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Farmland monitoring and livestock management based on internet of things

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A R T I C L E I N F O

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A B S T R A C T

In order to improve the development of modern agriculture, this paper uses the Internet of Things technology to conduct research on farmland monitoring and livestock management, and build an intelligent system. Moreover, this paper combines farmland monitoring and livestock management, and designs a sensor network based on microkernel operating system. Based on the idea of modular design, the functional modules and control modules are organically combined, and an API interface is provided to manage and control nodes and networks, so as to realize the monitoring and collection of farmland information and livestock management. The experimental evaluation shows that the farmland monitoring and livestock management system based on the Internet of Things proposed in this paper meets the needs of intelligent agricultural production.

1. Introduction

Through the Internet of Things technology and Internet technology, a relatively complete farmland information monitoring system is established, which has certain industrial application value. At present, more mature traditional schemes are adopted for farmland information collection and information transmission. However, the IoT cloud platform adopts a relatively new technical framework, so that it can withstand the challenges of high concurrent access and massive data storage, and can serve more users [1].

The farmland information monitoring system mainly consists of three parts, the information acquisition module, the information transmission module, and the IoT cloud platform, which correspond to the perception layer, network layer and application layer of the IoT technology architecture respectively. The information collection module is responsible for the collection of farmland information, such as soil temperature, humidity and other information [2]. The information transmission module can transmit farmland data to the IoT cloud platform through local area network, wide area network and Internet. The IoT cloud platform can accept data and display data with high concurrency, and support mass data storage, and the IoT cloud platform is the core of the entire system [3].

China has a large agricultural population. Since the reform and opening up, China's agricultural production level has developed greatly, but there is still a certain gap between the management level and developed countries. With the rapid development of Internet of Things technology, in order to better develop smart agriculture, many scholars have studied the farmland environment, explored the impact of the environment on the growth of field crops, and focused on the proportional relationship between soil, air and their components.

Wireless sensors play an important role in the Internet of Things and are the basic carrier of information transmission and perception. The application of wireless sensor network in farmland soil moisture control can effectively solve the problems of

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equipment arrangement, high installation cost and insufficient power supply in wired transmission in traditional mode. Through automation control, Internet of Things and wireless perception and other technologies, the intelligence of agricultural production can be improved, which is an important guarantee for environmental protection and sustainable agricultural development. In the design of soil moisture related monitoring system, for farmland microclimate, sensors, wireless transmission technology and data acquisition card MODBUS and other modules can be used to dynamically monitor soil moisture in farmland. Generally, agricultural land is land that is used for farming, which is the planned and organized utilization of certain other living creatures, primarily the raising of cattle and the growing of vegetables, to provide sustenance for people. It is frequently used interchangeably with grassland or pastureland and also farming or soils.

Various environmental parameters are collected, and the collected data information can be transmitted to the computer terminal and cloud platform at the same time to realize automatic storage. With the innovation of FDR tubular monitoring device, the dynamic monitoring of soil moisture is realized. For wireless water-saving irrigation, the operation is mainly realized through irrigation controllers, wireless repeaters and handheld terminals. At the same time, the data information provided in the farmland environmental monitoring system is used as the basic guidance to realize precise farmland irrigation. The farmland environment monitoring module in the monitoring system is composed of sensors, spread spectrum transmission LORA, data acquisition card, online transmission NB-IOT and data transmission module. In the collection operation for soil moisture information, the data acquisition card can use the basic protocol to realize data interaction between multiple sensors. The main advantage of a single site is that it can efficiently collect the relevant data information of 32 sensor devices, and at the same time combine multi-parameter fusion. Algorithms and bipolar information calibration further improve the accuracy and reliability of farmland monitoring.

1.1. Contribution

This paper uses the Internet of Things technology to conduct research on farmland monitoring and livestock management, and builds an intelligent system that combines farmland monitoring and livestock management to realize the ecological treatment of agricultural production, which provides a theoretical reference for subsequent agricultural development.

2. Related work

Literature [4] designed a wireless sensor network architecture for vegetable greenhouses. Based on the analysis of the characteristics of the greenhouse environment, a low-cost wireless sensor network technology and a practical greenhouse environment monitoring system were designed. Literature [5] proposes a wireless environmental monitoring system using wireless sensing technology. In remote farmland environmental monitoring systems in remote areas, the use of this technology greatly reduces labor costs and the cost of replacing sensor batteries. Literature [6] uses sensors to collect real-time agricultural environmental information such as air temperature, humidity, CO2 concentration, light intensity, soil temperature and humidity, and provides strong data support for precise control of agricultural production and farming plans. Literature [7] designed an automatic control drip irrigation system to monitor the temperature of the farmland environment, changes in light and plant soil moisture and other parameters in real time.

Literature [8] designed a crop environmental information collection system based on ZigBee technology, set up fixed monitoring points, collected information such as light, soil temperature and humidity, air temperature and humidity by using ZigBee wireless communication technology, and transmitted the data to the host computer through the gateway. processing. Literature [9] deploys a number of different sensor nodes in the greenhouse, uses LoRa wireless technology to aggregate and send them to the server, and then to the control terminal for control, with strong anti-interference ability, low power consumption, and long-distance transmission. Literature [10] designed a system for collecting environmental information based on the Internet of Things. Multiple sensor nodes are set up in the monitoring area, adjacent nodes form clusters, and the cluster head node of each cluster integrates all the data collected in the cluster through data fusion, Then, through the Internet and satellite, the data is finally sent to the task management node for management. by

Literature [11] studies the underground visual monitoring system based on VR technology, constructs different monitoring substations composed of multiple sensors, and displays the collected speed, pressure and other data in the coal mine underground drainage system and its structure that has completed 3D modeling. distribution diagram. Literature [12] designed a VR-based intelligent inspection scene for substations, carried out refined 3D modeling of substations, and used virtual reality technology to comprehensively display various data information with 3D modeling as a carrier. Literature [13] designed a water environment detection system based on virtual reality and the Internet of Things, using technologies such as MQTTQ protocol stack and thread pool to display water in real time in a virtual reality environment according to the water quantity, water quality and pollutants collected by sensors. The current situation of the environment is monitored, and the data obtained in real time and the actual water dispatch plan are monitored for consistency through sensors.

In recent years, researchers have carried out a lot of useful research work in the monitoring of farmland microclimate environment. Literature [14] designed a set of agricultural meteorological automatic collection system based on remote monitoring, which realized the high integration of farmland microclimate and video image information collection and transmission; Literature [15] used virtual instrument technology to design a farmland microclimate automatic collection system set up in rice fields. The observation system provides high-precision farmland microclimate information for agricultural disaster prevention and mitigation; Literature [16] designed a complete farmland microclimate automatic meteorological observation system, which can combine multiple observation stations in the region into an observation network, so as to achieve Observation of various environmental parameters.

