Research on data transmission model of agricultural wireless sensor network based on game theory

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ABSTRACT
In order to improve the effect of agricultural data collection and transmission, based on the technology adopted by the mainstream agricultural environmental information monitoring system on the market, this paper uses game theory to innovatively improve the algorithm mechanism of wireless sensor nodes, optimise the clustering structure and routing method of wireless sensor networks, design a remote monitoring platform for field farm information and finally build a complete agricultural information monitoring system. Moreover, taking the temperature and humidity sensor as an example, this paper improves the parameters on the basis of testing the various performance of the sensor, and develops the software of the main chip on the basis of the improved node, and completes the driver design of the sensor. In addition, this paper constructs a wireless sensor network data transmission model based on game theory, and combines simulation experiments to conduct experimental research on the system model constructed in this paper. From the test results, it can be seen that the model constructed in this paper has a better effect.

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Introduction
In recent years, with the development of science and information technology, my country’s agricultural industry management mode has gradually transitioned from extensive agriculture to precision agriculture. In sustainable agriculture, extensive agriculture refers to a process of crop production that uses a modest quantity of factors of production in regards to the quantity of ground actually cultivated. Crop output in extensive agriculture is essentially determined by the soil’s inherent fertility, geography, temperature and water resources. Precision agriculture is a management tool that collects, procedures and analyses spatial, temporal and employee data, as well as other documentation, in order to promote managerial decisions based on the estimated variance for efficient resources use productivity, efficiency, availability, profit margins and sustainability of agricultural output. Precision agriculture uses information and knowledge as the technical support, and takes the environmental factors that affect the yield and quality of crops as the research goal. Moreover, the obtained crop growth environment parameters usually have certain differences in time and space, which mainly include crop environment temperature and humidity, soil pH and light intensity. In addition, precision agriculture needs to obtain accurate agricultural environmental information so that farm managers can make management decisions in a timely manner and implement positioning control as needed (Chaware et al. 2017). The traditional agricultural environment monitoring system mainly relies on wired communication technology to realise the information exchange between facilities, such as field bus technology and serial bus technology. Fieldbus is a genuine nonlinear control solution for corporate systems. It is a method of interconnecting equipment in a processing plant. Fieldbus uses a network topology that enables topologies such as daisy-chain, star, ring, branching and branch. The Serial bus is a standard platform that allows devices to communicate with a host device, such as a computer or mobile device. At the same time, the facilities in the traditional system are simple and easy to operate, and have strong anti-noise interference capabilities, but the facilities are poorly expandable, difficult to deploy and costly to install and maintain, which restricts the promotion and development of traditional agricultural environmental monitoring systems in the agricultural field. With the continuous in-depth research on communication technology and sensor technology, wireless sensor
network (WSN) technology is well known by scholars at home and abroad, and is widely used in the field of agricultural environmental monitoring (Tushar et al. 2018). In agriculture, communication technology supplies producers with crucial information about planting, seed production and enhancing soil quality, allowing them to increase agricultural output. Smart farming makes use of a variety of sensor systems to provide information that allows producers to evaluate and improve plants as well as respond to changing climatic conditions. Geographical sensors, optical sensors, electromechanical sensors and agriculture weather data are just a few examples. Sensors are used to collect information on environmental variables and to monitor them. The information is electronically transferred to the gateways, where it is gathered, interpreted and presented by the software (Manogaran et al. 2021). Wireless sensor networks were born at the end of the twentieth century and were mainly used for the detection and tracking of nuclear submarines at the beginning. With the continuous innovation and development of wireless communication technology, wireless sensor networks have played a role in promoting the development of Internet of Things technology, and have continuously become the focus of attention of scholars in the field of wireless communication at home and abroad (Abawajy and Hassan 2017). The American Business Weekly and MIT Technology Review listed wireless sensor networks as the 21 most influential technologies of this century and the top 10 technologies that changed the world in the report predicting future technology development. The wireless sensor network combines embedded technology, sensor technology and communication technology to realise real-time monitoring of the growth process of crops. Moreover, it can collect environmental factors that affect the growth of crops, feed them back to managers in real time through wireless communication technology, and provide guidance and suggestions for managers’ next management implementation. Wireless sensor network technology has been applied and developed in many fields such as agricultural ecological environment monitoring, farmland intelligent irrigation and field management operations, and can provide reliable technical support for precision agriculture and realise real-time digital management of agriculture. An aggregator is a person or company that gathers and distributes products from many sources. A food market, a food centre, a supplier, or an independent farmer who markets the products of many other producers are all instances of aggregates of producers’ products. Cluster analysis is a method of categorising data into groups based on shared properties. In agriculture, cluster could be used to obtain information on moisture levels and meteorological factors that affect crops, such as temperatures, humid and precipitation information (Vangala et al. 2020).

