International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

Design of Intelligent Farm Environment Monitoring System

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Abstract*—Intelligent farm is through the network technology, automatic control technology, computer technology to farm crop growth environment related information through the equipment together, coordinate work, realize the intelligent management of the farm, change the traditional farming production mode, provide a more modern agricultural production mode. Intelligent farm is the development trend of agriculture in the future. Compared with the traditional farm which needs a lot of manual work, the greenhouse system which simulates the growth of crops can greatly reduce the artificial burden. On the basis of making full use of the Internet of things technology, the traditional functions such as temperature and humidity detection, irrigation water and water storage in the farm can realize intelligent and refined operation. In this paper, Arduino is designed as the main controller, which has DHT11 temperature and humidity sensor module, WiFi module, photosensitive sensor, water level sensor module and other functional modules. Through each module to collect and monitor the relevant temperature, light, humidity, light intensity, water level of farm pool and other signals, which are displayed by LCD; if there is an abnormal or emergency situation, it will be fed back to the user in the form of sound and light through the alarm module and display device. Through the use of computer technology and Internet WiFi technology, the system integrates and summarizes the information of various farms. At the same time, it has the characteristics of low cost, intelligence, high integration and low power consumption. It is a new idea and direction for the development of intelligent farms in the future. It is of great practical significance to help upgrade the industrial structure, adjust the economic strategy, and realize the agricultural informatization.*

Keywords*—Smart farm; intellectualization,;modularization; control, feedback.*

I. INTRODUCTION

A. Background

In today's world, with the continuous development of science and technology, intelligent environmental monitoring has become a topic of concern for human beings, among which the environmental monitoring problem of intelligent farms is also widely concerned, and some intelligent farm environmental monitoring systems have emerged as the times require. At present, because the population in rural areas is decreasing and agricultural production is declining due to aging, smart farms are gradually becoming an alternative to modern agriculture. The government is also actively promoting smart farms, with higher expectations and interests for the next generation of agriculture. Intelligent agriculture refers to a new management form based on information and intelligent agricultural management and service, which takes cloud computing as the core, makes full use of the Internet of Things and mobile Internet, integrates network communication technology into various agricultural environments, and provides a safe, convenient, modern and intelligent environment for all agricultural participants. [1]The intelligent farm environment monitoring system is to connect various sensing devices and detection modules together through the Internet of Things technology, and realize the farm's temperature and humidity monitoring, agricultural irrigation, voice recognition information anti-theft alarm and other functions through a unified integrated system, so that the farm can achieve intelligent management and reduce manual work. As a new concept, the intelligent farm environmental monitoring system is at the critical point of an exploration period and a growth period. With the popularization and further implementation of the intelligent farm environmental monitoring system, and the replacement of simple and complex daily manual management by intelligent management, the growth and development potential of the intelligent farm is bound to be huge and bright.

The system, under the control of Arduino as the control center, can monitor the temperature and humidity, light intensity, water level of water pump, etc. in the farm in real time, and give alarm feedback when the relevant environmental parameter data in the farm is abnormal.

This system mainly studies the following aspects:

(1) The component module of the intelligent farm environmental monitoring system. This design involves Arduino development board, DHT11 temperature and humidity sensor module, water level sensor, photoresist and other functional modules, which need to be learned and used correctly for assembly, programming and debugging to complete the design and achieve the design purpose.

(2) Arduino is compatible with all modules. Although Arduino motherboard has rich library functions and is highly modularized, there is some uncertainty about its compatibility with other modules, so the design clock needs to solve the compatibility problem.

(3) Module alarm feedback and display. The design of the intelligent farm environment monitoring system also involves displaying and triggering alarms to feed back to users when the monitored environment related quantity is abnormal. Therefore, 1602 LCD, LED and buzzer are also used to realize parameter display and abnormal state feedback.

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II. Overall System Design

A. Overall system structure

Hardware design

(1) Arduino SCM development platform, DHT11 sensor module, photoresistor sensor, esp8266WIFI module, water level module, etc.

(2) The module is connected and assembled.

Software design

(1) Arduino programming.

(2) Program the relevant parameters.

(3) Implement basic functions.

This design involves DHT11 temperature and humidity sensor module, ESP8266WIFI module, photoresistor sensor module, alarm module and other functional modules to identify and monitor temperature, humidity, light intensity, farm water level, etc. If the relevant monitoring objects are abnormal, the user can be alerted and displayed. It is a highly integrated and diversified intelligent farm environmental monitoring system, which is characterized by low cost, multi-function and intelligence.