Literature [17] developed a desktop-based remote sensing support system for drought monitoring, and displayed the monitoring

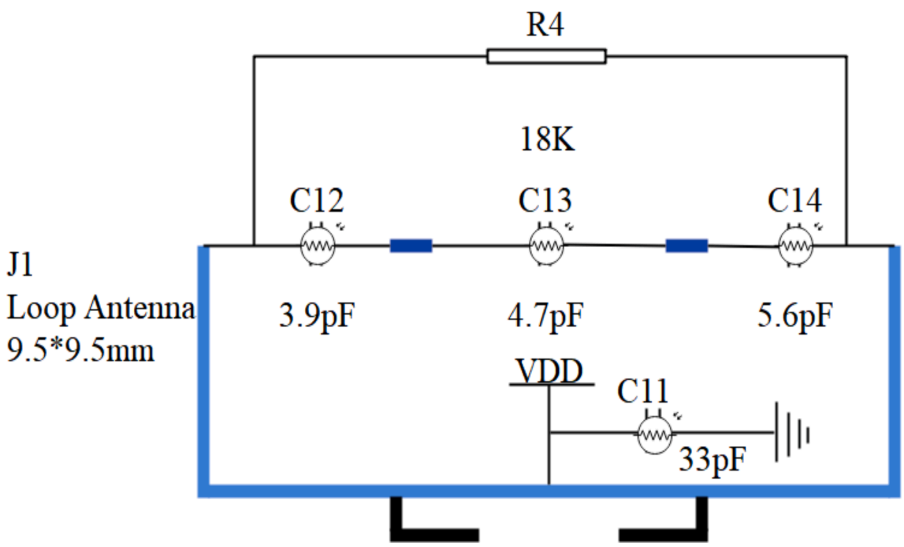


Fig. 1. Design of PCB loop antenna.

results in combination with the practical application in the Ningxia pilot area; Literature [18] developed a remote sensing rapid reporting system for agricultural conditions, using remote sensing and field observations. The combination of data integrates various monitoring indicators such as crop area, drought and yield, but there are still some problems in the current farmland drought monitoring system. Most of the farmland drought monitoring systems are desktop terminals, which have poor portability and cannot meet the needs of users for field operations. However, mobile smart phones have the advantages of easy portability and touch interaction, and have the advantages of timely information acquisition and convenient operation. And with the continuous advancement of 5G communication technology, the communication delay has been greatly reduced, which also laid the foundation for the rapid transmission of image data between mobile terminals [19]. Cloud computing technology provides a solution for the proper management of massive remote sensing data. Combining with remote sensing technology, the remote sensing cloud computing platform is not only greatly facilitates the retrieval and acquisition of various remote sensing image data, but also provides the necessary information for data processing. The computing resource environment is realized in the cloud, which solves the problem of insufficient local computing power [20].

3. Monitoring technology based on wireless network and wireless communication

A gain in a transmission line refers to how successfully the transmitter transforms voltage level into electromagnetic radiation travelling in a particular area. The efficiency of a transmission medium indicates how effectively it transforms electromagnetic radiation that is coming from a certain source into electricity generation. Antenna gain (Gant) characterizes the ability of the antenna to radiate or receive radio waves. Under the same conditions, the higher the gain, the farther the radio wave travels. G_{ant_tx} and G_{ant_rx} denote the gain of the transmitter antenna and the receiver antenna, respectively. P_{out} represents the transmit power, path_loss represents the transmission path loss, and the receiver received signal power P_{rec} can be expressed as:

$$P_{rec} = \frac{P_{out} \bullet G_{ant\_tx} \bullet G_{ant\_rx}}{path\_loss} = \frac{P_{out} \bullet G_{ant\_tx} \bullet G_{ant\_rx}}{(4\pi r/\lambda)^2} \tag{1}$$

r represents the transmission distance (unit: m), in represents the carrier wavelength (unit: m), c represents the speed of light, and f represents the carrier frequency (unit: Hz).

If we take dB as the unit and take the logarithm of base 10 on both sides at the same time, we can get:

$$P_{rec}[dB] = P_{out} + G_{ant\_tx} + G_{ant\_rx} - path\_loss \tag{2}$$

The signal strength battery voltage is many levels underneath the broadcast signal rated power due to route degradation. The communication range, antennae efficiency, duty cycle, and the separation among the sender and receiver are all elements that affect the transmitted voltage levels. If the transmit power and the gain of the receiving and transmitting antennas are known, then the transmission path loss when the sensitivity limit of the receiving end is reached, the antenna gain corresponding to the maximum transmission distance is proportional to the area of the antenna.

A transmitter that broadcasts electromagnetic radiation is one that transforms electronic signals into those waves. A transceiver is one that transforms electrical signals from electromagnetic fields in the acquired stream. The similar transmitter can be utilized for both transmitters and receivers in two-way communications. According to the basic theory of antenna, there are:

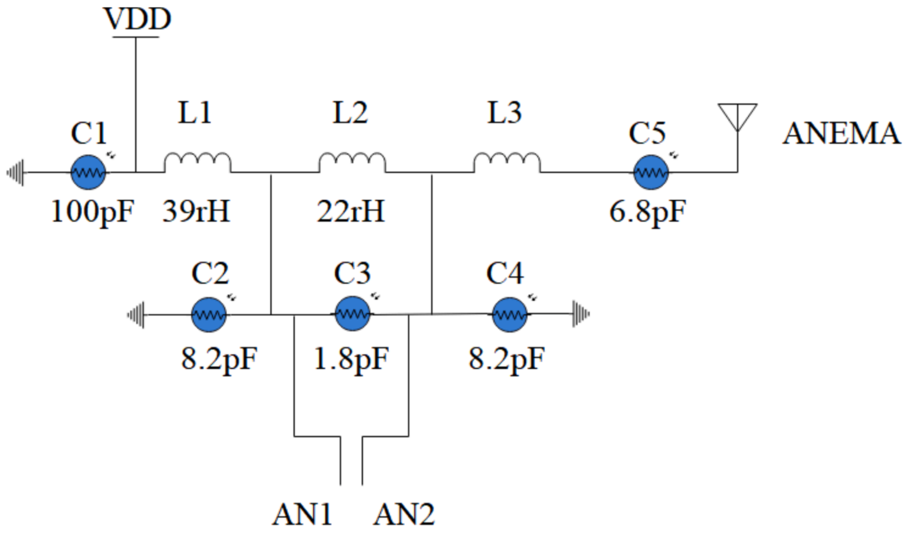


Fig. 2. Antenna design of single whip antenna.

$$G_{ant} = \frac{4 \times \pi \times A_e}{\lambda^2} \tag{3}$$

In the formula, A_e represents the effective area of the antenna (unit: m^2), λ represents the carrier wavelength (unit: m). When it is converted into dB, there are:

$$G_{ant}[dB] = 101g\left[\frac{4 \times \pi \times A_e}{\lambda^2}\right] \tag{4}$$

A microstrip transmitter in the context of communications is often an array made on an electronic circuit utilizing photolithographic methods (PCB). A sort of inside transmitter, that is. The majority of their usage is in frequency range. It is frequently preferable to utilize looping transmitters in tiny radio equipment for a number of considerations. The fundamental divergent architecture of a loop antenna interacts well with equivalent hardware, which is used by many current RFICs to improve services and provide denial for common-mode transmissions. The design method of the PCB loop antenna of the cheek-radiating module working in the 433MHz frequency band is shown in Fig. 1. The bold part is the PCB antenna, and its effective area is 9.5mm x 9.5mm. The gain of the PCB loop antenna is calculated according to formula (3) to be about -26dB. When the PCB antenna is used for both transmission and reception, $G_{ant\_tx} = G_{ant\_rx} = -26dB$. It is known that the maximum transmit power is 10mw, and its conversion in dB is 10dBm, and the receiving sensitivity is -104dBm. Therefore, it can be calculated that the maximum path loss allowed by the guaranteed communication link is 62dB, and the ideal communication distance can be obtained by substituting in formula 1 to meet the system requirements (Fig. 2).