Field data gathering refers to getting necessary details as well as the crops produced, the farmer’s economic techniques, and information upon on chronologically and spatially cultivation of plants when using RS in sustainable agriculture. The use of remote sensing in agricultural management is given special focus. Using wireless sensor networks to study corresponding equipment systems in the field of smart agricultural production has important practical significance and academic value. The intelligent agricultural environmental information collection system based on wireless sensor network uses a large-scale data collection technology based on wireless sensor network to observe environmental parameters such as soil temperature and soil moisture all-weather uninterruptedly. The collected data are finally transmitted to the observers, that is, the workers in agricultural production, through the cluster head node and the management node. Through this system, real-time monitoring, information collection and automatic control of large areas of farmland or greenhouses can be realised. The staff only need to use the management node in the office to complete the monitoring of agricultural production and realise the management of agricultural production. Therefore, it saves labour costs, improves production efficiency, increases operation accuracy, improves unit output and quality, reduces agricultural production costs, and ensures the automation, refinement and integration of agricultural production.

**Related work**

When solving the security problem of wireless sensor networks, it is necessary to consider the reliability of data generation, the security of data transmission, the confidentiality of task execution and the efficiency of data fusion (He et al. 2018). It can be said that the security problem of wireless sensor networks is a very key factor restricting its development (Ray 2017). Game theory is to study the behaviour of decision-making subjects, the decision-making when interaction occurs, and the equilibrium problem of decision-making (Qadri et al. 2020). Game theory is a theory that uses mathematical tools to study the strategies and decision-making problems of two or more participants. In the game situation, all decision-making subjects choose the strategy that maximises their expected returns. Because the interests of both parties in the game are interrelated, each decision-making subject must consider the strategy
selection behaviour of other participants when choosing its own best strategy (Dobkin 2017).

The sensor network reputation basic framework (RFSN) proposed in the literature (Yao and Ansari 2018) is a relatively complete reputation-based trust management system in wireless sensor networks. The literature (Siegel et al. 2017) summarised the characteristics, classification methods, frame design, etc. of trust management in the environment including WSNs, and expounded typical trust management systems. The literature (Abd-Elmagid et al. 2019) reviewed the trust model in wireless sensor networks. The literature (Sheth et al. 2018) proposed a trust management system based on a secure communication architecture, and found out various parameters and trust factors of the trust management system framework. The literature (Joyia et al. 2017) reviewed the reputation management system and trust management in the field of wireless communication. The literature (Kshetri 2017) analyzed various applications of trust models and classified various trust models against hostile attacks. Finally, it gave several basic trust management models in wireless sensor networks, and pointed out the research direction of trust management models. In sensor networks, the literature (Siboni et al. 2019) used trust for data fusion based on data fault tolerance, and applied trust management mechanisms to data fusion and cluster head election, security architecture, routing and other wireless sensor network technologies, thereby improving the security of wireless sensor networks. In a multi-sensor network, when dealing with conflicting data, the previous rules do not apply, and problems such as data explosion and one-vote veto will occur (Yang et al. 2018). These problems will cause a big difference between the fused data and the actual results. It uses the concept of analyzing distance-based evidence conflicts and uses the data cosine theorem to propose a method of identifying and expressing evidence conflicts. This method has a great improvement in the accuracy of fusing two contradictory data. In wireless sensor networks, the literature (Li et al. 2018) proposed a multi-level delegation management framework for establishing trust relationships between nodes. The framework establishes node trust relationships through subjective trust, objective trust and recommendation trust. The literature (Ray 2018) proposed a trust evaluation framework to determine the malicious behaviour of sensor nodes, and gave a locally distributed protocol, which can effectively improve the ability of nodes to resist capture attacks and reduce the ability of malicious nodes to attack. The literature (Mayer and Baeumner 2019) proposed a dynamic trust model based on fuzzy theory. This model is based on fuzzy set and grey theory, and evaluates the trust degree of each node by combining direct trust and indirect trust relationship. Only nodes with higher trust value can choose to forward data packets. This dynamic model can resist attacks from selfish nodes. The literature (Saez et al. 2018) proposed a routing protocol that takes into account both energy and security. The protocol uses a new measurement method to select the route that maximises the life of the network. Moreover, the protocol selects the safest route by evaluating the security risk of the route. Compared with other protocols, this protocol can not only significantly reduce sensor mortality and prolong the life of the network, but also find routes with the most optimised security level.

