Design of Monitoring and Controlling System for Smart Home

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Abstract. An intelligent lifestyle has become a hotspot for researchers and industries nowadays. The smart home monitoring and controlling system with the Arduino as the main controller is designed in this paper, combined with sensors, Wi-Fi, and cloud technologies. Various sensors collect household environmental information, such as indoor temperature and humidity, soil moisture, combustible gas concentration, and light intensity. The main controller processes the collected signals and automatically operates the devices, including a refrigeration equipment, water pump, buzzer, fan, stepping motor. The data can also be transmitted to the cloud platform through Wi-Fi for processing, and the home environment information and device can be remotely monitored and controlled by the cloud platform or smartphone APP.

1. Introduction
With the continuous development of related technologies in the field of the IoT (Internet of things), the improvement of sensor technology and the reduction of cost have promoted the process of intelligent life[1]. The IoT has unconsciously integrated into people's life and brought great convenience to people. The smart home system is based on residence, using automatic control technology, communication technology, cloud technology, and other home device to jointly build an intelligent home system[2].

In this paper, several sensors are used to collect the home environment information. The system automatically controls the device according to the information. At the same time, users can also monitor and control the device remotely. Combined with the typical functions and requirements of smart home[3], the specific functions in this paper are as follows: the temperature and humidity sensors are used to collect indoor temperature and humidity, based on which the refrigeration equipment can automatically control the indoor temperature; the soil moisture sensor is used to collect the soil moisture content, based on which the water pump can automatically irrigate flowers; the combustible gas concentration sensor is used to collect the indoor combustible gas concentration, based on which the fan and buzzer can automatically exhaust and alarm; the photosensitive sensor is used to collect the outdoor light intensity, based on which the stepping motor can automatically realize the switching of the curtain; the system can also transmit the data to the cloud platform and smartphone APP through Wi-Fi, so that the remote monitoring of home environment information and manual control of device can be implemented.

2. Overall System Framework
The overall block diagram of the smart home monitoring and controlling system is shown in Figure 1. The main controller is the Arduino based on the ATmega2560 processor. The sensor module is used to collect environmental information, which includes a temperature and humidity acquisition circuit, soil...
moisture acquisition circuit, combustible gas concentration acquisition circuit, and light intensity acquisition circuit. The collected environmental information is transmitted to the main controller module and displayed in the display module after processing. After judging the environmental information, the main controller module sends on/off instructions to the devices such as refrigeration equipment, water pump, fan, buzzer, stepping motor. In addition, the main controller module can also transmit the environment data and device status information to the cloud platform or smartphone APP through the Wi-Fi module. The cloud platform or smartphone APP can also manually send on/off instructions to the devices through the Wi-Fi module.

![Diagram](image.png)

**Figure 1.** Overall block diagram of the system

### 3. Hardware Design

#### 3.1. Design of Temperature and Humidity Acquisition Circuit

The temperature and humidity acquisition circuit based on DHT11 is shown in Figure 2. The DHT11 is a temperature and humidity composite sensor with a calibrated digital signal output[4]. A single line serial interface is used in the sensor, and one I/O interface can measure temperature and humidity at the same time.

![Diagram](image2.png)

**Figure 2.** Temperature and humidity acquisition circuit

#### 3.2. Design of Soil Moisture Acquisition Circuit

The soil moisture acquisition circuit is shown in Figure 3. When the probes are inserted into the soil, the resistance value will change with the soil moisture content[5]. The output voltage is different as the resistance change. The adjustable resistor is connected to the INA- pin, where the voltage is the reference voltage. When the voltage in AC pin is greater than the reference voltage, the indicator lights up and a high level is output. When the resistance caused by the probes decreases, the voltage in AC pin output also decreases.
3.3. Design of Combustible Gas Concentration Acquisition Circuit

The combustible gas concentration acquisition circuit is shown in Figure 4. The MQ-2 smoke sensor is used to detect combustible gas and smoke. According to the actual environment, the circuit needs to be calibrated. The smoke detection circuit is placed in a pure environment. The potentiometer R4 is adjusted to change its sensitivity so that the voltage between pins 4 and 6 is within the range of 0.3 ~ 1V. After calibration, R4 is about 2.5 KΩ.

![Figure 3. Soil moisture acquisition circuit](image)

![Figure 4. Combustible gas concentration acquisition circuit](image)

3.4. Design of Light Intensity Acquisition Circuit

The light intensity acquisition circuit is shown in Figure 5, which is used to collect light intensity. The photoresistor is a resistor made of special semiconductor materials. Its working principle is based on the photoelectric effect. In the absence of light, the resistance is in a high resistance state; when the light intensity increases gradually, the carriers generated by the effect move under the action of the applied electric field, resulting in a gradual decrease in resistance.
3.5. Design of OLED Module Circuit
In this paper, the OLED display screen is used for display, and the circuit of the OLED module is shown in Figure 6. The OLED display screen and the main control board transmit data through the I2C protocol[6], and the SCL pins and SDA pins of both sides are connected.