The common issues are acid traps, missing solder mask between pads, desperate insulating layers, copper too close to the board edge, an insufficient annular ring, and so on. All antennas, like other electronic components, require at least two connections. A 360-degree signal-transmitting transmitter is referred to as a whip antenna. Whip antennas are nearly uniform, with a width of less than 6 inches, or may reach heights of up to 18 feet. The terms "unidirectional radiation, branch, or pipe antennas" are also used. They are often utilized as the transmitters for cell devices, landline devices, walkie-talkies, FM systems, stereo systems, and Wi-Fi smart device. They are also mounted on cars as the transmitters for sound systems and two-way communication devices for heavy trucks and aero planes. For the whip antenna, one end must be connected to the ground, and the circuit between the antenna and the ground layer forms a magnetic field between the two, and when the current flows through the field, the entire circuit is deformed. The design of the whip antenna is simple. It only needs to connect a 1/4 wavelength antenna vertically to the ground and the cheek-emitting module. It can be simply replaced by a copper wire of the corresponding length. For example, the length of the antenna used by the

433MHz RF module is:

$L = \frac{\lambda}{2} = \frac{c}{4f} = 17.3cm.$

It can be seen that if the 1/4 wavelength whip antenna is used, the external size will be too large. In theory, whip antennas are broad, difficult to lowpass, and simple to include into wireless designs. They are frequently employed in commercial settings since they are outwardly placed, however portable types are becoming less prevalent. A PCB antenna, on the other hand, is a converter that transforms electrical pulses in a high-frequency PCB into electromechanical (EM) radiation. High frequency electricity is transformed into Wave propagation that travels through the air via PCB transmitters.

Considering that the farm site is relatively open, and the interference sources such as path loss, building impact, and absorption by the surrounding environment are relatively small, this paper decides to use a PCB loop antenna. If the single whip antenna can be made into a curve, it can not only adapt to the size of the shape but also increase the transmission distance, and its reference circuit diagram 2 is also given here.

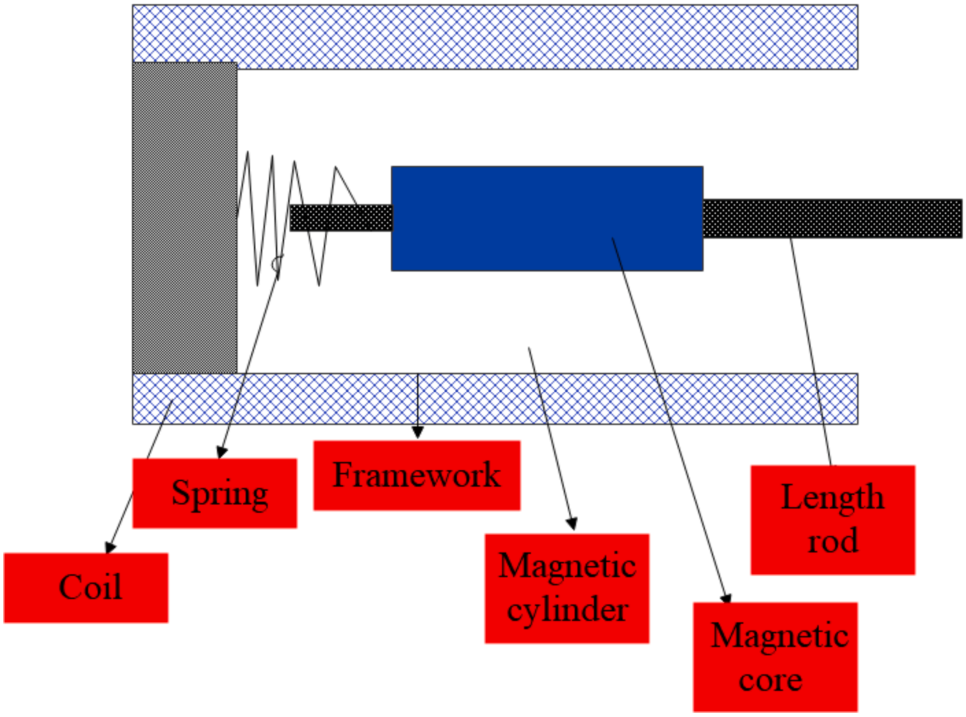


Fig. 3. Single-coil solenoid self-inductive sensor

The main parts of the sensor are the magnetic core, the magnetic cylinder, the bobbin and the coil. Among them, the function of the magnetic cylinder is to help form a closed magnetic circuit, increase the sensitivity and provide a magnetic shield to prevent the interference of external magnetic fields. The skeleton is the support of the coil. A magnetic controller is a device that detects or measures items using the electromagnetism concept. A power flows via a network that contains an inductor whenever the magnetic flux around it varies, as opposed to whenever a flow passes through an inductance and it creates a magnetosphere. The magnetic core of the self-inductive solenoid type linear displacement sensor is a cylindrical iron rod, and there is a butterfly hole on each end surface to connect the spring guide rod and the measuring rod respectively. With the aid of a projectile with an orthogonal stroke that may move whether in a push or a pull motion, straight electromagnets transform electricity into mechanical energy. These transmitters are made of a secondary winding that is occasionally coiled across a ferromagnetic material, and when a power is increased, it creates a magnetic flux. The measuring rod is directly connected to the measured object, and the magnetic core moves in the coil solenoid with the displacement of the measured object. Its parts diagram is shown in Fig. 3.