In this paper, a detection system focuses on functional Wireless Heterogeneous Network Connection (WRAN) technologies for environmental monitoring is suggested. A Consumer Premise Equipment (CPE) and a ground station interact across incumbent lines unscrupulously without interfering with incumbents’ activities in WRAN technology (Bayrakdar 2020). A monitoring strategy based on a wireless sensor node is examined in this research. The monitoring sensors are created in a modelling environment. To guarantee that the proposed method runs in an energy-efficient fashion and without control packets, the time-division multiple access (TDMA) protocols were used as the data transmission mechanism (Bayrakdar 2019). A novel strategy is presented in this thesis, where a number of sensors are distributed across a huge agricultural region. In particular, a fuzzy logic-based channel allocation strategy is recommended to evaluate smart farming network resilience. Sensor networks are used to detect variables in an agricultural region such as temperature, humidity, pressure and so on (Bayrakdar 2020). A numerical simulation model was used to study an intelligent insect pest detection technique using certified subterranean wireless sensor nodes for agricultural development in this research. The monitoring of insect pests is believed to be performed out with a competent acoustic sensor in a modelled smart technique (Bayrakdar 2019).

System model

The typical network structure of hierarchical wireless sensor network is shown in Figure 1. The sensing layer node (SN) is responsible for information collection, and the convergence layer node (CN) is responsible for aggregating the information collected by multiple sensing layer nodes and communicating information through multi-hop between different convergence layer nodes. The primary function of sensing input layer is to gather and transmit data; data transfer should include the desired data quantity, actual data
transfer and transmitting data duration. Between the higher protocol levels and the MAC layer, the CL serves as an adaptability layer. The CL’s major job is to collect traffic again from upper supported tiers and sum it up for the SDUs. Common Part Convergence Sublayer (CPCS) and Service Specific Convergence Sublayer (SSCS) are the main sublayers that make up the CL (Deepa et al. 2020). This article assumes that the 3D wireless sensor area to be covered is M, and the nodes of the sensing layer and the convergence layer are randomly distributed in M (Jagadeeswari et al. 2018).

\[ SN = \{SN_1, SN_2, \ldots, SN_{n_s}\} \]

is the set of perception layer nodes, where \( n_s \) represents the number of perception layer nodes, and \( SN_i = \{x_{SN_i}, y_{SN_i}, z_{SN_i}\} \) is the position of the \( i \)th perception layer node. \( CN = \{CN_1, CN_2, \ldots, CN_{n_c}\} \) represents the aggregation layer node set, \( n_c \) is the total number of aggregation layer nodes, and \( CN_j = \{x_{CN_j}, y_{CN_j}, z_{CN_j}\} \) represents the location information of the \( j \)th aggregation layer node. This article assumes that all nodes at the convergence layer have the same receiving sensitivity \( \alpha_0 \).

During the propagation of wireless signals, there is not only path loss, but also loss when penetrating obstacles. The propagation of wireless signals in this paper is given by the following formula (Smys et al. 2020):

\[ \beta = \alpha + 10 \gamma \log \frac{d}{\sigma} + \beta_0 \]  

(1)

In the formula,

\[ d = \sqrt{(x_{SN_i} - x_{CN_j})^2 + (y_{SN_i} - y_{CN_j})^2 + (z_{SN_i} - z_{CN_j})^2} \]  

(2)

d is the distance from \( SN_i \) to \( CN_j \), \( \gamma \) is the path loss index, which represents the growth rate of path loss with distance, \( d \) is the reference distance, \( \alpha \) is the received power at the reference distance \( d \), \( \beta_0 \) is the signal attenuation value caused by obstacles, and the attenuation value caused by different obstacles is different. This value is usually calculated by discounting any obstacles or reflections that might occur in its path. The loss between two isotropic radiators in free space, expressed as a power ratio and it can be evaluated with Frequency, Distance and System gains to calculate the Free Space Path Loss. This model introduces the key principles of such two Boolean models, as well as the easiest analytical and process simulation that have been created for them. They shall explain that Boolean predictions are based on fairly constant research on convergences in the Methodology chapter, as well as the connection between probability Boolean network and bayesian Neural networks. This article introduces the following Boolean expression \( l(SN_i, CN_j), i \in [1, n_s], j \in [1, n_c] \) to judge whether there is a valid link between \( SN_i \) and \( CN_j \), that is, whether \( SN_i \) effectively covers \( CN_j \). The specific expression is as follows:

\[ l(SN_i, CN_j) = \begin{cases} 1 & \text{if} \; p_i - \beta \geq \alpha_0 \\ 0 & \text{otherwise} \end{cases} \]  

