Intelligent Agricultural Automatic Control System Based on Internet of Things

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Abstract. The advanced technology of the Internet and extensive agricultural transformation and upgrading have made the overall agricultural industry chain and modern agriculture better. In view of the high cost and suffering of traditional agricultural planting management, the Internet of Things (I O T) is applied to agriculture to realize real-time detection and intelligent management of crop growth conditions, remote control, and change the traditional agricultural equipment planting mode. The purpose of this article is to design and research the I O T automatic control (A C) system for smart agriculture. This article first introduces the core technology of the I O T through an overview of the basic theories of the I O T. Combined with the current status of agricultural automation in my country, the existing problems and deficiencies are analyzed. On this basis, use the core technology of the I O T to supplement and improve it. This article systematically expounds the overall scheme design, module function design and A C algorithm realization of the I O T brake control system. And use field investigation method, comparative analysis method and other research forms to carry out research on the theme of this article. Experimental research shows that the sampling data of the greenhouse is selected as the sample, the appropriate initial membership function is selected, and the fuzzy control rules obtained through the training of the fuzzy neural network algorithm are relatively correct. The output result of the automatic temperature control system is mostly consistent with the actual data on site. Overall, the temperature A C system designed in this subject can meet the A C requirements of agriculture.

Key words: Smart Agriculture, A C, System Design, Research and Analysis

1. Introduction
China is a big country of agricultural production, and agriculture is the foundation of the national economy [1-2]. With the increasing national strength of our country, food supply safety and hygiene safety have attracted more and more attention. The problems of multiple human and material resources in traditional planting methods need to be solved urgently. The establishment of a modern intelligent agricultural control system is proposed[3-4].

In the United States, Britain, Israel and other countries, the development of agricultural I O T is very advanced [5-6]. Intel has established the world's first I O T vineyard, which has realized the monitoring of soil temperature, humidity and the quantity of harmful substances. In China, agricultural
production is the foundation of the national economy [7-8]. Today's agricultural products often have problems such as industrial emissions and pollution, and the current level of agricultural production automation is low. Product monitoring and tracking rely on manpower, which increases labor costs [9-10]. In order to solve this problem, the country is actively promoting the construction of the combination of the Internet and agriculture, and promoting the construction of agricultural standardization and informatization [11-12].

The purpose of this article is to design an intelligent system for modern agriculture. The system can realize the collection and remote control of agricultural data through the establishment of the I O T cloud platform, and realize the functions of automatic water-saving irrigation and automatic temperature control through the A C algorithm based on fuzzy neural network.

2. Automatic Control System of Internet of Things for Smart Agriculture

2.1. Internet of Things Technology

(1) Internet of Things
The I O T is also called the "sensor network", which is a strategic emerging industry in the "informatization" era. The I O T connects "people and people, things and people, things and things" through perception. Specifically, the I O T is a network extended from the Internet, using mobile communication technology to realize information transmission, cloud computing technology to realize data analysis and processing, and finally achieve information communication and decision-making. The I O T is widely used in network integration through data transmission technologies such as intelligent perception, identification technology, intelligent calculation, processing technology, and information communication network, which is a new economic growth point.

(2) Architecture design of agricultural I O T system
The application of the I O T in the agricultural field has become more and more widespread, triggering a new information technology revolution after the Internet. The cultivation, fertilization, and irrigation of traditional agriculture mainly rely on farmers' experience. Although farmers' experience guarantees the production of crops to a greater extent, they cannot guarantee their accuracy. Environmental indicators such as temperature, humidity, light, and CO2 concentration are difficult to fine-tune through perception.

According to the basic characteristics of the I O T, it can be 5 layers:

1) Information perception layer
Various physical data are collected mainly through sensors, controllers, etc. The main task of this layer is to perceive, identify objects and collect information. Such as soil nitrogen and potassium content.

2) Network transport layer
Including various wired or wireless communication networks and gateways. Through the combination of downward and perception layer and upward and business layer, data can be transmitted over long distances and in a wide range.

3) Processing the business layer
Combine the I O T technology with agricultural technology, and establish the corresponding monitoring, early warning, decision-making, expert, control and other intelligent information processing platforms through the processing of data at the business layer.

4) Management application layer
For specific agricultural application areas, system application users include administrators, producers, experts, and consumers. Information query, precise monitoring and intelligent control of agricultural
production process.

5) User use layer
System users can log in to the unified intelligent agricultural monitoring platform through PCs, mobile phones, etc.

2.2. System Overall Scheme Design

(1) Automatic acquisition/control terminal
Realize the signal input and signal output in the agricultural field. Considering that there are many types of collection and control in the agricultural field, this system uses an ARM-based high-performance embedded processor to cooperate with various sensors and controllers to complete the collection and control of information. The system has two operating modes: passive control and active control: in the passive control mode, the control terminal performs control according to the commands transmitted by the cloud platform; in the active control mode, the control terminal controls the field controller according to the A C algorithm in the software program Take control.

(2) Network transmission
The system can collect data from multiple collection nodes through the gateway, transmit the collected data to the cloud platform through the TCP/IP-based MODBUS protocol, and remotely control the field equipment, or transmit the collected data to the cloud platform through the 3G network.

