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The Influence of the Design of Environmental Intelligent Control System in Greenhouses on the Growth of Tomatoes

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Abstract: With the continuous advancement of intelligence, the arable land area of the city has been decreasing, and the demand for vegetables has been increasing. This has put forward higher supply requirements for the vegetable industry in N city. The rational development of smart greenhouses can give play to the advantages of the vegetable industry in N, which will result in higher economic and social benefits. The purpose of this paper is to explore the value of smart greenhouses by studying and analyzing the growth of tomatoes in greenhouse environmental intelligent control systems. This paper first studies the specific design of the smart greenhouse system, proposes and plans the system architecture, the related technology used in the system, and then proposes a sequential learning algorithm of the metacognitive interval T-S/2 neural network inference system. The algorithm can quickly reduce the system calculation interval and metacognition order to achieve higher economic benefits. Next, this article uses tomatoes to study the growth and production of tomatoes in smart greenhouses in N city. The tomatoes were placed in the three environments of open field, steel frame greenhouse and smart greenhouse environment for a comparative study of maturity. Then, the detailed research records of the output value, cash income, net profit and output value of tomato in three different environments were carried out to reveal the input-output relationship of the cultivation of greenhouse greenhouses in N city. Finally, the conclusion was drawn: wisdom greenhouse greenhouse Compared with the other two traditional cultivation methods, it can greatly increase the yield and profitability of tomatoes, and can generate greater economic benefits.

1. Introduction

Agriculture is the foundation of the national economy. China has a large population and eats more than 200,000 tons of fruits, vegetables and other foods. Most of them come from China except for a few years to import for variety adjustment. As the world's largest agricultural country, agriculture plays an important role in China's economic and social development. Agricultural greenhouses are an important part of facility agriculture and one of the key points of China's agricultural development [1-2]. Good climate and ecological environment are important guarantees for agricultural production. China has accumulated rich experience and knowledge in agricultural production [3]. However, in most parts of China, there are many unfavorable factors, such as mountainous land, poor soil quality, lack of soil resources, and complex and variable climatic conditions, which are extremely unfavorable for the growth of crops. Therefore, the emergence of agricultural greenhouses has restricted agricultural production from environmental, climatic, regional and other factors, and has changed the status quo to some extent. Our general understanding of traditional agricultural greenhouses is that they use artificial physical labor, which is characterized by intensive cultivation, small scale of production, backward production technology, single structure of the agricultural sector and low agricultural output. With the development of society, the traditional agricultural production mode can no longer meet the needs of modern economic development. The traditional agricultural cultivation mode has gradually been replaced by many intelligent technologies [4-5].

Agricultural greenhouses have been more and more widely used in China's agricultural production process, but there is a common phenomenon in China, that is, the degree of automation of traditional agricultural greenhouses is relatively low [6]. The collection technology of environmental data in agricultural greenhouses is relatively backward, and it is time-consuming and laborious. The control is basically a large number of manual operations, which limits the economic benefits of agricultural greenhouses to a certain extent, is not conducive to the expansion of production scale in agricultural greenhouses, and improves agricultural information. Level [7]. With the development of science and technology, agricultural development has also been promoted, using existing intelligent technology to update and transform traditional agricultural greenhouses. The use of intelligent technology to transform agricultural production mode is a major event in the sustainable development of China's agriculture and national economy [8]. With the advent of microcomputers and the rapid development of sensor technology, its low price and high reliability have brought many conveniences to the transformation of agriculture. Therefore, according to the current monitoring requirements for environmental parameters of agricultural greenhouses, sensors are used to monitor environmental parameters in agricultural greenhouses, analyze data and control equipment to adjust environmental parameters within a suitable range, thus forming a complete intelligent control of agricultural greenhouses. system. The intelligent control system can accurately control environmental parameters such as temperature, humidity, CO2 concentration, soil temperature, soil moisture and light intensity in the shed, which can save manpower and physical strength, improve the quality and yield of crop cultivation in the greenhouse, and change traditional agriculture. The past of the greenhouse has fallen behind [9].