(3)

In the formula, \( p_i \) represents the transmit power of the \( i \)-th sensing layer node. In order to collect data completely, it is necessary to ensure that there is an effective link between any sensing node and a sink node. To this end, we define the connection rate of the entire network as (Butun et al. 2019):

\[ L_\Omega = \frac{1}{n} \sum_{i=1}^{n_s} l(SN_i, CN_j) \]  

(4)

Obviously, when all sensing nodes can have an effective link with the sink node, \( L_\Omega = 1 \), that is, the sensing layer is fully connected. On the other hand, we introduce the standard deviation of the transmitting power of the sensing layer nodes to measure the energy consumption balance among the sensing layer nodes, namely:

\[ \sigma_p = \sqrt{\frac{1}{n_s - 1} \sum_{i=1}^{n_s} (p_i - \bar{p})} \]  

(5)

In the formula,

\[ \bar{p} = \frac{1}{n_s} \sum_{i=1}^{n_s} p_i \]  

(6)

In summary, the optimisation problem in this paper can be summarised as: Under the premise of ensuring the connection rate is 100%, by jointly optimising the deployment location of all convergence layer nodes.
and the transmit power of all sensing layer nodes, the sum of the transmission power of all the sensing layer nodes is minimised, and the standard deviation of the transmission power between all the sensing nodes is as small as possible, so as to achieve the purpose of energy saving and energy consumption balance and extending the network life. The above optimisation problem can be defined as follows:

\[
\text{OP}: \min \left( \sum_{i \in n} p_i \right) \\
\text{s.t.} C_1: \forall \Omega = 1 \\
C_2: \sigma_p \leq \varepsilon \\
C_3: 0 \leq p_i \leq p_{\text{max}} 
\]

(7)

A wireless sensor node could be static or movable, due to the nature of the design requirements. Data gathering by the sinks from multiple sources will be challenging and time-intensive whenever the nodes are fixed. Also, because the nodes in a sink’s one-hop neighbour must constantly be operational to transfer data from various participants downstream to it, static distribution of sink and source nodes results in an energy gap. Any sensor network channel’s life expectancy is reduced as a result of this energy hole problem. As a result, a portable sink-based strategy might be employed to extend the life of a wireless sensor network while also reducing energy consumption (Ahmad et al. 2015). In the formula, \( \varepsilon \) is the given standard deviation threshold, the constraint condition \( C_1 \) restricts the full connection.

Figure 2. System block diagram.
between SN and CN, $C_2$ restricts the transmit power of all SNs to achieve energy balance, and $C_3$ restricts the transmit power range of all SNs. Standard Deviation Threshold examines a current Volume of Interest and calculates the standard deviation of image intensity as well as other information. Then, utilising user-defined criteria such as a set of reference deviation and values from outside region, its threshold a photograph.

The Marine Predators Algorithm (MPA) is an evolution optimisation method that plays by the rules that regulate optimum feeding technique and predator-prey contact rates in aquatic ecosystems. When there is a small amount of prey, marine predator adopts the Lévy method, but in places where there is ample prey, they use Brownian mobility (Shah et al. 2018). The MPA algorithm mainly involves two kinds of motion strategy selection, namely, Levi flight and Brownian motion strategy. Several creature species have been identified performing Levy flights, which are the best approach for arbitrarily searching for a destination in an unfamiliar area. Fluids are made up of particles that flow arbitrarily in liquids or gases. Brownian motion is the name for this type of movement. These do it because they’re attacked by the fluid’s accompanying moving fluid. Tiny, quickly electrons can pass bigger molecules.

Levi flight is a kind of random walk, which uses the following function to generate random numbers according to Levi distribution:

$$R_L = \frac{0.05a}{|b|^{1/\lambda}}$$  \hspace{1cm} (8)

In the formula, $R_L$ represents a random number $a \sim N(0, \sigma_a^2)$, $b \sim N(0, b)$, $\lambda = 1.5$ based on the Levi distribution, and $\sigma_a$ is calculated by the following formula:

$$\sigma_a = \left[ \frac{\Gamma(1 + \lambda) \times \sin \left( \frac{\pi \lambda}{2} \right)^{1/\lambda}}{\Gamma(1 + \lambda) \times \lambda \times 2^{(\lambda - 1)/2}} \right]$$  \hspace{1cm} (9)