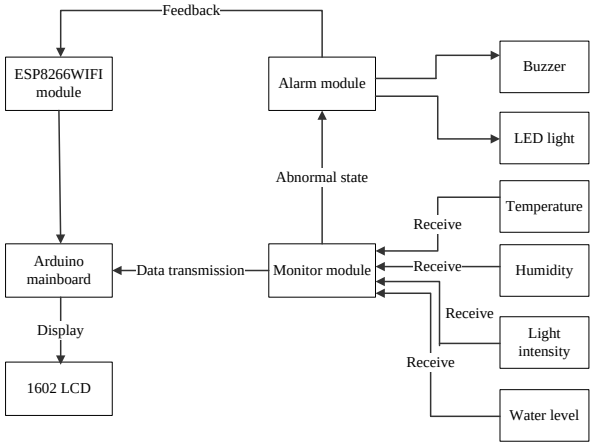

Fig. 1. Overall flow chart of the system.

B. Technology roadmap

The first step is to purchase Arduino development board, DHT11 temperature and humidity sensor module, ESP8266WIFI module, water level module and other components, and be familiar with the hardware structure of each module.

The second step is to learn how to use Arduino, how to write Arduino programs, and how to understand the main interfaces and integrated functional components on the Arduino control board.

The third step is to understand and learn the software programming methods of each module component, and to write relevant programs.

The fourth step is to connect and debug each module with the Arduino development board to realize the functions of temperature, humidity, light intensity and user voice recognition.

III. Hardware Design of Environment Monitoring System for Intelligent Farm Math

A. Temperature and humidity signal acquisition - DHT11 temperature and humidity sensor module

DHT11 temperature and humidity composite sensor is selected as the module for collecting temperature and humidity signals in this system design. It is a temperature and humidity composite sensor with calibrated digital signal output, which applies special digital module acquisition technology and temperature and humidity sensing technology. Its precision humidity is controlled at+- 5% RH, temperature is controlled at+- 2 ℃, range humidity is 20-90% RH, and temperature is 0-50 ℃. The power supply voltage is 3.3-5.5V DC, and the output signal is a single bus digital signal, which basically meets the coverage of Dapeng Farm. The sensor consists of a resistive humidity sensor and an NTC humidity sensor, which are connected to a high-performance 8-bit microcontroller. It has the characteristics of simple and fast system integration, small size, low power consumption, stable transmission capability, etc.

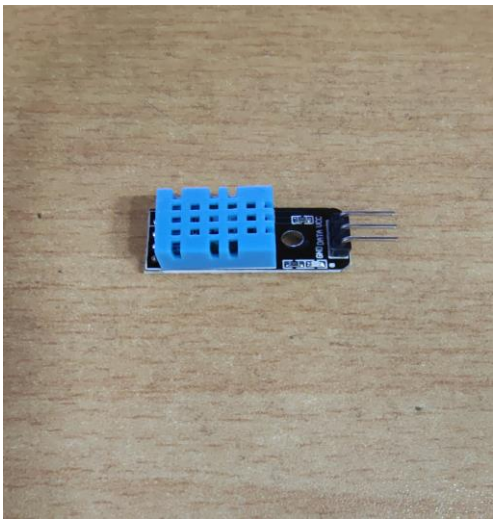

Fig. 2. DHT11 physical image.

B. WiFi connection - ESP8266WIFI module

The WiFi module used in this system design is ESP8266, which is a low-voltage low-power wifi chip with a high degree of integration. A 32-bit ultra-low power processor is built in to control the real-time operating system and the wifi protocol stack. The general operating temperature range is - 40~125 ℃. ESP8266 is widely used in serial port transparent transmission, WIFI remote monitoring, etc. It has the advantages of fast data transmission and high transmission reliability. [2] Based on the above characteristics, the ESP 8266 module can be used to quickly process the signals received by other modules in the farm system, and if necessary, it can also be connected to the user to achieve remote control.