Domestic and foreign scholars have achieved initial results in the field of smart greenhouses. In 2015, Jahnavi and other scholars proposed a wireless sensor network design for smart greenhouses, which can monitor greenhouse temperature, humidity and soil moisture in real time. The developed sensor node is capable of processing data from the sensor and triggering the actuator based on a threshold algorithm programmed into the microcontroller. The gateway receives sensor data and control information through Zigbee and transmits the data to a web application for remote monitoring. The monitor software provides a visual interface with nodes and their information [10]. In the same year, researchers such as Yoon proposed a flexible, intelligent sensing system platform that uses the available hardware components to monitor the operation of the greenhouse. Smart sensors are based on ZigBee MCU embedded systems with multiple connectivity options. Each node can simultaneously monitor many physical parameters such as temperature, relative humidity, carbon dioxide, light intensity, etc. through appropriate sensors [11]. In 2018 last year, Kang and other scholars introduced a agricultural network physical social system (CPSS) for agricultural production management for more efficient greenhouse management, taking the solar greenhouse as an example. The system inputs data from sensors that collect the price of agricultural products in the wholesale market and collect the necessary environmental data in the solar greenhouse [12].

The advantages and innovations of the wisdom greenhouses on tomato growth in this paper are mainly reflected in: 1) In order to improve the growing vegetable production requirements, this paper designs and develops a smart greenhouse measurement and control and information management system, which can save a lot of manpower. And physical strength, improve the quality and output of crop cultivation in greenhouses, and change the backward appearance of traditional agricultural greenhouses. 2) Introduce the overall architecture of the system and the technologies used in the system, including wireless communication technology, sensor technology, and system development framework. 3) Innovatively proposed a sequential learning algorithm for the metacognitive interval T-S/2 neural network inference system. The algorithm can quickly reduce the system calculation interval and metacognition order to achieve higher economic benefits. 4) The output value, cash income, net profit and output value profit rate of N city tomatoes under three different cultivation conditions in open field, steel frame greenhouse and smart greenhouse were studied, and detailed data analysis was made. Finally, conclusions were drawn: Compared with the other two traditional cultivation methods, the smart greenhouse can greatly increase the yield and profit rate of tomatoes, and can generate greater economic benefits.

2. Proposed Method

Next, the specific design of the smart greenhouse system and the sequential learning algorithm of the metacognitive interval T-S/2 neural network inference system that can quickly reduce the system computation interval and metacognitive sequential learning algorithm will be described.

2.1 System Structure

The system of this subject is mainly composed of sensors, measurement and control modules, communication modules, control modules, databases, servers and computer information management system platforms. The overall architecture of the system is shown in Figure 1. The measurement and control system communicates with the server using a WiFi wireless communication module. The measurement and control module is placed in the appropriate position in each agricultural greenhouse, and the data is collected by the sensor. The sensor adopts the sensor of 485 signal and is connected with STM32 through the RS-485 bus. The measurement and control module collects the sensor data through the ModBus communication protocol, according to the collected data. Analyze the process and then compare and control the device executor with the specific values set. For example, if the setting value is 25 ℃, when the temperature in the shed is higher than 25 ℃, the system judges whether to open the fan ventilation according to the rules and cool the greenhouse. Finally, the data is transmitted to the server through wireless transmission. The user can view various environmental parameters and historical data in the greenhouse through the information management system in real time, and can also perform data analysis based on historical data, so that the user can more scientifically manage the agricultural greenhouse.