In the formula, $\Gamma$ represents the gamma function, and for integers $\lambda$, $\Gamma(1 + \lambda) = \lambda$. Brownian motion is a random process. They come from a Gaussian distribution with a mean of 0 and a variance of 1. According to Darwin’s survival of the fittest theory, the top predators in nature are more competitive when looking for food. We use $T_{\text{top}}$ to represent the top predators. It is replicated $n$ times to construct the predator matrix $E$, which is expressed as follows:

$$E = [T_{\text{top}}^1, T_{\text{top}}^2, \ldots, T_{\text{top}}^n]^T$$  \hspace{1cm} (10)

In the formula, $T_{\text{top}}^i = [X_{i,1}^j, X_{i,2}^j, \ldots, X_{i,d}^j]$  \hspace{1cm} (11)

$n$ represents the number of the population, $d$ represents the dimension of the individual, and $X_{i,j}^j$ represents the $j$-th individual of the $i$-th group in the predator matrix. Another matrix with the same dimensions as the predator matrix is the prey matrix. The interactions between two creatures in which one is the sought farming industry with the other are known as predator-prey relationships. The predator is the creature that eats, while the victim is the creature that’s also eaten. Predator and prey groups react to one another in a compelling manner (Billah et al. 2021). The predator uses this matrix to update its position. The prey matrix is represented as follows:

$$Pr = [X_1, X_2, \ldots, X_n]^T$$  \hspace{1cm} (12)

In the formula,

$$X_i = [X_{i,1}, X_{i,2}, \ldots, X_{i,d}]$$  \hspace{1cm} (13)

$X_{i,j}$ represents the $j$ dimension of the $i$th individual in the prey matrix. The prey matrix is initialised with the following formula:

$$X = X_{\text{min}} + \text{rand}() \times (X_{\text{max}} - X_{\text{min}})$$  \hspace{1cm} (14)

In the formula, $X_{\text{min}}, X_{\text{max}}$ is, respectively, the lower and upper bounds of the solution space in the optimisation problem, and $\text{rand}()$ is the random number in $(0, 1)$.

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**Figure 3.** Hardware structure diagram of cluster head node.
The fitness of each individual predator is calculated, and the optimal solution is designated as the top predator. MPA divides the entire algorithm process into three stages. We use the current iteration number \( k \) to compare with the maximum iteration number \( M_{\text{max}} \) to map. The first stage of the MPA algorithm is mainly used for the global search of the solution space. The specific process is as follows:

When \( k < \frac{1}{3} M_{\text{max}} \),
\[
S = R_B \otimes (E - R_B \otimes P_i) \\
P_i = P_i + \theta \times R \otimes S, \, v = 1, 2, \ldots, n
\]  

(15)

In the formula, \( \theta = 0.5 \) is a constant, \( S \) represents the moving step length of the prey, and \( R \) is the uniform random number vector in \((0, 1)\). \( R_B \) is a vector based on the standard normal distribution, which represents Brownian motion. \( \otimes \) means that the elements in the vector are multiplied in sequence. The second phase of the MPA algorithm transitions from the global search of the solution space to the local search of the current optimal solution position in the solution space. The specific process is as follows:

When \( \frac{1}{3} M_{\text{max}} \leq k \leq \frac{2}{3} M_{\text{max}} \),
\[
S = R_L \otimes (E - R_L \otimes P_i) \\
P_i = P_i + \theta \times R \otimes S, \, v = 1, 2, \ldots, n
\]  

(16)

In the formula, \( R_L \) is a random number vector based on the Levi distribution, representing Levi flight, \( CF \) will change according to the increase of \( K \), which is

\[
S = R_B \otimes (E \otimes R_B - P_i) \\
P_i = E + \theta \times CF \otimes S, \, v = n/2 + 1, n/2 + 2, \ldots, n
\]  

(17)

In the formula, \( R_L \) is a random number vector based on the Levi distribution, representing Levi flight, \( CF \) will change according to the increase of \( K \), which is

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**Figure 4.** The transmitting end of the system set.
calculated by the following formula:

\[ CF = \left(1 - \frac{k}{M_{\text{max}}}\right) \left(\frac{2k}{M_{\text{max}}}\right) \]  

(18)

In the formula, \( k \) represents the current iteration number, and \( CF \) is used as an adaptive parameter to control the predator’s moving step length. The third stage of the MPA algorithm mainly performs a local search for the current optimal solution position in the solution space. The specific process is as follows:

When \( k > \frac{2}{3} M_{\text{max}} \),

\[ S = R_L \otimes (E \otimes R_L - P_i) \]

\[ P_r = E + \theta \times CF \otimes S, \nu = 1, 2, \ldots, n \]  