The diagram and schematic diagram of ESP8266 are as follows:

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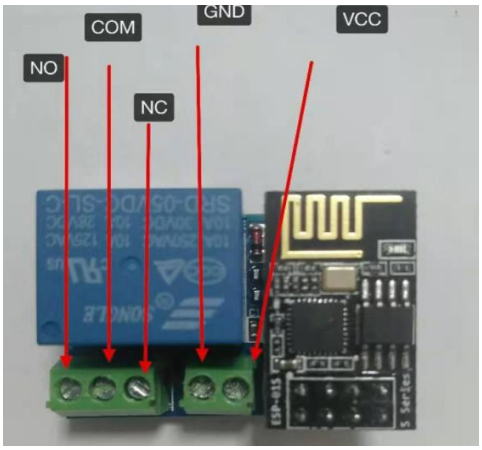

Fig. 3. ESP8266 module chip.

C. Light intensity acquisition - photoresistor sensor module

Photosensitive sensors use photosensitive elements to convert light signals into electrical signals, and their sensitive wavelengths can be within the range of visible light. The light intensity signal acquisition module designed in this system selects the photoresist sensor module, which is sensitive to the ambient light and is generally used to detect the brightness of the ambient light. The photoresist sensor module adopts a sensitive photoresist sensor, with a comparator output, clean signal, waveform number, strong driving ability, and a working voltage of 3.3V-5V. This design is to use its characteristics to detect the light intensity in Dapeng Farm and display it in real time.

When the ambient light brightness of the module cannot reach the set threshold, the DO terminal outputs a high level, and when the ambient light brightness exceeds the set threshold, the DO terminal outputs a low level. In addition, the DO end can be directly connected to Arduino to detect high and low levels through Arduino, thereby detecting changes in the light intensity of the environment. The small board analog output AO can be connected to the AD module, and more accurate values of ambient light intensity can be obtained through A/D conversion.


Fig. 4. Photoresistor sensor.

D. Water level monitoring - water level sensor module

The water level sensor module of Arduino is selected as the module for collecting and monitoring the water level in this system design. It is an analog input module, which judges the water level by measuring the water volume with a series of exposed parallel wire traces to complete the conversion of water volume to analog signal. The output analog quantity can be directly read by the Arduino development board to achieve the function of water level alarm.

The working voltage of the sensor module is 3-5 V, the working current is less than 20 mA, and the working temperature range is 10 ℃ - 90 ℃. It has the characteristics of low power consumption and high sensitivity. When the water level sensor is not inserted into the water, the output value is 0. As the water level sensor gradually submerges into the water, the value of the analog pin becomes larger and larger. When the water level sensor is completely submerged, the maximum output value is about 770. After the water level sensor is gradually pulled out, the value of the analog pin gradually decreases.


Fig. 5. Water level sensor module.

The pins of the water level sensor are shown in Table 1 below:

TABLE 1. Pin Description of Water Level Sensor.

Pin No	Name	Pin notes
+	VCC	Connected to positive pole of power supply
-	GND	Connected to power cathode
S		Analog signal output

The analog wiring diagram of water level sensor is shown in Figure 6 below:

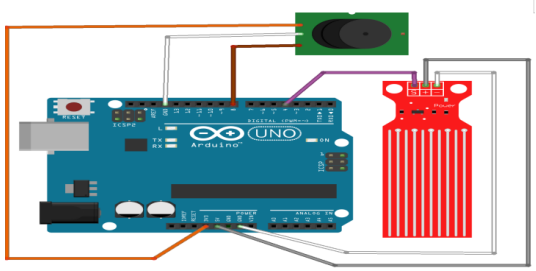
Fig. 6. Wiring diagram of water level sensor.

E. LCD 1602

The signal output module in this system design uses LCD1602 display screen to display temperature and humidity, light intensity, water level and alarm signals. It is a dot matrix LCD module specially used to display letters, numbers, symbols, etc. It is composed of several 5X7 or 5X11 dot matrix character bits. Each dot matrix character bit can display a character, with a dot space between each bit and a space between each line, which plays a role of character space and line space. Because of this, it cannot display graphics very

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well,. 1602LCD means that the displayed content is 16X2, that is, it can display two lines, with 16 characters in each line. Most character LCDs on the market are based on HD44780 LCDs. The control principle is identical, so characters and numbers can be displayed perfectly.

Because the indirect control scheme uses the four wire parallel data transmission mode, which greatly reduces the excessive dependence of the LCD module on the I/O port, the system uses the indirect control mode.

Fig. 7. I2C1602 LCD.

IV. SOFTWARE DESIGN OF INTELLIGENT FARM ENVIRONMENT MONITORING SYSTEM

The program operation of this system is mainly composed of initialization, main program, temperature and humidity, water level and light intensity monitoring, alarm feedback, display information and other steps.