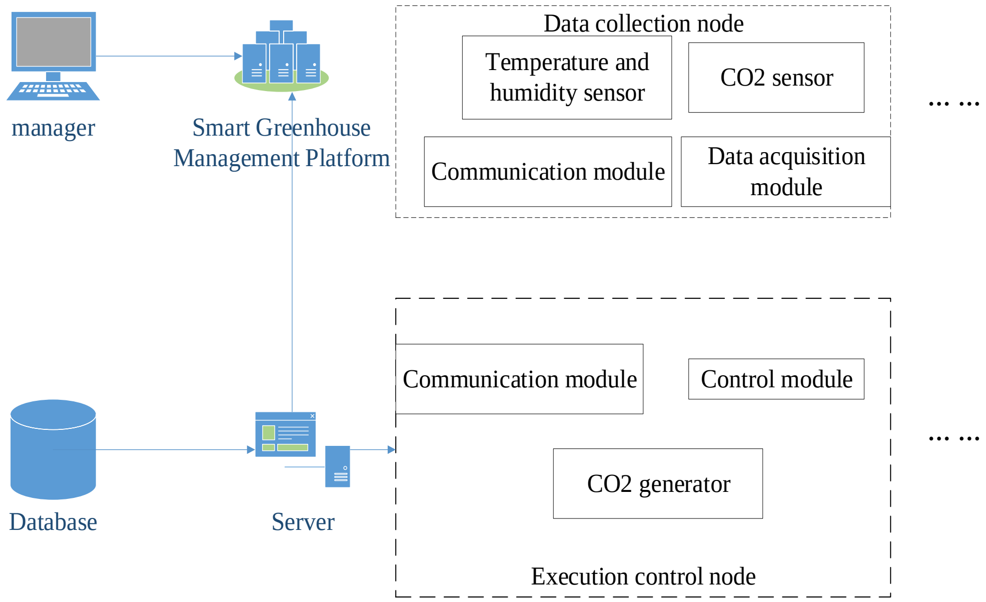

Figure 1. System architecture

2.2 System Related Technology

(1) Wireless communication technology

Wireless Communication is a communication method whose principle is to exchange information by utilizing the characteristics that electromagnetic wave signals can propagate in free space. Compared with traditional communication technology, wireless communication technology requires no wiring, system maintenance is more convenient, and it is convenient for users to manage and use. It has high scalability and flexibility, and can save manpower. In addition, wireless communication technology has a strong.The ability to resist environmental changes makes it easier to diagnose faults. Commonly used wireless communication technologies are ZigBee, GPRS, WiFi, and the like.

1) ZigBee

ZigBee is a short-range low-power wireless communication technology mainly used for short-range wireless connections. The main features of ZigBee communication are low power consumption, high efficiency, low cost, short delay and low speed. ZigBee usually works at a lower rate of 20-250 kbps. Mainly used in home building control, industrial site automatic control, agricultural information collection and control, public place information detection and control, smart labels and other fields, can be embedded in a variety of equipment. However, ZigBee used the F8X26 gateway (where x represents the network standard, such as F8126 represents the GPRS gateway) networking topology. The basic design is to realize the remote collection of 4-20mA current of the temperature sensor in the agricultural greenhouse through the cloud management platform, so that the temperature of the greenhouse can be monitored in real time, and the crops can be properly controlled and controlled. It can also be collected locally through the LAN port, WiFi wireless local acquisition or RS232. The serial port performs local acquisition. Of course, the temperature sensor (signal output is 4~20mA) can also be replaced by RS232/485 serial device.

2) GPRS

GPRS is a technology that can process data at high speed and delivers data to the client in packets. Packet switching technology is a relatively important data transmission technology in computer networks. Therefore, the GPRS network can be easily connected to the Internet, which promotes the initial leap of mobile data services and realizes the perfect combination of mobile communication technology and data communication technology. GPRS communication is used to realize data packet transmission and reception, and has the characteristics of high speed and high utilization. The sensor data at the bottom of the agricultural greenhouse can be transmitted to the monitoring center via GPRS. The user can view the data at any time. If there is a fault or abnormal data, the user can be notified by SMS alarm.

3) WiFi

The full name of WiFi is Wireless Fidelity, which translates to wireless fidelity. WiFi is based on the IEEE 802.11 family of protocols and is a technology that allows electronic devices to connect to WLANs. WiFi technology has the advantages of simple networking, no wiring, and no restrictions on wiring conditions; Terminal support is relatively rich, economical, low networking cost; Flexible application, flexible for small networks with only a few users, can also be applied to a large network with thousands of users; For the convenience of users, it also provides roaming services for users. The design scheme of WiFi communication is relatively simple. It only needs to control the WiFi module through the MCU, communicate with the motherboard through the CAN bus, and then transmit the data information to the server through the WiFi module. By connecting to the server, the server then saves the data to provide basic data support for the system platform. Its design scheme is shown in Figure 2.