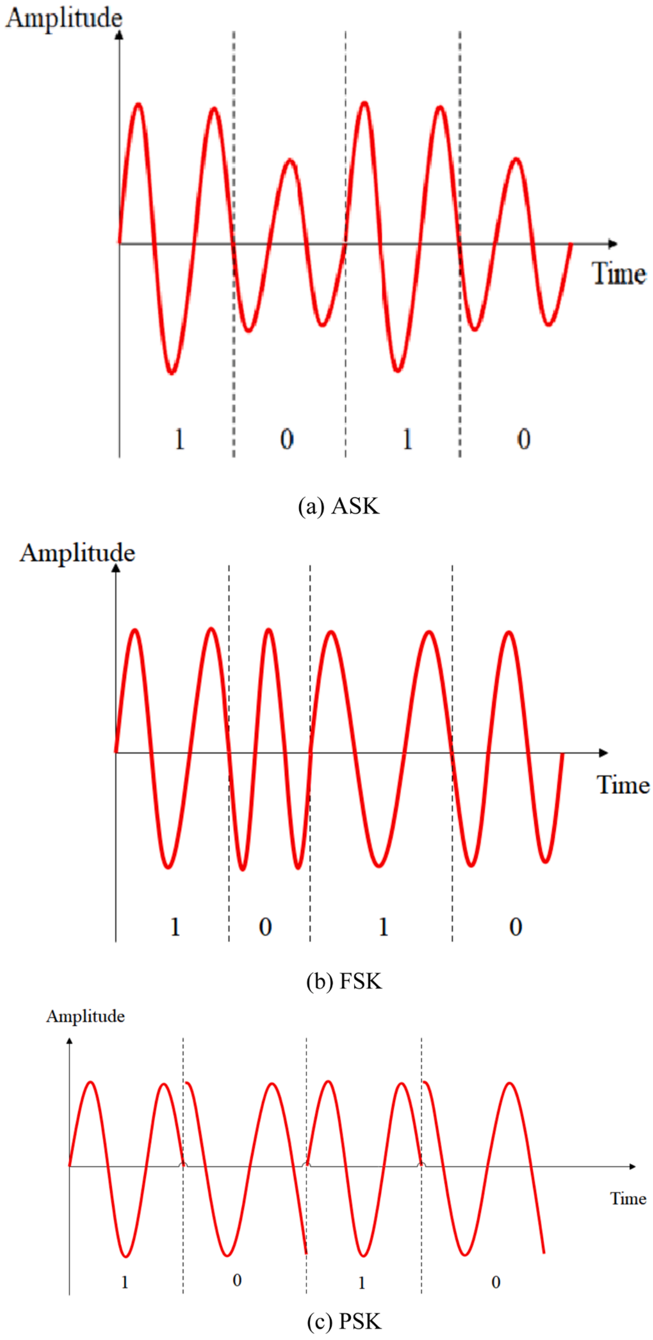
According to the Biot Savart Law, a steady electrical discharge produces an electromagnetic field in accordance with the special electromagnetic of science. It provides information on the electromagnetic current's strength, amplitude, orientation, and proximity towards the magnetosphere. The benefit of the Biot-Savart law is that it operates in any flux generated by a control loop. Summarize the magnetism produced by the current flowing through cables that are tightly wound about one another and linked towards the inverting input of an electromotive force device. According to the Biot-Savart law, we can get

$$B_1 = \frac{IN}{2l}\mu_0\left(\frac{l-x}{\sqrt{(l-x)^2+r^2}}+\frac{x}{\sqrt{x^2+r^2}}\right) \tag{5}$$

In the formula, μ_0 is the air permeability, N is the number of turns of the coil, l is the length of the solenoid coil, and r is the average radius of the solenoid coil.

When the magnetic core enters the solenoid coil, the magnetic field is excited to make it magnetized, the magnetic domain inside the ferromagnet turns to the same direction as the excitation magnetic field, and an additional magnetic field is generated, which strengthens the total magnetic field. The additional magnetic field generated by a uniformly magnetized cylindrical core can be replaced by a magnetic field generated by a circular current flowing around the core surface, which is equal to the sum of the magnetic fields generated by the circular current per unit length of the core surface. According to the method of finding B1, the additional magnetic field can be obtained:

$$B_a = \frac{\mu_0 B_1}{2}\left(\frac{l_a-x}{\sqrt{(l_a-x)^2+{r_a}^2}}+\frac{x}{\sqrt{x^2+{r_a}^2}}\right) \tag{6}$$



(a) ASK

(b) FSK

(c) PSK

Fig. 4. Modulation method of digital signal.

The total magnetic field is $B = B_1 + B_a$.

The inductance is defined as $L = \psi/I$, and the flux linkage of the coil is $\psi_1 = \int_0^1 B_1 S_1 n d_x$.

The total magnetic induction is $L = L_1 + L_a = \frac{N^2 S_1 \mu_0}{l} + \frac{\mu_0 \mu_r N^2 l_a}{l^2} S_a$, and the first term is constant, so the change of the total magnetic induction is only related to l_a. At this time, the change of the inductance is proportional to the change of the displacement of the magnetic core.

The sensor sensitivity is $\frac{\Delta L}{\Delta l_a} = \frac{\mu_0 \mu_r N^2}{l^2} S_a$.

It can be seen that increasing the number of coil turns, increasing the cross-sectional area of the magnetic core, and using materials with high magnetic permeability can improve the sensitivity.

A self-inductive sensor converts the measured change into a change in inductance. Inductive transducers typically operate on the

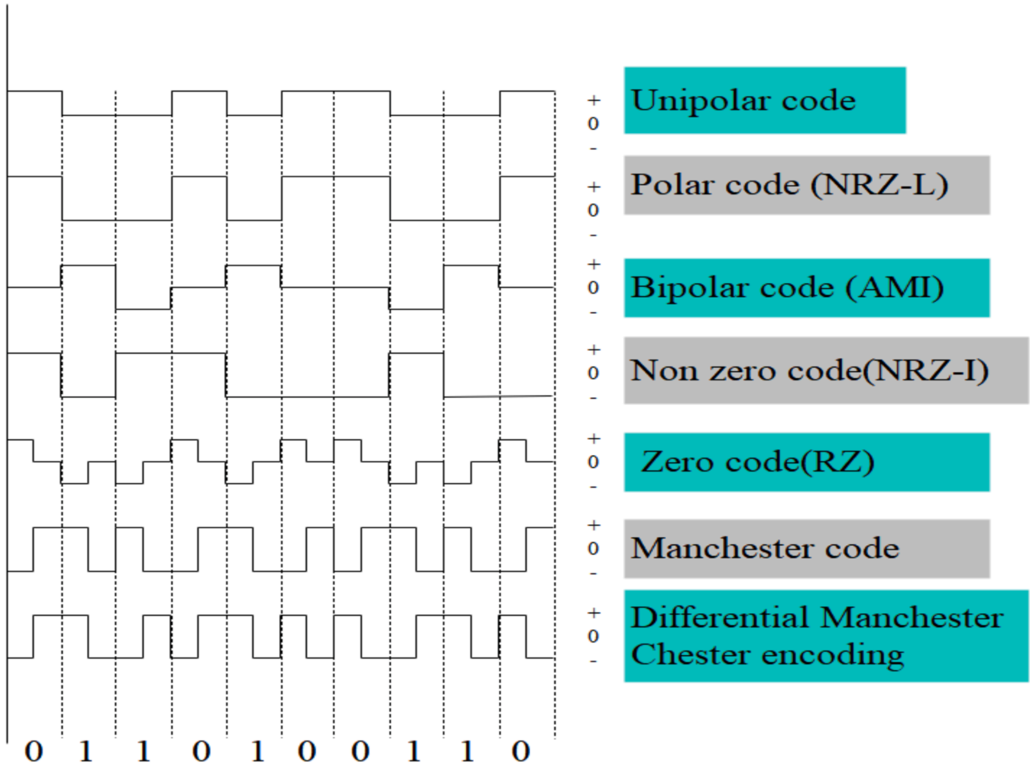


Fig. 5. Comparison of common codes.

basis of eddy current generation, increase in coupled inductor of primary and secondary coils, including self-inductance of one loop. The variation in permeability in the loops causes a potential differential as well as a shift in capacitance. In order to measure the change of the inductance, and also to send it to the lower-level circuit for amplification and processing, a conversion circuit must be used to convert the inductance change into a voltage (or current) change. After connecting to different conversion circuits, the change in inductance can be converted into changes in amplitude, frequency and phase of voltage (or current), which are called amplitude modulation, frequency modulation and phase modulation circuits respectively. Among them, the amplitude modulation circuit is used more, and the frequency modulation and phase modulation circuits are used less. The AC bridge is a major form of AM circuit:

There are many forms of AC bridges. Circuits called AC bridges are utilized to test electrical characteristics including hysteresis, capacitors, and impedance. We may also test retention component, reflection coefficient, dielectric constants, and other factors using an ac bridge in addition to these. Exclusively AC signals are used to control AC bridges. When there is no load, the output voltage when it is open is:

$$U_0 = \left(\frac{Z_1}{Z_1 + Z_2} - \frac{Z_3}{Z_3 + Z_4}\right) U \tag{7}$$

In the formula, u is the power supply voltage.