(3) Cloud platform
The cloud platform runs on a core server, which mainly receives collected information sent back via the network. This system uses the I O T cloud as the data processing platform, which can ensure the stable operation of the system and reduce maintenance costs.

(4) Terminal
The system can be accessed through mobile phones, smart TVs, and PCs. Users can accurately understand the conditions of the agricultural site through this page and can remotely control the on-site controller through this page.

2.3. Functional Module Design

(1) Data acquisition module
First, initialize the sensor. The function AM_Read_Data() reads the signal collected by the sensor and converts the analog signal into a digital signal. The sensor data mainly includes data such as temperature, humidity and light intensity. The array LongLatistr mainly stores the detected data, and then transmit the collected data to external applications through the network.

(2) Control module
The monitoring center issues a control command, and STM32 changes the working state of the relay. In the control task, first initialize the IO port of STM32, and transmit the signal to the STM32 system via Ethernet. Once the STM32 reads the control signal, it will pull down the level of the IO port PE9, control the pull-in of the relay, open the channel switch, and then Implement control operations.

(3) Serial communication module
Serial communication is to receive and send data bit by bit. First, you need to specify the name of the serial device, read the data of the serial port, and start the data transmission. If the detected data is judged as junk data, the data will be discarded [43,44,45], if it is the correct data, it will be Data is packaged and stored.
(4) 3G communication module
The chip used in the system’s 3G communication is SIM800. The SIM800 in this design will work in single link mode. Set the module to transparent transmission mode, and the module can receive and send data. After the transparent transmission mode is successfully established, the module is in the data mode, and all data received from the serial port will be packaged and sent over the network.

2.4. Monitoring Platform Design
The monitoring center of this design selects MyEclipse as the development platform, which has rich functions and can meet the needs in the software development process. MyEclipse has very rich functions, including coding, debugging and testing functions, and can develop databases, JSP, Javascript, CSS, etc. In the design of the monitoring center, through the HTML under the B/S architecture, it has strong interoperability. In this design, Javascript language and Java language are mainly used to realize related functions. It has dynamic characteristics and can respond to various operations of users.

2.5. Design of Agricultural A C Algorithm Based on Fuzzy Neural Network
The fuzzy neural network algorithm can not only process fuzzy information in the agricultural field, but also obtain the optimal control rules through training. The topological structure of the fuzzy neural network mainly includes 4 layers, and the transfer rules between each two layers are:

$$\text{net}_k^i = W_{ij}^k \ast u_j^k$$  \hspace{1cm} (1)

Among them, net$_k^i$ is the input of the k-th node; wkij is the weight of the connection between the i-th node in the k-th layer and the j-th node in the k-1 layer; ukj is the j-th input connected to the i-th node, oki represents the output of the k-th layer node.

The first layer is the input layer. In this layer, the input of this layer is directly passed to the output of the next layer. The input-output relationship is:

$$\text{net}_1^i = W_{ij}^1 \ast u_j^1$$  \hspace{1cm} (2)

$$o_i^1 = \text{net}_i^1$$  \hspace{1cm} (3)

Where O$^1_i$ is the output of the first layer node.

The second layer is the membership function layer, which describes the membership degree of the input variables, generally bell-shaped functions, trigonometric functions, and so on.

The third layer is the control rules layer, where all fuzzy control rules are processed. In the operation, the multiplication operation is selected instead of the minimization calculation, and W$^3_{ij}$ is set to 1, and the input and output relationship of the i-th rule is:

$$\text{net}_3^i = \prod_{j=1}^{n} W_{ij}^3 U_j^3$$  \hspace{1cm} (4)

$$o_i^3 = \text{net}_i^3$$  \hspace{1cm} (5)

Where O$^3_i$ is the output of the third layer node.

The fourth layer is the output layer, where the data processed by the network is output. The input-output relationship of the i-th output unit in this layer is:

$$\text{net}_4^i = \sum_{j=1}^{n} W_{ij}^4 U_j^4$$  \hspace{1cm} (6)

$$o_i^4 = \text{net}_i^4$$  \hspace{1cm} (7)

Where O$^4_i$ is the output of the fuzzy neural network.

Before the neural network training starts, the weights and output thresholds must be initialized with random numbers. Then use the gradient descent method to train the samples, and the objective function is:
\[ E = \frac{1}{2} \sum_i (d_i^4 - o_i^4)^2 = \frac{1}{2} \sum_i (d_i^4 - f^4(\text{net}_i^4))^2 \] (8)

In the formula, \( d_i^4 \) is the expected output value.
After neural network training, the trained membership function and optimal fuzzy control rules can be obtained.

3. Experimental Research on the Automatic Control System of the Internet of Things for Smart Agriculture

3.1. Experimental Protocol
In order to make this experiment more scientific and effective, this experiment tested the automatic irrigation function and automatic temperature control function of the A C system involved in this article. In this experiment, 2000 sets of soil moisture, precipitation and irrigation data, and 2000 sets of temperature difference, temperature change rate and ventilation time data were used as training samples for the neural network algorithm. The training sample data is trained by Matlab software, and the optimized membership function and fuzzy control rules are obtained. Let the system work in active control mode, set the soil water potential target to 0 (the soil moisture is appropriate) and the temperature target to 25 degrees celsius. Select 10 sets of verification sample data input system, compare the output results and field data according to the training membership function to verify the automatic irrigation and temperature control.