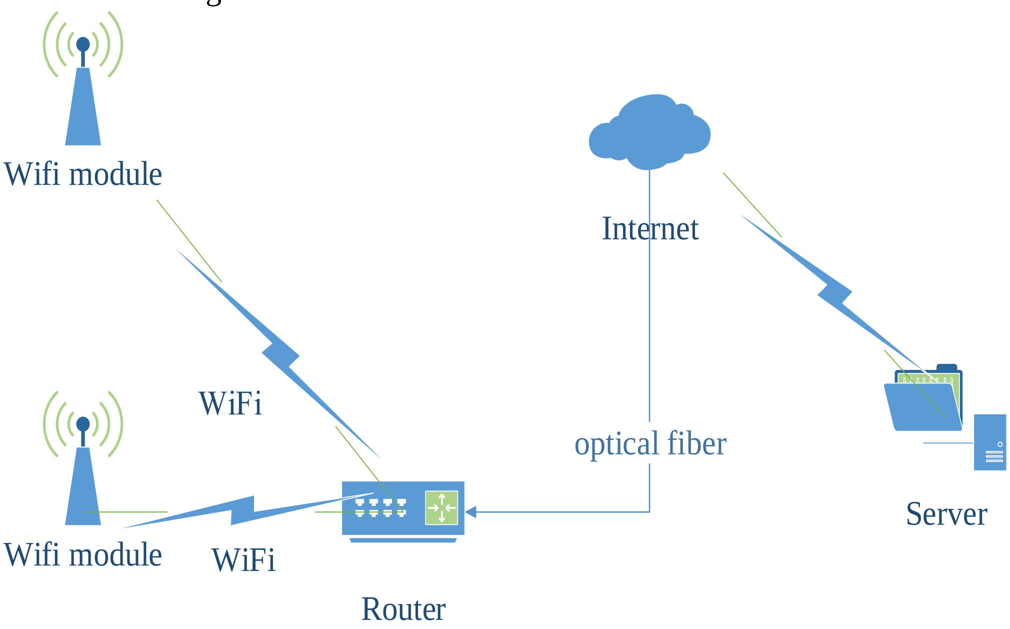

Figure 2. WiFi communication design

For agriculture, issues such as cost, installation and wiring need to be considered. The WiFi communication has a fast transmission speed and low cost, no wiring, a wide range of use, and is generally used, and basically meets the demand. Therefore, the research on wireless communication technology uses WiFi communication.

(2) Sensor technology

A sensor is a device that senses various types of signals. Its working principle is to use the materialization effect to convert the measured non-electricity into electricity. With the development of information technology, sensor technology is becoming more and more important in the Internet of Things. As the basis for collecting information, sensor technology is also developing rapidly.

There are various types of sensors on the market, and sensors of the right precision should be selected according to the requirements of the design system. For some applications, too high precision does not make much sense; too wide a range will also reduce measurement accuracy, and will lead to excessive cost and increase technical difficulty [50]. Therefore, first of all, all systems require sensors with high stability and durability, and it is very important to select the accuracy and range according to the requirements of the measurement object.

With the rapid development of science and technology and the maturity of relevant conditions, sensor technology plays a very important role in the development of smart agriculture. Data is collected by sensors, analyzed and controlled to improve the greenhouse environment, so that agricultural production can not only get rid of weather and other natural conditions. The limitation of factors can also realize remote scientific monitoring of fields such as farmland, greenhouses, aquatic products and livestock, thus effectively reducing labor. It can also use scientific analysis to improve the ability of agriculture as a whole to withstand disasters and risks, increase agricultural production, and increase economic income.

Smart agricultural greenhouses have also been widely used in the production of crops. Its main function is to carry out the main data of various parameters in the crop environment, including temperature, humidity, 2CO concentration, soil temperature and humidity and light intensity. The acquisition and detection will be transmitted to the main control microcomputer to realize the adjustment of various environmental conditions. The data can also be uploaded to the server and then saved to the database to provide a basis for the client to query and analyze the data.

(3) System development framework

The development of the information management system studied in this topic uses the SSM framework. SSM is short for Spring, SpringMVC and MyBatis, and SpringMVC is part of the Spring framework. Usually used in the relatively simple Web project of the data source, the use is relatively simple and clear. The following describes each framework and its main role in system implementation.

1) Spring

Spring is a lightweight container framework for controlling inversion and face-oriented. Spring's framework doesn't require programmers to create a new object, but instead lets the Spring framework do all the work.