When the bridge is balanced, $Z_1 Z_4 = Z_3 Z_2$, and $U_0 = 0$. When the relative changes of the bridge arm impedance are $\Delta Z_1 / Z_1$, $\Delta Z / Z$ respectively:

$$U_0 = \left(\frac{\Delta Z_1/Z_1 + \Delta Z_4/Z_4}{(1 + \Delta Z_2/Z_1)(1 + \Delta Z_3/Z_4)} - \frac{\Delta Z_2/Z_2 + \Delta Z_3/Z_3}{(1 + \Delta Z_1/Z_2)(1 + \Delta Z_4/Z_3)}\right) U \tag{8}$$

In the process of using wireless transmission, only analog transmission can be used in the band-pass channel. The data generated by the terminal are all digital signals, so people are required to modulate the digital signals into analog signals.

A few of today's most popular modifications can be employed. Commonly used digital signal modulation methods include Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK) and Phase Shift Keying (PSK), etc. These modulation methods are briefly introduced below.

1 Amplitude Shift Keying (ASK): In many low-frequency RF applications, amplitude shift keying (ASK) is a common transmission method employed in digitized transmitting data. In this method, the strength of the carrier signal changes continuously with the binary 1 or 0 represented. Moreover, only the amplitude changes, while the frequency and phase remain the same, as shown in Fig. 4(a):

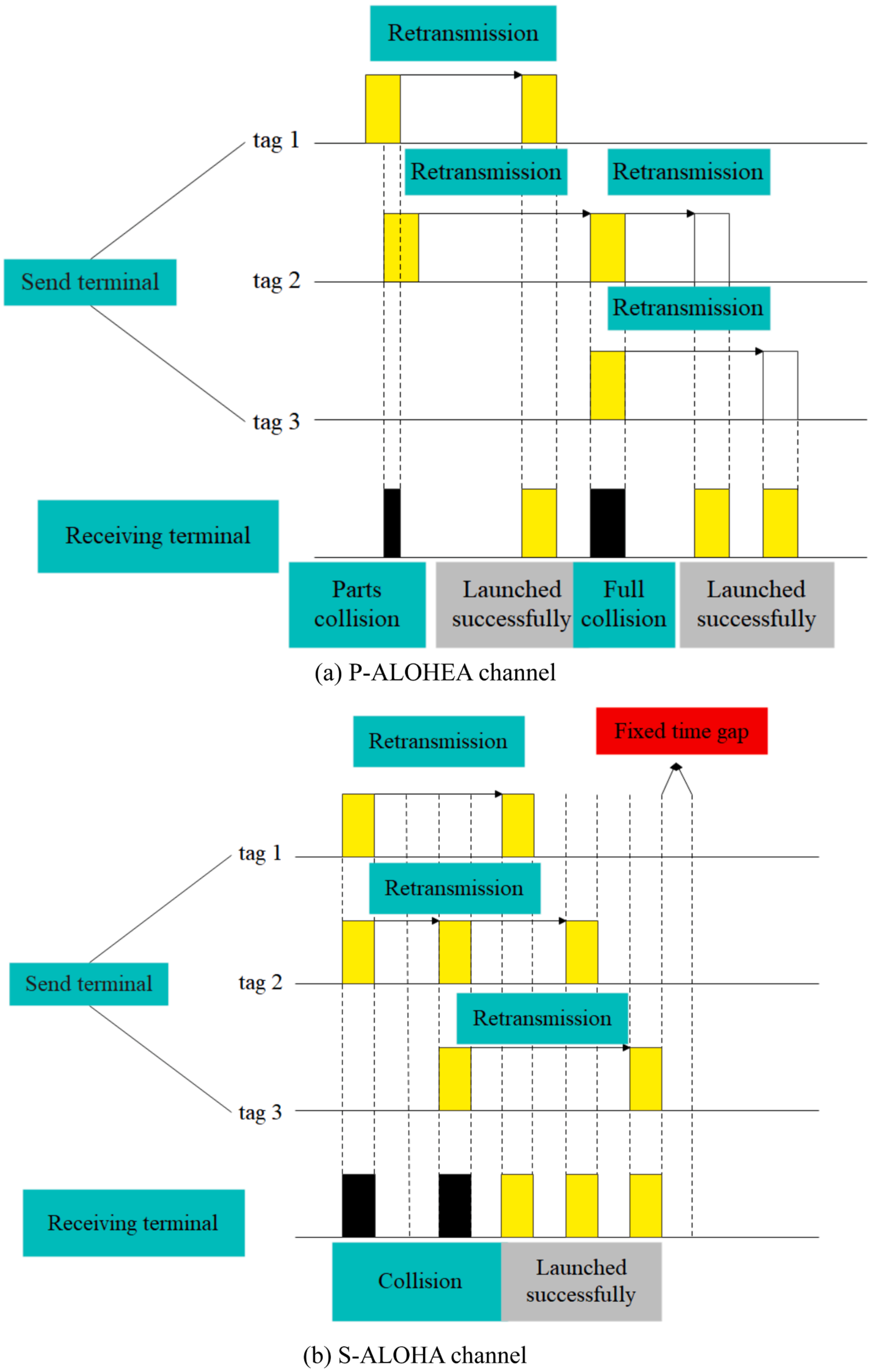


Fig. 6. Channel Diagram.

2 Frequency Shift Keying (FSK): Utilizing distinct communications, frequency-shift keying (FSK) is a technique for transferring quantitative messages. In this method, the frequency of the carrier signal changes continuously with the binary 1 or 0 represented. Only the frequency changes, while the amplitude and phase remain unchanged, as shown in Fig. 6(b):

3 Phase Shift Keying (PSK): Phase Shift Keying (PSK) is a modulation scheme wherein the sinusoidal and cosine sources are adjusted at a certain moment to modify the amplitude of the signal generator. In this method, the phase of the carrier signal changes continuously with the binary 1 or 0 represented. Only the phase changes, while the frequency and amplitude remain unchanged, as shown in Fig. 6(c).

4 Minimum Frequency Shift Keying: MSK, or Minimum Shift Keying, is an interfacial tension quadrature phase shift keying technique that offers bandwidth utilization and makes it possible to operate RF power amplifiers effectively. It is an improved version of Frequency Shift Keying (FSK). In FSK mode, the buccal rate of adjacent symbols does not change or jumps to a fixed value. Between two adjacent frequency-hopping symbols, their phases are usually discontinuous. MSK is a kind of modulation that makes some improvement to the FSK signal so that its phase remains continuously unchanged. The minimum frequency shift keying (GMSK) of Gaussian filtering before modulation is used in this paper. The working principle is that the baseband signal is first shaped by a Gaussian filter and then modulated by Minimum Cheek Shift Keying (MSK).