As the main program and data information receiving point, the Arduino development platform can monitor the water level when the system operates normally; Or monitor whether the temperature, humidity and light intensity in the farm shed are abnormal. In case of any abnormality or when the relevant monitoring amount reaches the set threshold, the 1602 LCD can display information in time and give an alarm.

A. Development environment

The programming development environment used by this system is Arduino IDE, which supports the use of multiple platforms. Windows, Mac OS, and Linux operating systems can operate normally. The operating system selected in this design is Windows.

B. Set flag bit

The output pins of sensors are distinguished by high and low potentials. When multiple sensors are involved in the system, it is difficult to judge whether they operate normally if there is no clear and unified high and low potential setting rule. Therefore, the default flag of the sensor is designed as low potential 0 in this system.

```
int WenDu = 0 ;  //Temperature marker
int ShiDdu= 0;  //Humidity marker
int GuangZhao = 0;  // Light intensity marker
int ShuiWei= 0;  // Water level marker
int FlagAlarm = 0;  // Alarm flag
```

C. Water level sensor module

When the water level sensor is not inserted into the water, the output value is 0. As the water level sensor gradually submerges into the water, the value of the analog pin becomes larger and larger. When the water level sensor is completely submerged, the output value reaches the maximum, about 770.

Some procedures:

```
Double temp,data;
Void setup()
{
Serial.begin(9600);
}
Void loop()
{  Temp=(long)analogRead(A0);
data=(temp/770)*40;
Serial.print("the depth is:");
Serial.print(data);
Serial.println("mm");
Delay(1000);
```

D. Alarm settings

Alarm condition: the water level is lower than the set threshold.

```
if ( (SW<200)
  {
    FlagAlarm = 1;
    digitalWrite(Speaker, LOW);
    digitalWrite(LED, LOW);
}
 else
  {
    FlagAlarm = 0;
    digitalWrite(Speaker, HIGH);
    digitalWrite(LED, HIGH);
  }
```

E. WiFi module

ESP8266 working mode

(1) STA mode: The ESP 8266 module connects to the Internet through a router, and uses mobile phones, computers or other upper computer devices to remotely control the terminal through the Internet.

(2) AP mode: As a hot spot, the ESP 8266 module can directly communicate with the module by mobile phone or computer, and realize wireless control of the LAN.

(3) STA+AP mode: The coexistence mode of the two modes can not only be used as a hotspot, but also be directly connected to WiFi, and can be switched freely.

The system can only use AP mode.

Part of ESP 8266 Procedures

```
void setup()
{
 Serial.begin(9600);  //The ESP module connection Arduino is not applicable to 115200 baud rate
WiFi.int(&Serial1);
}
While ( status != WL_CONNECTED)
{ Serial.print("Attempting to connect to WPA SSID:");
 Serial.println(ssid);
Status = WiFi.begin(ssid,pass);   // Access WiFi
```


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V. System Commissioning Results

A. System function realization

Temperature and humidity monitoring

Connect the DHT11 temperature and humidity sensor and LCD1602 to the Arduino development board according to the pin, and then input the compiled program code into the Arduino motherboard. The sensor works normally, and the measured real-time temperature and humidity signal detection quantity is displayed on the LCD.

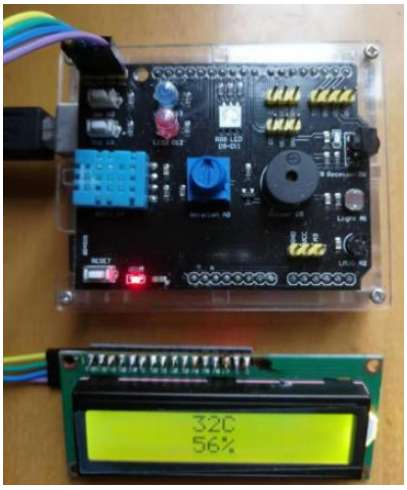

Fig. 8. Temperature and humidity monitoring display.

Light intensity monitoring

Connect the photoresistor sensor to the Arduino development board according to the pin, and then burn the compiled program code into the Arduino motherboard. The sensor works normally, and displays the measured real-time light intensity signal detection amount in the command window.

Luminance data reference:
Evening: 0.001-0.02;
Moonlight: 0.02-0.3;
Cloudy outdoor: 50-500;
At noon in summer: 10 * 6 light energy.