2) SpringMVC

SpringMVC's job is to intercept user requests in the project. MVC (Model, View, Controller) is the overall abbreviation of model, view and control. This mode can divide the overall Web system into functions. Each unit performs the corresponding functions. MVC forces the input, processing and output of the Web application to be separated. Each handles the assigned task.

3) MyBatis

MyBatis is a package for JDBC, which makes the operation of adding, deleting, and deleting databases more simple and convenient for users to configure and use. For the work process of MyBatis, we can simply understand that MyBatis is a framework for managing the addition, deletion, modification and inspection of data.

2.3 Sequential Learning Algorithm for Metacognitive Interval T-S/2 Neural Network Inference System

(1) Architecture of metacognitive interval T-S/2 fuzzy neural inference system

In this paper, according to the previously designed greenhouse control system model architecture, it is necessary to design an IT2FIS (TS/2 type fuzzy neural inference system, which is TS type II), which can quickly reduce the system calculation interval and metacognitive sequential learning algorithm. After processing, this algorithm forms a metacognitive interval TS/2 type fuzzy neural inference system (McIT2FIS). The fuzzy sets used in the current greenhouse system include the use of the most interval T-S/2 type fuzzy sets, and their fuzzy rules are all T-S-K/3 type, but the T-S-K/3 type fuzzy rule theory is still immature. In this paper, we choose the interval TS/2 type fuzzy set, and the interval TS/2 type fuzzy rule. For the interval TS/2 type fuzzy set in the input variable, we need to study two kinds of membership functions, one is the uncertain mean and the other is Uncertain standard deviations, the commonality is that membership functions are implemented using Gaussian functions. A computationally fast and data-driven interval reduction technique has been successfully synthesized into interval type 1 fuzzy sets, while recombining type 1 fuzzy values. This computational fast and data-driven interval reduction technique fusion algorithm In the adaptive learning process, the adaptive fuzzy network starts from the zero rule and presents a new sample to the neural network; In addition, the integrated adaptive learning algorithm is based on the existing sample. The knowledge structure evolves a new structure and parameter model; in the process of adding rules, a new rule is added to the fuzzy network system, using the localization attribute of the Gaussian rule, and using the learning algorithm based on extended Kalman filter to adjust Parameters of the network, including center, width, output weight, and interval reduction parameters for all rules.

In fuzzy neural inference systems and software computing systems, it has been demonstrated that algorithms using metacognitive self-regulation have better generalization capabilities. These algorithms can help to effectively capture underlying data distribution and prevent overtraining by effectively determining what to learn, when to learn, and how to learn from me to adjust learning. Through the metacognitive learning system and the metacognitive model of inline Nelson and Naryns, the fuzzy network system is composed of cognition and metacognition, in which the metacognitive component passes the knowledge in the cognitive model architecture. Select an effective learning strategy to adjust the control strategy.

(2) Metacognitive interval Sequential learning algorithm for T-S/2 neural network inference system

In the sequential learning algorithm, the training samples are presented only once to the learning network, and the structure and parameters are adjusted in the learning network based on their knowledge differences with the current sample. From this we assume that a training data stream consists of {((x(1), y(1)),...,(x(t), y(t)),...)}, where X(t) =[x1(t),...,xm(t)] ε R1*m is the m-dimensional input vector of the t-th sample, Y(t)=[y1(t),...,ym(t)] εR1*n is the n-dimensional output vector of the tth sample, assuming some functional relationship between the input and the output (x→y):

$$y = F[x] \tag{1}$$

The goal of the metacognitive interval T-S/2 type fuzzy neural inference system McIT2FIS is to approximate f[.] so that for a given input x(t), the predicted output:

$$\hat{y}(t) = \hat{f}[x(t), \theta] \tag{2}$$

As close as possible to the actual output y(t), it should be noted that θ in the formula represents the regular parameter vector, and only the error e(t)=[e1(t),...,en(t)] defines the actual output. The difference between the predicted output and the predicted output is as follows:

$$e_j(t) = y_j(t) - y_j(t), j = 1,2, \dots, n. \tag{3}$$

During the sequential learning process, as each sample is presented to the network, the metacognitive component monitors the knowledge in the current sample (identified by the use of errors and spherical potential) to determine the knowledge base that exists in the network and ultimately decide whether to delete the sample. Do not learn (sample deletion strategy) or learn the knowledge (sample learning strategy) or retention (sample retention strategy) in the sample for future use.