Unipolar Code: This encoding method is very simple and primitive. Although it is currently deprecated, its simplicity provides an easy entry for more complex coding as it evolves. It uses only one voltage level, and positive (or negative) voltages represent data. As shown in Fig. 5, a positive level is used to represent 0, and a zero level is used to represent 1. The cost of unipolar encoding is relatively low to implement, but its anti-noise performance is not good, and there is a synchronization problem with the receiver when it is used, and a separate clock signal must be matched for timing.

Polar code: This coding method uses positive and negative levels to represent binary numbers 0 and 1, respectively. Its level difference is larger than that of unipolar encoding, so the anti-noise ability is better than that of unipolar encoding. However, an additional clock signal is still required.

Information is used in Manchester Encoding to adjust an output waveform carrier's frequency. The carrier's bandwidth and communication rate are the identical. The countdown and information inputs work together to create a unified, synchronized, two-level transmitted signal in Differential Manchester Encoding. Manchester coding and differential Manchester coding are both bi-phase codes, and each symbol of bi-phase code must be modulated to two different levels, so the modulation rate is twice the symbol rate. This puts forward higher requirements on the bandwidth of the channel, so it is more difficult and expensive to implement. However, due to its good anti-noise characteristics and self-timing capability, it is widely used in local area networks.

Hamming codes have the ability to repair one-bit mistakes without detecting untreated faults or to identify one-bit and two-bit errors. The basic parity code, in comparison, can only identify bits that are off by an arbitrary amount and cannot remedy the situation. A fundamental consideration when deriving the Hamming code is to determine the minimum required check digit r. When considering information with a length of k bits, if r check bits are attached, the total length sent is k+r. There are r parity checks to be performed in the receiver, each result being either true or false. The result of this parity check can be represented as an r-bit binary word, which can determine the maximum number of different states. One of these states must be true for all parity tests, which is the condition for determining that the information is correct. Therefore, the remaining $(2^r - 1)$ states can be used to determine the location of the bit error. Thus, the following relationship is derived:

$$2^r - 1 \geq k + r$$

If it is required to detect and automatically correct one-bit errors, and to detect two-bit errors, it should meet:

$$2^{r-1} \geq k + r$$

ALOHA is a sharing networking channels media access control (MAC) technology for data delivery. This method allows the transfer of that many information flows coming from various nodes across a multi-point communication system. ALOHA systems are divided into two typical types: pure ALOHA (P-ALOHA) and slotted ALOHA (S-ALOHA). Every device in Pure Aloha has the ability to send information at any moment. Any node can only broadcast information at the start of a time slot in Slotted Aloha. Timing is continuously and not completely synced in Pure Aloha. Timing is distinct and synced worldwide in Slotted Aloha.

This is the original ALOHA system, each tag can send information to the controller, the data packet is coded for error detection. When the receiving terminal sends data to two terminals at the same time, it will be judged as a collision of data. If the tag does not receive an acknowledgment signal ACK after sending the information, it will wait for a random long time before re-sending until it succeeds. Fig. 6(a) shows a typical example of a P-ALOHA channel. It is assumed that there are 3 terminals tag1, tag2, and tag3 sharing an ALOHA channel.

We assume that the length of a frame is T, and the start transmission time is t. Then if the start sending time t of another frame satisfies: $t_0 - T \leq t_1 \leq t_0 + T$, then the two frames collide. The advantage of the P-ALOHA protocol is its simplicity. It works well under low system load. However, if a site broadcasts frequently, or there are many sites, as the traffic increases, the possibility of collision is also greater, and even an "avalanche" phenomenon occurs, making the entire network unable to work normally.

It can be seen from the analysis of the pure ALOHA protocol that since each station sends the generated frame randomly, the time when each data packet is sent is arbitrary from the time axis. This results in a relatively large collision window for pure ALOHA. If the collision window is reduced, the throughput must be improved. Therefore, the concept of slot ALOHA is proposed, that is, the time discretization of tag information transmission, as shown in Fig. 6(b).

The performance of the ALOHA algorithm is generally measured by throughput. Throughput S refers to the average number of frames successfully transmitted within the frame transmission time T. We assume that the data frame sent by each tag obeys the Poisson distribution. Under this assumption, it is easy to analyze the performance of the ALOHA method. In steady state, the rela-

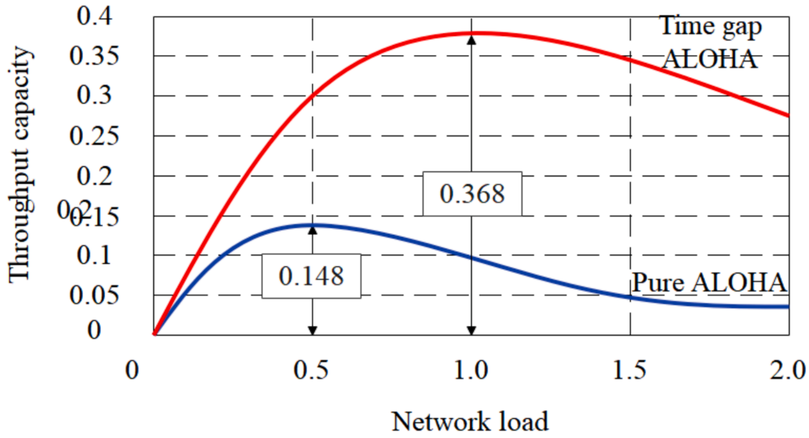


Fig. 7. Performance comparison of A-ALOHA and S-ALOHA channels.