(19)

The FAD, (Fish Aggregating Devices) effect is mainly used to jump out of the local optimal solution of the algorithm. The mathematical expression of FAD, effect is as follows:

\[ Pr = \begin{cases} 
Pr + CF[X_{\text{min}} + R \otimes (X_{\text{max}} - X_{\text{min}}) \otimes U] & \text{if} r < F_A \\
Pr + [FA(1 - r) + r] \times (Pr_r1 - Pr_r2) & \text{if} r \geq F_A
\end{cases} \]  

(20)

In the formula, \( F_A = 0.2 \), and \( U \) is binary vectors including 0 and 1. By generating a random direction in \((0, 1)\), the value in the vector is compared with \( F_A \). If the value is greater than \( F_A \), the value is changed to 0, otherwise the value is changed to 1. MPA is the random number \( r1 \) and \( r2 \) in \((0, 1)\), and the subscript represents the random index vector of the prey matrix.

Data transmission model of agricultural wireless sensor network based on game theory.

This system adopts a double-layer network topology structure, and there are three kinds of nodes to form the whole hardware system, namely management node, cluster head node and sensor node. The overall
The framework of the system is shown in Figure 2. The management node and the cluster head node both use the processor STM32F103ZE with ARM Cortex-M3 core as the processor, and the sensor node uses the low-power processor MSP430 as the MCU. In addition, the management node is made into a portable handheld device instead of using a computer as the management node, which ensures the real-time monitoring. Even if the workers leave the studio, as long as they are in the farm, they can achieve the purpose of real-time monitoring of the production of smart agriculture.

For the practical requirements of smart agriculture, the cluster head node of this system also integrates high-performance ARM processor, large-capacity data storage, USB transmission and other technologies to realize real-time monitoring, forwarding, storage and analysis of network data. The cluster head node is mainly composed of a central processing unit module, a Zigbee wireless communication module, a short-range communication NRF2401 module, a NandFlash storage module, a real-time clock module, a USB transmission module and a power supply module. The hardware system structure is shown as in Figure 3.

The sensors on the agricultural site collect data information and convert the data into corresponding electrical signals, which are then converted into signals that can be processed by the microprocessor through the internal AID. The output signal of the sensor selected in this paper is a digital signal, which does not need to be converted. The microprocessor stM32 of the front-end data acquisition module packs the data and sends it to the STM32 microprocessor of the host control module through the wireless sensor network composed of the wireless transceiver module nRF24L01. After corresponding processing, the information collected in real time can be seen on the human-computer interaction interface. Data information can be saved in the SD card, and there are switch control buttons on the human-computer interaction interface, and remote control can be realised by touching the button. Figure 4 is a block diagram of the system hardware.

Socket is located between the application layer and the transport layer, and the user process needs to connect to the transport layer through Socket, as shown in Figure 5.

1. The system adopts a tree-shaped network topology structure and deploys a certain number of ZigBee test nodes in the monitoring area to collect the soil moisture and soil temperature parameters of the farmland in real time; 2. The node design of the system is composed of sensor nodes, routing nodes and aggregation nodes. Data collection, processing, transmission and storage are completed by sensor nodes and routing nodes, and unified data aggregation management is completed by sensor aggregation nodes; 3. The system monitoring node transmits the real-time temperature and humidity values to the data collector through the ZigBee network channel. The data collector synchronises the monitoring nodes distributed everywhere with it by sending commands, and controls the monitoring nodes to periodically enter a low-power state to save power; 4. The system is equipped with an on-site control unit to undertake the task of a gateway node and is mainly responsible for processing nodes. The transferred collected data are sent to the pre-prepared system server through the fieldbus serial communication interface. All node data are finally routed to the gateway node, and finally unified to the base station; 5. In this system, the central processing server of the host system is responsible for storing and archiving the received data, optimising the range value, and analyzing and processing the development trend. The monitoring personnel can according to the analysis conclusions, early warning information will be released to users in time, and the monitoring behaviour of nodes will be adjusted and improved in time as needed.

Figure 6. Data transmission model of agricultural wireless sensor network based on game theory.
Figure 7. Two-dimensional architecture of the software of the wireless sensor network.

