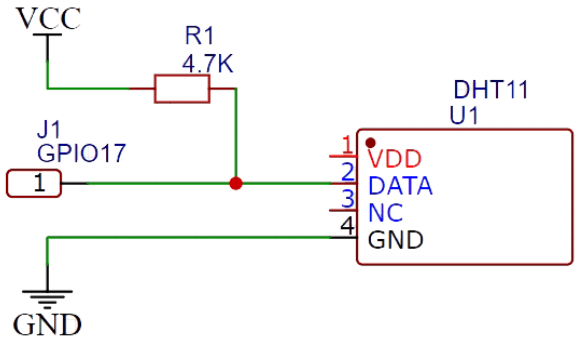

Figure 3. Temperature and humidity sensor measurement circuit diagram

2) *Light Intensity acquisition module*

Light intensity acquisition module, used to collect the strength of the light in the home environment, monitoring the extent of the surface area of the object is illuminated sensor. As an important sensor type, it is mainly used to detect the light intensity in the home environment and convert the detection results into electrical signals for subsequent processing and control. It is easy to adjust the indoor lighting immediately, maintain the appropriate indoor lighting conditions, improve the comfort of the home environment, save energy, and also have a certain security guarantee. For example, the brightness of the lighting equipment is adjusted according to the preset threshold to ensure the appropriate lighting level [8]. When the light is sufficient, the brightness of the indoor light can be reduced to save energy [9]; At night or in low light, use the light sensor to detect abnormal lighting and trigger the alarm system or other safety measures. Light intensity sensor measurement circuit diagram, as shown in Figure 4.

The specific calculation formula used is:

$$\text{Light intensity} = \frac{(\text{Register value}[15:0] * \text{Resolution})}{1.2} \quad (1)$$

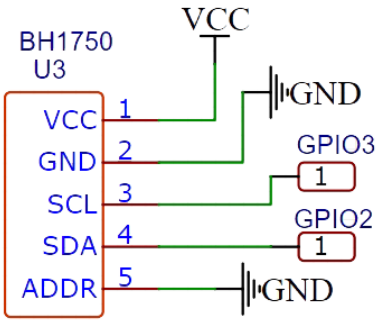

Figure 4. Light intensity sensor measurement circuit diagram

3) Carbon dioxide concentration measurement module

TGS4160 produced by FIGARO is selected as the CO_2 concentration sensor to detect the CO_2 concentration. Compared with traditional gas detection, it has high accuracy and rapid response. Given that raspberry does not have a built-in digital-to-analog interface, its externally connected PCF8591 digital-to-analog conversion module is designed to convert the analog signal output from the sensor into a digital format. The CO_2 concentration value is represented by the horizontal coordinate x of the sensor sensitivity characteristic curve, so the specific concentration value can be obtained by using the value x at a certain point on the curve and the concentration slope α.

The specific concentration is calculated as follows:

$$x = 10^{\wedge}\frac{log(\frac{RS}{R0}) - y}{\alpha} + x \qquad (2)$$

When the output voltage of the signal to be measured is greater than the threshold voltage, the comparator outputs a low level and lights up the LED lamp to issue an alarm. The alarm module includes a buzzer, which is used to issue an alarm when the harmful gas in the surrounding environment reaches the preset threshold. The buzzer will make a sound to warn the user and send a warning email to the user. The experimental results show that the concentration of CO_2 and smoke are both in the range of 300-450 ppm, and the system considers the environment to be safe within the range of acceptable error. When the concentration exceeds 1000 ppm, the system determines that the environment is unsafe and triggers the alarm module to issue an alarm. Carbon dioxide concentration monitoring circuit diagram, as shown in Figure 5.

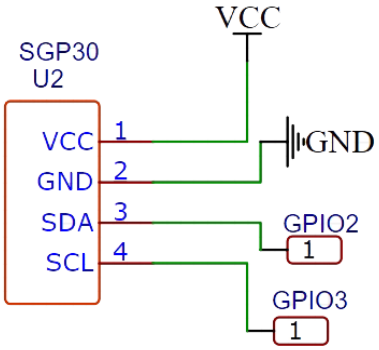

Figure 5. CO_2 concentration monitoring circuit diagram

C. System software design

The software is mainly based on Linux operating system, using C language to carry out modular design, and through multi-thread programming to realize the module start and stop. The system can process and store the data collected by different kinds of sensors, and also has display function and alarm function.