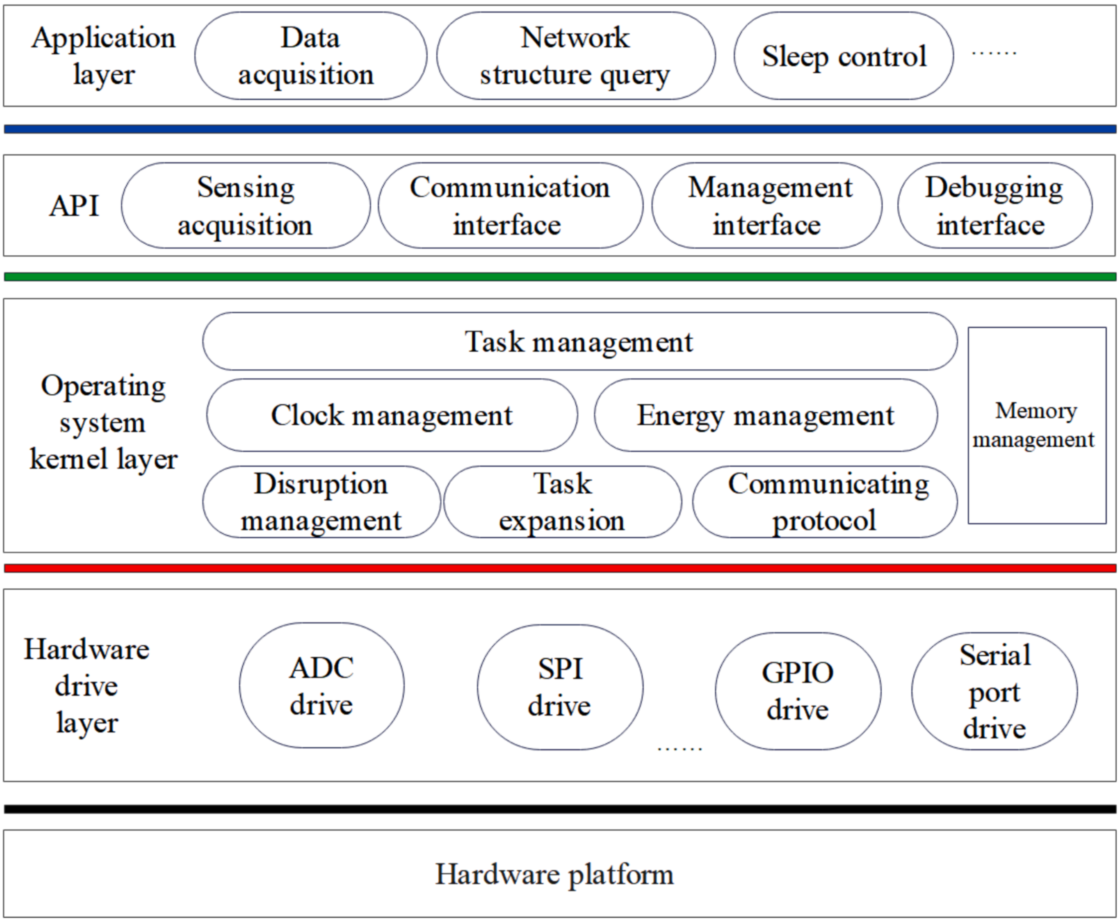


Fig. 8. Structure diagram of node software system.

tionship between throughput S and network load G is:

$$S = G * P[successfultransmission](probabilityofsuccessfulframetransmission) \quad (9)$$

According to the characteristics of Poisson distribution, after calculation P[Send successfully]= e^{-2G}, then S= Ge^{-2G}. It can be obtained that the maximum throughput of pure ALOHA algorithm is 0.184, while the maximum value of slotted ALOHA algorithm is

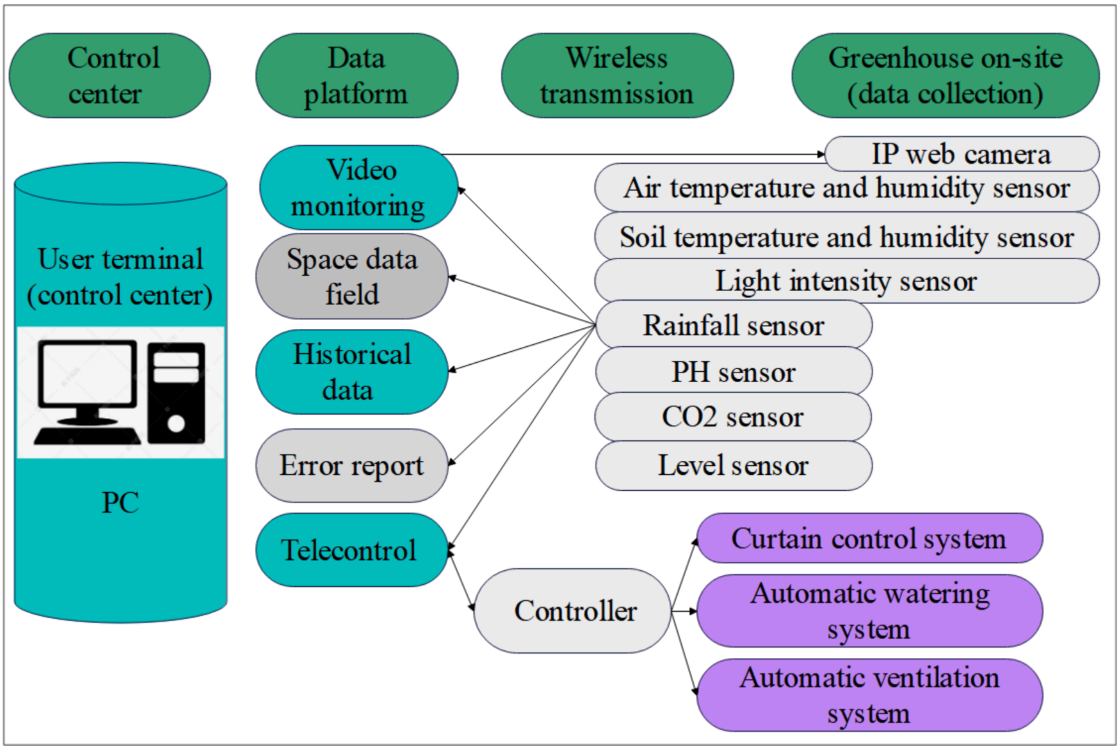


Fig. 9. Architecture of farmland IoT.

0.368. Fig. 7 shows the performance comparison between ALOHA and slotted ALOHA.

4. Farmland monitoring and livestock management based on Internet of Things

The main purpose of wireless sensor network is to monitor the growth information of crops in real time, such as light, soil moisture and temperature. The collection of farmland information needs to be determined according to the transit time of the satellite, which is periodic, and the amount of data collected at one time is small. The simplicity of operating system extension is one advantage of the microkernel method. Since the kernel does not need to be changed, all additional services are introduced in user space. Because most operations are run as parallel processing instead of kernel-level ones, the microkernel also offers greater privacy and dependability. According to these characteristics, a sensor network based on microkernel operating system is designed. According to the idea of modular design, the functional modules and control modules are organically combined, and API interfaces are provided to manage and control nodes and networks, so as to realize the monitoring and collection of farmland information. The key factor in the development techniques and interaction techniques used by servers in a network infrastructure are specified at the protocol stack, which is an intermediate level. Both the OSI framework as well as the Internet Protocol Suite (TCP/IP) define an abstraction for the operating system. An aggregating surrogate of every one of the business solutions is what an API level (application framework) essentially is. Exchange of information is provided via graphical user interface design, and APIs sales coordinator in encapsulation form behind the scenes. The kernel is the core component of a system software for a processor (OS). All other components of the OS rely on the core to supply them with essential functions. It serves as the primary interface between the operating platform and the equipment and aids in the administration of devices, communications, disk storage, and application performance allocation. The hierarchy's bottom tier is the equipment level. It offers direct equipment accessibility, making this element's procedures the only ones that can communicate object variables immediately. The only component of the software that is truly technology reliant is the interface level. At the same time, it is also necessary to manage livestock and monitor the group behavior of livestock. The node software architecture diagram is shown in Fig/ 8.

The architecture of the farmland IoT is shown in Fig. 9 below.

In this paper, a prototype system of a cloud service platform for farmland monitoring and livestock management based on the Internet of Things is developed and constructed to realize the main functions of service management. The prototype system takes the ontology as the knowledge guide, REST as the main service interface, and uses Java to develop the service management system. Fig. 10 is the system frame diagram of the prototype system.