Table 1. Statistical table of the monitoring effect of the data transmission model of agricultural wireless sensor network based on game theory.

| Dataset number | Data monitoring | Dataset number | Data monitoring | Dataset number | Data monitoring |
|----------------|-----------------|----------------|-----------------|----------------|-----------------|
| 1              | 87.3            | 28             | 88.6            | 55             | 92.6            |
| 2              | 82.6            | 29             | 91.5            | 56             | 89.0            |
| 3              | 91.1            | 30             | 87.4            | 57             | 82.7            |
| 4              | 92.1            | 31             | 84.0            | 58             | 88.3            |
| 5              | 83.6            | 32             | 87.2            | 59             | 90.3            |
| 6              | 85.2            | 33             | 85.0            | 60             | 86.9            |
| 7              | 85.5            | 34             | 84.1            | 61             | 87.8            |
| 8              | 81.1            | 35             | 85.0            | 62             | 88.2            |
| 9              | 85.0            | 36             | 91.9            | 63             | 81.6            |
| 10             | 85.0            | 37             | 90.5            | 64             | 90.8            |
| 11             | 87.8            | 38             | 91.0            | 65             | 83.5            |
| 12             | 92.5            | 39             | 89.1            | 66             | 85.0            |
| 13             | 90.2            | 40             | 92.3            | 67             | 83.0            |
| 14             | 87.9            | 41             | 89.5            | 68             | 83.2            |
| 15             | 87.1            | 42             | 81.6            | 69             | 82.5            |
| 16             | 83.2            | 43             | 88.8            | 70             | 89.1            |
| 17             | 81.7            | 44             | 86.3            | 71             | 81.9            |
| 18             | 84.1            | 45             | 91.0            | 72             | 91.9            |
| 19             | 85.1            | 46             | 86.0            | 73             | 81.3            |
| 20             | 91.1            | 47             | 86.2            | 74             | 89.3            |
| 21             | 81.8            | 48             | 89.2            | 75             | 81.7            |
| 22             | 92.3            | 49             | 90.6            | 76             | 88.0            |
| 23             | 85.1            | 50             | 83.3            | 77             | 81.5            |
| 24             | 87.1            | 51             | 82.6            | 78             | 91.6            |
| 25             | 91.8            | 52             | 86.8            | 79             | 83.0            |
| 26             | 81.4            | 53             | 88.6            | 80             | 85.7            |
| 27             | 92.7            | 54             | 82.0            | 81             | 89.9            |
According to the special requirements of agricultural environmental monitoring, the system must achieve the dual goals of monitoring and monitoring. The data collected by sensor sensing must be processed and transmitted to the monitoring centre through the network. Therefore, the system must include a wireless sensor monitoring network and a remote data centre. What this system wants to realise is the short-distance part of the remote monitoring system responsible for data collection, transmission and collection. The follow-up function design mainly completes the data wireless communication and early warning system.

The overall structure of the system is shown in Figure 6.

In the software architecture, the wireless sensor network architecture adopts a typical horizontal and vertical two-dimensional structure design. In this two-dimensional structure design, the horizontal communication protocol layers, from bottom to top, are the physical layer, the chain layer, the network layer, the transport layer and the application layer. The vertical network management plane is composed of an energy management plane, a mobility management plane and a task management plane to manage node energy usage, maintain routing and schedule tasks. The two-dimensional architecture is shown in Figure 7.

The wireless sensor network mainly adopts the communication method of data packet transmission. Designers can obtain a range of interesting occurrence evidence supporting network devices using wireless sensor networks (WSN) and multicast interactions. In other words, the data are transmitted from the source node to the target node, and the data transmission is realised through the relay and forwarding of the sensor node. Each node has 2 policy choices: trust and

![Data monitoring](data.png)

**Figure 8.** Statistical diagram of the data transmission effect of the agricultural wireless sensor network data transmission model based on game theory.

**Table 2.** Statistical table of the data transmission effect of the agricultural wireless sensor network data transmission model based on game theory.