3.6. Design of Wi-Fi Module
The circuit of the Wi-Fi module based on EMW 3080 is shown in Figure 7. The Wi-Fi module communicates with the main control board through the UART protocol[7]. The TXD pin of the Wi-Fi module is connected to the RXD pin of the main controller, and the RXD pin is connected to the TXD pin of the single-chip microcomputer.

4. Software Design
4.1. Overall System Software Design
The overall program design of the system is shown in Figure 8. After system initialization, the main controller judges the control mode. In the case of automatic control, the environmental parameters are
collected and displayed on the OLED screen. At the same time, the main controller judges whether to turn on or off the device according to the parameter value to realize automatic control. In the case of manual control, the main controller turns the device on or off according to the control command received.

The opening and closing of different device are somewhat different. The opening and closing of the refrigeration equipment, water pump, fan, and buzzer only need to be controlled by high and low levels. The opening or closing of the curtain is realized by the forward and reverse rotation of the stepping motor.

![Flowchart](image)

**Figure 8.** Overall system program design

4.2. *Sensor Module Programming*

After initializing each sensor, the values of the environmental parameter collected by the sensor can be obtained by calling the `analogRead()` function.

4.3. *OLED Module Programming*

After initializing OLED, the display position and data can be set by using the `u8g.drawStr()` function.

4.4. *Wi-Fi Module Programming*

The Wi-Fi module has been pre-burned with the AT basic firmware. The Wi-Fi module can be controlled by sending AT instructions through the serial port of the main controller.

4.5. *Cloud Platform Programming*

This design uses the Internet of things cloud platform service provided by Alibaba Cloud to manage the device and selects the MQTT (message queuing telecommunications transport) protocol for communication. The MQTT is based on the TCP/IP protocol framework. It has the advantages of low overhead, traffic saving, and asynchronous communication. It is suitable for Internet of things communication.

Firstly, it is necessary to build products on the Alibaba Cloud platform and define the devices used in the products, which are respectively smart home devices and control terminals. After adding devices, the Product key, Deviceid, and Devicesecret of each device can be got. These three parameters are
called device triples and are the authentication information necessary to build connection messages and log in to the cloud platform. The first byte of the fixed header of the connection message is 10, and the next byte is the length of this message. The variable header contains information such as protocol name and connection flag bit, and the load is mainly composed of ClientID, UserName, and PassWord. According to the requirements of the cloud platform, the ClientID is defined as * | securemode = 3, signmethod = hmacsha1 |, where * represents the client ID, which can be customized, securemode = 3 represents the security mode, TCP direct connection mode is selected, and signmethod = hmacsha1 represents hash encryption. UserName is defined as DeviceName&ProductKey. The message input is hashed and encrypted with DeviceSecret as the key, and the message summary is used as the login password. The message input is also constructed with the device triples.

After sending the connection message, when the connection reply message is received, it indicates that the login to the cloud platform is successful. The device changes from offline state to activated state. Similarly, functions such as publish and subscribe can be built according to MQTT protocol to realize the communication between the device and the cloud platform.

The instruction to publish data to the cloud platform is "AT + MQTTSEND = <len>" , where len represents the byte length of the published data, and the function snprintf() is used to calculate the byte length of the data packet. After sending the instruction, it is necessary to judge whether the expected reply ">" is received. If received, the data is converted to a JSON string format by using the sprintf() function before sending the data packet. If the expected reply "+MQTTEVENT: PUBLISH, SUCCESS" is received, it indicates that the data is sent successfully.

Subscription is similar to publishing. The return value of the function Serial.available() is used to determine whether there is buffered data on the serial port, and the function Serial.read() reads the serial port data.

4.6. Smartphone APP Programming
In the mobile visualization development module of Alibaba Cloud, users can use the templates provided by the cloud platform to customize the displayed content according to the created product information. Then, the executable APK files are generated by compiling based on Android platform. In this way, the design of smartphone APP for smart home system is realized.

5. Test
The physical hardware diagram is shown in Figure 9. After testing, the system can meet the design requirements of the smart home monitoring system. The overall operation of the system is stable and easy to operate.
6. Conclusion
Thanks to the development of Internet of things technology, the smart home will provide users with a better life experience. This design takes the Arduino as the core controller, combined with sensor detection, network communication, cloud platform, Android, and other technologies, puts forward a practical, reliable and easy operate smart home monitoring system. The system can not only realize the automatic control of home device but also remotely monitor the home environment parameters and manually control the device through the cloud platform and smartphone APP. The test results show that the system can obtain environmental parameters timely and accurately, and the communication between the device and cloud platform and the APP is stable. It can be widely used in families and other scenes that need to be monitored.

7. Acknowledgments
This work was supported by National Science Foundation of China (Grant No. 61801412), High-level Talent Project of Xiamen University of Technology (Grant No. YKJ17021R, and No. YKJ20013R), Scientific Research Climbing Project of Xiamen University of Technology (Grant No. XPDKT19006), and Education and Scientific Research of Young Teacher of Fujian province (Grant No. JAT190677, No. JAT200471, and No. JAT200479).

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