This paper builds a cloud service covering data collection, transmission and analysis, which provides a basis for the development of application information systems in production practice. To effectively manage and utilize the service platform, it is first necessary to realize the management of cloud services, so that system developers can access services at a lower cost and complete the migration to

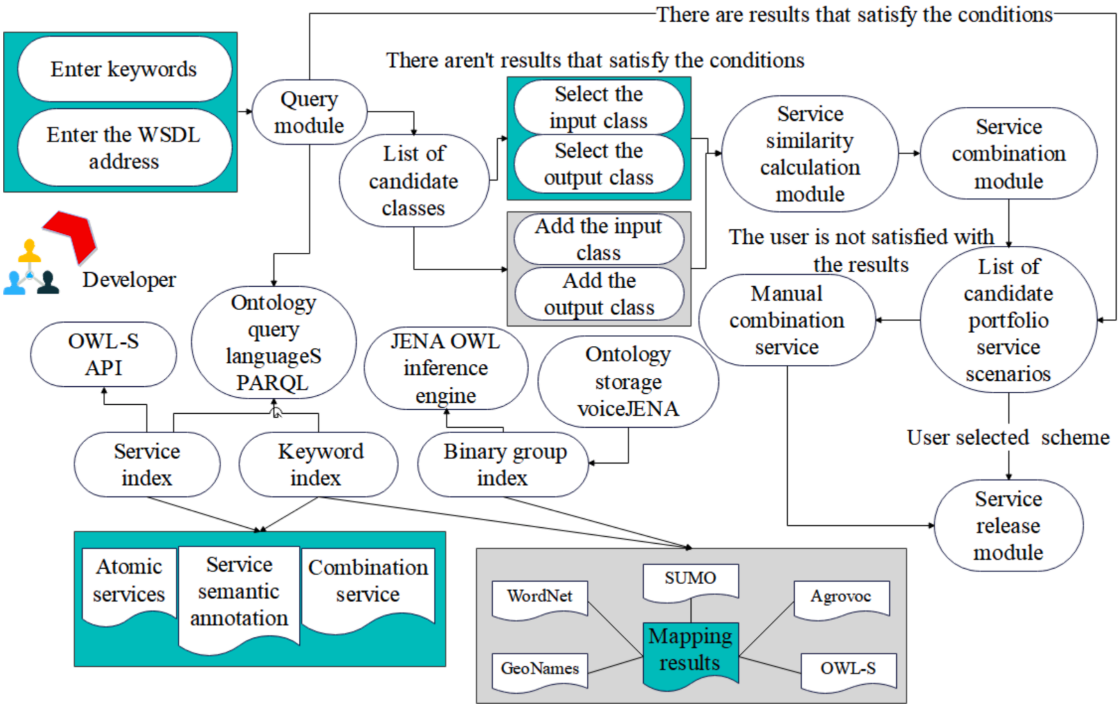


Fig. 10. System frame diagram of the prototype system.

Fig. 11. Example of farmland livestock detection images.

the cloud platform. In order to meet the above requirements, the cloud platform needs to provide basic service search, matching, combination and publishing functions. The user can retrieve the atomic service that meets the requirement, or construct a new service by modifying the service closest to the requirement or combining several services and publish and consume it. On the other hand, the cloud platform also needs to design service interfaces according to the characteristics of farmland monitoring and livestock management, so that the software system can seamlessly integrate professional functions and cloud services and exchange data. At the same time, the interface function and user interface of the application system are built based on the service to realize a simple service integration method and reduce the cost of technical support and use and maintenance. Fig. 10 shows an image example of farmland monitoring and livestock management in this paper (Fig. 11).

On the basis of constructing the prototype system, the effect evaluation of the farmland monitoring and livestock management

Table 1
Effect evaluation of farmland monitoring and livestock management system based on Internet of Things.

Number	Monitor performance	Number	Monitor performance	Number	Monitor performance
1	93.06	21	88.15	41	92.40
2	93.78	22	87.41	42	92.88
3	91.77	23	92.53	43	88.27
4	92.56	24	93.58	44	91.54
5	88.97	25	93.43	45	90.84
6	89.36	26	92.09	46	88.37
7	87.32	27	88.89	47	90.05
8	87.76	28	90.93	48	93.04
9	87.96	29	87.30	49	93.79
10	92.88	30	87.42	50	93.34
11	88.25	31	87.02	51	91.94
12	91.37	32	87.77	52	93.84
13	91.20	33	89.85	53	87.69
14	87.01	34	88.55	54	90.62
15	89.41	35	88.88	55	88.94
16	90.02	36	90.66	56	88.45
17	90.02	37	91.30	57	90.18
18	93.45	38	89.41	58	89.71
19	91.91	39	93.74	59	92.85
20	89.55	40	89.53	60	89.66

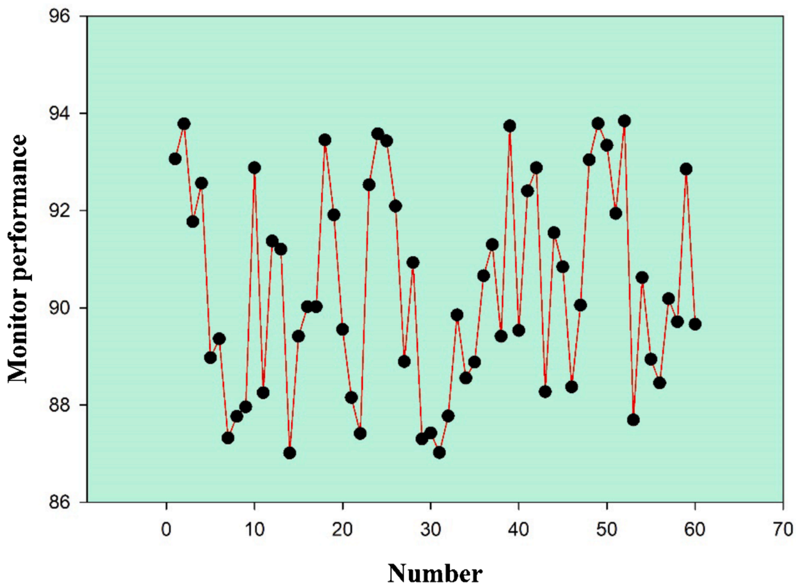


Fig. 12. Graphical Representation of Effect evaluation of farmland monitoring and livestock management system based on Internet of Things.

system based on the Internet of Things proposed in this paper is carried out, and the results shown in Table 1 are obtained and the graphical representation is shown in Fig. 12.

From the above test evaluation, it can be seen that the farmland monitoring and livestock management system based on the Internet of Things proposed in this paper meets the needs of intelligent agricultural production and plays an important role in promoting the development of modern intelligent agriculture.

5. Conclusion

In a modern society, precision agriculture is the mainstream direction of the development of new agriculture. Based on the Internet of Things, scientific design is carried out for the monitoring system related to farmland soil moisture, which promotes the effective realization of technical routes, and the development of related applications is also deepening. Moreover, a wireless sensor network is proposed, which can dynamically and automatically collect, process and store information such as soil moisture and temperature in farmland. Through the comprehensive application and promotion of this information system, it can provide information support for agricultural production in the new era, provide reliable technical support for collecting accurate plant growth environment information, and promote the comprehensive development of current precision agriculture. This paper uses the Internet of Things technology to conduct research on farmland monitoring and livestock management, and builds an intelligent system that combines farmland monitoring and livestock management to achieve ecological treatment of agricultural production. The experimental evaluation shows that the farmland monitoring and livestock management system based on the Internet of Things proposed in this paper meets the needs of intelligent agricultural production. In the future, the livestock management will be much developed with the help of novel technologies.

Declaration of Competing Interest

None to declare.

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