This time, the rainfall is divided into five fuzzy thresholds: 1 (small), 3 (medium), 5 (large), 7 (very large), and 9 (extra large);
Divide the soil water potential into five fuzzy thresholds: 1 (extremely low), 3 (very low), 5 (a bit low), 7 (appropriate), 9 (appropriate);
The temperature difference and temperature change rate are divided into five fuzzy thresholds: -1 (indicating negative), 0 (no change), 1 (small change), 5 (medium change), 9 (large change).
The irrigation amount is divided into five fuzzy thresholds: 1 (very small amount of irrigation), 3 (small amount of irrigation), 5 (medium amount of irrigation), 7 (large amount of irrigation), 9 (very large amount of irrigation).

3.2. Research Methods
(1) Comparative analysis method
In this experiment, 10 different control groups were set up for comparative analysis. The purpose of this experiment is to test the A C system studied in this article.

(2) Field research method
In this research, we go deep into the agricultural planting area of a certain place, and investigate the status quo of its planting and collect data, and organize and analyze the collected data. These data provide a reliable reference for the final research results of this article.

(3) Mathematical Statistics
Use related software to make statistics and analysis on the research results of this article.

4. Experimental Analysis of the Internet of Things Automatic Control System for Smart Agriculture

4.1. Automatic Irrigation Control Test
In order to make this experiment more scientific and effective, this experiment selects 10 different verification sample data for testing. The data obtained is shown in Table 1.

It can be seen from Figure 1 that the sampling data of the paddy field is selected as the sample, the
appropriate initial membership function is selected, and the fuzzy control rules obtained through the training of the fuzzy neural network algorithm are relatively correct. The output result of the automatic irrigation system is mostly consistent with the actual data, and the irrigation time of a small part of the data is slightly different. Because temperature, light and other factors were not considered in the modeling process, the actual irrigation time may be slightly longer than the output time of the automatic irrigation system when the light is too strong and the evaporation is too large. Overall, the automatic irrigation control system designed in this subject can meet the requirements of A C in agriculture.

**Table 1. Automatic irrigation system output and field data comparison result**

|   | Soil water potential | Rainfall | Field data | Irrigation system output |
|---|----------------------|----------|------------|--------------------------|
| 1 | 9                    | 1        | 3          | 1                        |
| 2 | 7                    | 1        | 3          | 3                        |
| 3 | 7                    | 5        | 3          | 3                        |
| 4 | 5                    | 7        | 7          | 7                        |
| 5 | 9                    | 1        | 1          | 1                        |
| 6 | 9                    | 1        | 1          | 1                        |
| 7 | 5                    | 1        | 9          | 7                        |
| 8 | 5                    | 1        | 7          | 7                        |
| 9 | 7                    | 3        | 1          | 1                        |
| 10| 3                    | 1        | 9          | 9                        |

![Figure 1. Automatic irrigation system output and field data comparison result](image)

**4.2. Test of temperature A C system**

In order to further research and analyze this experiment, this experiment selects 10 sets of verification sample data to enter the system, and compares the output results and field data to verify the
temperature A C system according to the membership function after training, as shown in Table 2.

Table 2. Temperature A C system test

| Levels | Temperature change rate | Temperature difference | Field data | Temperature control system output |
|--------|--------------------------|-------------------------|------------|-----------------------------------|
| 1      | -1                       | 5                       | 1          | 1                                 |
| 2      | 9                        | 1                       | 5          | 5                                 |
| 3      | -1                       | -1                      | 1          | 1                                 |
| 4      | -1                       | 9                       | 1          | 1                                 |
| 5      | 5                        | 9                       | 1          | 1                                 |
| 6      | 5                        | 5                       | 3          | 3                                 |
| 7      | 1                        | 1                       | 7          | 5                                 |
| 8      | 9                        | 1                       | 5          | 5                                 |
| 9      | 1                        | 0                       | 7          | 7                                 |
| 10     | 5                        | 9                       | 1          | 1                                 |

Figure 2. Temperature A C system test

It can be seen from Figure 2 that the sampling data of the greenhouse is selected as the sample, the appropriate initial membership function is selected, and the fuzzy control rules obtained through the training of the fuzzy neural network algorithm are relatively correct. The output result of the automatic temperature control system is mostly consistent with the actual data on site. On the whole, the temperature A C system designed in this subject can meet the A C requirements of agriculture.

5. Conclusion

The widespread application of I O T technology has brought unprecedented development opportunities to our country's agricultural green development, high-yield and high-efficiency, and full-chain upgrades. This article is based on the I O T to build a precision A C system. This article takes automatic irrigation and temperature A C functions as an example, designs an agricultural A C system based on fuzzy neural network, and obtains the optimal control strategy through fuzzy inference and neural network training. After testing, the designed A C system can meet the A C requirements of agriculture.

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