The main program flow design, mainly for raspberry power on, connected to the OneNET platform, every 10 seconds to obtain temperature and humidity, light intensity, CO_2 sensor value, if the monitoring data reaches the threshold to send a warning or buzzer alarm to the OneNET platform; On the contrary, the data does not reach the set threshold without alarm, and the data is directly transmitted to the OneNET platform. The specific main program flow is shown in Figure 6.

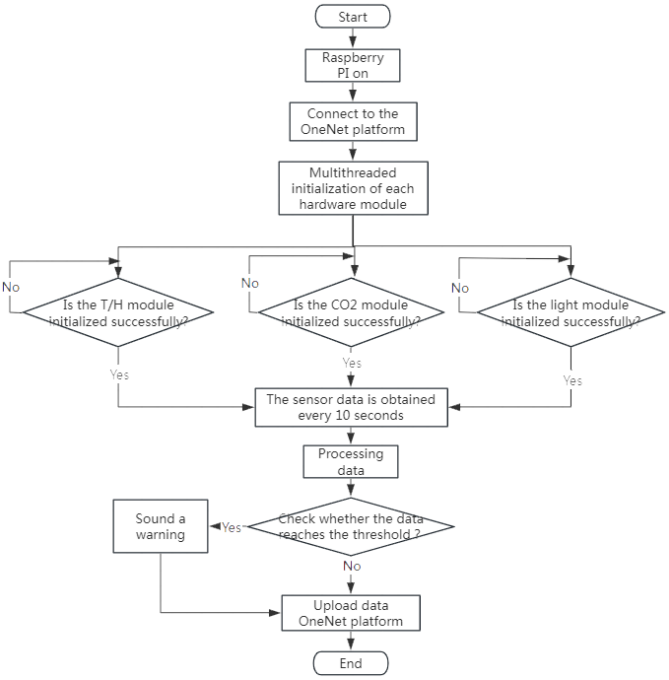

Figure 6. Main program flow chart

D. Visual data and user interface design

Use visual man-machine interface, including control interface and real-time data display interface. This user interface not only helps users to carry out data statistics, but also provides a convenient way for residents in their daily life, through this interface, they can better understand the indoor environment, so as to achieve the main purpose of real-time query.

Through home intelligence technology, residents can further improve the comfort of the entire environmental window, while also helping to achieve human-computer interaction and integrated management of the system. During the initialization of raspberry's powered IO port, the system sends ambient temperature, humidity, CO_2, and light intensity monitoring data to OneNet for visualization, as shown in Figure 7.

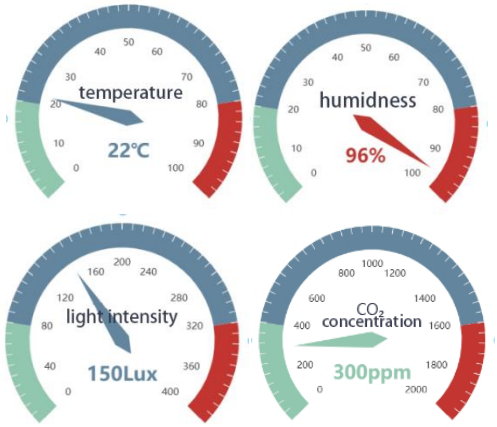

Figure 7. Main program flow chart

V. CONCLUSIONS

The monitoring of the home environment plays an important role in improving the comfort and convenience of residents. In this study, raspberry as the central processing unit, proposed a smart home environment monitoring system architecture, using raspberry equipped with sensors to collect and process real-time environmental parameters, and upload the data to the OneNET platform for continuous monitoring. The experimental results show that the system can meet the basic requirements of intelligent home environment monitoring, and successfully passed the function test of intelligent home monitoring system. After many tests, the system shows that the collection, upload and control of environmental parameters have stability, and the cost is not high, and compared with other smart home systems on the market, the function is more complete and targeted. However, in terms of intelligent control, this paper lacks an automatic control system in the absence of the Internet. Later, it is expected to add more sensor acquisition in the controller, so that when unmanned equipment is controlled, the device can make self-judgment through its own collection of surrounding conditions, and perform corresponding actions to ensure the home monitoring environment.

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