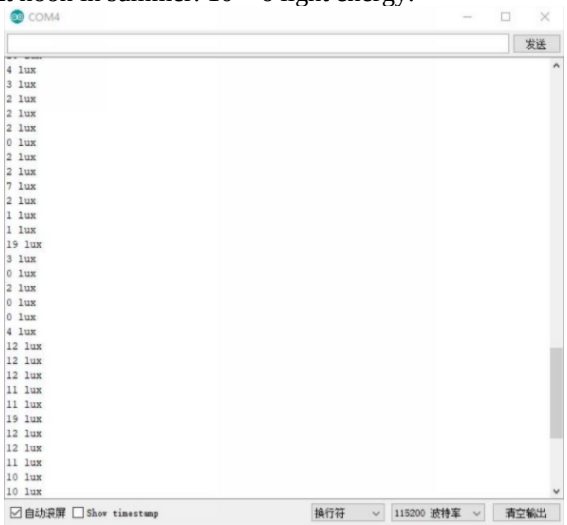

Fig. 9. Light intensity monitoring.

Water level monitoring

Connect the water level sensor to the Arduino development board according to the pin, and then burn the compiled program code into the Arduino motherboard. The sensor works normally and displays the measured real-time water level signal detection.

Fig. 10. Working diagram of water level sensor module.

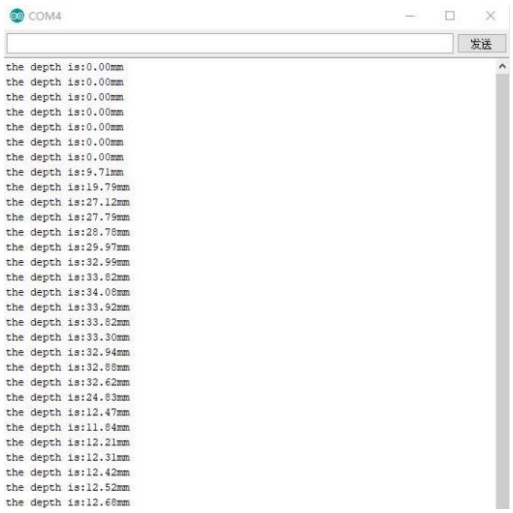

Fig. 11. Water level numerical display diagram.

B. System improvement

The system is still in the primary design stage, and there are still many places to be improved.

For this intelligent farm environmental monitoring system, the following aspects can be further improved:

(1) Due to the limitation of time and technical level, this design only monitors the temperature, humidity, light intensity and other related quantities. Later, if necessary, other modules can be added to enrich the farm functions, such as monitoring flood disasters, mud rock flows, illegal intrusion, etc.

(2) The farm system can be subsequently connected to the Internet of Things to realize the data sharing linkage function for the alarm work after the environment is abnormal or an emergency occurs.

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(3) This design is used to display the Arduino command window and LCD1602 LCD, which can only display characters and numbers. In the subsequent improvement and upgrading, OLED display boards that can display images and graphics can be selected to make the presentation of collected data more beautiful and diverse.

VI. CONCLUSION

This paper mainly introduces the design concept of intelligent farm, and designs the environmental monitoring system of intelligent farm according to the existing sensors and advanced modular integration ideas. In this design, the Arduino development board is used as the overall processor of the system, and the DHT11 temperature and humidity sensor module, ESP8266WiFi module, photoresist sensor module and water level sensor module are used to design the intelligent farm environment monitoring system.

(1) After the hardware connection, installation and software programming, the system can detect the temperature and humidity in a certain area, monitor the light intensity, and monitor the water level in the farm, basically realizing the original intention of the system design.

(2) The physical simulation function has achieved the expected effect. As this design has the characteristics of low cost, strong comprehensiveness, intelligence, modularization, high safety and reliability, compared with other farm system design schemes, I believe that it can provide experience and direction for the future innovation and development of the intelligent farm environmental monitoring system.

In general, there are still some shortcomings in this design. Due to the time and site problems, a simple small farm greenhouse model has not been built, but only the integrated simulation of each unit module has been carried out; At the same time, although the WiFi module code is basically completed, it has not been fully debugged. In the future, several more monitoring modules can be added to make the display form more diversified, not only limited to the display of characters and numbers, but also the whole system can be connected to the Internet of Things platform.

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