| Dataset number | Data transmission | Dataset number | Data transmission | Dataset number | Data transmission |
|----------------|-------------------|----------------|-------------------|----------------|-------------------|
| 1              | 80.8              | 28             | 82.6              | 55             | 93.8              |
| 2              | 91.1              | 29             | 84.6              | 56             | 92.7              |
| 3              | 85.5              | 30             | 87.8              | 57             | 92.0              |
| 4              | 93.5              | 31             | 92.3              | 58             | 86.2              |
| 5              | 90.9              | 32             | 79.5              | 59             | 92.6              |
| 6              | 79.8              | 33             | 87.9              | 60             | 92.4              |
| 7              | 85.2              | 34             | 88.6              | 61             | 88.8              |
| 8              | 89.4              | 35             | 79.3              | 62             | 93.4              |
| 9              | 83.8              | 36             | 82.9              | 63             | 82.7              |
| 10             | 90.3              | 37             | 85.2              | 64             | 81.8              |
| 11             | 87.5              | 38             | 91.0              | 65             | 89.0              |
| 12             | 84.9              | 39             | 93.9              | 66             | 86.0              |
| 13             | 85.2              | 40             | 88.6              | 67             | 85.6              |
| 14             | 88.0              | 41             | 83.7              | 68             | 92.0              |
| 15             | 86.9              | 42             | 89.3              | 69             | 90.4              |
| 16             | 83.3              | 43             | 81.4              | 70             | 91.8              |
| 17             | 90.0              | 44             | 87.0              | 71             | 89.3              |
| 18             | 88.7              | 45             | 79.4              | 72             | 88.2              |
| 19             | 93.9              | 46             | 86.6              | 73             | 79.7              |
| 20             | 89.7              | 47             | 80.0              | 74             | 94.0              |
| 21             | 87.1              | 48             | 87.3              | 75             | 92.9              |
| 22             | 91.7              | 49             | 92.1              | 76             | 82.4              |
| 23             | 86.5              | 50             | 91.4              | 77             | 91.3              |
| 24             | 81.7              | 51             | 91.5              | 78             | 84.6              |
| 25             | 80.4              | 52             | 80.2              | 79             | 86.4              |
| 26             | 82.6              | 53             | 81.0              | 80             | 80.6              |
| 27             | 86.5              | 54             | 84.2              | 81             | 84.0              |
During the game, if a node chooses a trust strategy, the node will forward data packets of other nodes, which can improve the credibility of the node itself and obtain credibility benefits from it; if a node chooses the untrust strategy, in order to save energy, it will discard the data packets forwarded by other nodes, but it will not gain any revenue. In this case, other nodes will suffer losses because of their refusal to forward data packets.

In the process of WSNs communication, it may be affected by factors such as climate, terrain, node spacing, node energy, etc. During network data transmission, data packet loss may occur. Sensor nodes sending or helping other nodes to forward data packets may not always succeed. The sensor node usually adopts the mechanism of resending the data packet, and repeats the sending until it succeeds. Retransmission of lost packets ensures the quality of data transmission, but it will increase the energy consumption of the node. Therefore, the data transmission reliability of wireless sensor networks is one of the important factors affecting node interaction. Network reliability is the characteristic of a network information system that can complete a specified function under specified conditions and within a specified time. Network unreliability is mainly manifested as data errors and packet loss in network communication, that is, the higher the network reliability, the lower the packet loss rate; the lower the network reliability, the higher the packet loss rate. Assuming that the network reliability of the wireless sensor network is consistent, that is, the node’s packet loss rate is the same, the probability of the sensor node sending a packet is the same.

**Effect verification**

After constructing an agricultural wireless sensor network data transmission model based on game theory, this paper verifies the performance of the model and conducts research through the simulation model. The model can simulate the wireless network communication situation in the real environment, follow the real physical environment and mechanism, and generate any number of related link data. Therefore, this paper uses simulation research to verify the performance of the agricultural data monitoring and transmission model in this paper. The monitoring results are shown in Table 1 and Figure 8.

From the simulation test, we know that the data transmission model of agricultural wireless sensor network based on game theory constructed in this paper can be used to realise real-time monitoring of agricultural data with the support of wireless sensor network. After that, the data transmission effect of the model in this paper is evaluated, and the results are shown in Table 2 and Figure 9.

From the above experimental research, we can see that the network data transmission model of agricultural wireless sensor based on game theory constructed in this paper can play a good effect in agricultural data monitoring and transmission.

**Conclusion**

The intelligent agricultural environment information collection system based on wireless sensor network proposed in this paper adopts a hierarchical network structure for the practical needs and objective conditions in the field of intelligent agricultural production. The upper layer uses a self-organising network, and the lower layer uses a star network structure. The network has many features such as good scalability, high reliability, low power consumption, low cost and high cost performance. It is very suitable for wide application and large-scale promotion in the field of agricultural production. Based on the traditional LEACH clustering routing algorithm, this paper optimises the clustering method and proposes the idea of multi-level clustering. Moreover, for the proposed optimisation algorithm, this paper studies it from two perspectives of theoretical analysis and simulation experiment, and the effectiveness of the algorithm model constructed in this paper is proved through experimental research.
Sensing activities must be distributed and performed amongst detectors in the shortest time are selected as key concepts for future directions. Moving objects can be regarded intelligent entities, and this trait typically increases the tracking difficulties.

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