In order to measure the knowledge difference between the current sample and the network sample, we use two measurement methods, namely prediction error and ball situation energy. The prediction error E(t) of the current sample at time t is given by the following formula:

$$E(t) = \sqrt{e^2(t)} \quad (4)$$

The ball situation can be a direct measure of novelty in the current sample, directly defined as the average distance between the current sample and the significant spatial rule in the hyperdimensional feature space. This potential energy formula is as shown in the following formula:

$$\Psi(t) = \frac{1}{K_s}\sum_{k=1}^{K_s} F_k(t) \quad (5)$$

Where Ks represents the number of significant contribution rules belonging to the network. If the membership of a rule is $F_k(t) > 0.1$, then this rule is considered to be a significant contribution to the rule members.

The three important strategies of the metacognitive interval T-S/2 fuzzy neural inference system are as follows:

1) Sample deletion strategy

If the prediction error of the current sample is less than the deletion threshold Ed, the knowledge content of the sample is similar to the knowledge existing in the network. Therefore, the sample is deleted from the training set and not used for learning. It can prevent network overtraining. The setting of the deletion threshold is selected according to the absolute prediction error required by the network. If the lower value of the threshold (close to zero) will result in No samples are deleted, which may result in overfitting, while higher values may cause the system to frequently prun the sample with an approximation of poor performance. For our smart greenhouse work requirements, choose a reasonable threshold interval, the final choice is [0.0001, 0.001].

2) Example learning strategy

The sample will learn when it contains new knowledge. In this strategy, add a new rule (rule growth criteria) or update the parameters of an existing rule (parameter update criteria). Now we will describe each of these underlying.

Rule growth criterion: If the network's prediction error is very high and the spherical potential is below the novelty threshold, then a new rule is added to the network. The updated rules add criteria as shown in the following formula:

$$E(t) > E_a(t), \quad \Psi(t) < E_s \quad (6)$$

Among them, Ea and ES are adaptive addition and novelty thresholds. The lower the ES value, the higher the resistance to the rule addition. In the course of this study, ES and Ea were initially set at [0.01, 0.60] and [0.10, 0.30]. Within the scope of, and when new rules are added to the network, the Ea and ES adaptation rules are as follows:

$$E_a = (1-\delta)E_a + \delta E(t) \quad (7)$$

$$E_s = (1-\gamma)E_s + \gamma\Psi(t) \quad (8)$$

The goal of adaptive thresholding is to let the learning network add rules to get new knowledge and then fine-tune it, with Ea increasing and Es decreasing, so the new rules are added to the wrong and novelty samples. Here, δ is the slope parameter that determines the increase of Ea, and γ is the slope parameter that determines the decrease of Es, and both are set to be close to 0 in the metacognitive interval TS/2 type fuzzy neural inference system McIT2FIS. The K+1 rule is added to the network based on the t-th sample, and the rule center is initialized to:

$$\mu_{K+1} = [x(t) - 0.1, x(t) + 0.1] \quad (9)$$

The width is assigned to the width of the rule, taking into account the distance of the nearest rule:

$$\sigma_{K+1} = k * \min_{\forall k}[\left|\left|(\mu^l_{K+1} - \mu^l_k)\right|\right|, \left|\left|(\mu^l_{K+1} + \mu^r_k)\right|\right|, \left|\left|(\mu^r_{K+1} - \mu^l_k)\right|\right|, ||(\mu^r_{K+1} - \mu^r_k)||] \quad (10)$$

Among them, k controls the overlap between the newly added rules and the most recent rules. According to the problems considered in the research of smart greenhouses, we set the value range of k to [0.4, 0.7]. The lower the k value, the less overlap between rules, which affects the ability of the network to generalize. Similarly, a high degree of overlap can have a negative impact on the rules.

Previous studies have shown that the initialization wK+1 of the output weight should fully utilize the localization property of the Gaussian membership function, and the output weight should be initialized so that the prediction error when adding a new rule is minimized. In general, in the sequential learning algorithm, the output weight is initialized to the error of the current sample, but after initializing the output weight wK+1, the predicted output y(t) with the K+1 rule must be compared with the actual output y(t). Therefore, we initialize the weight of the output by considering the contribution of the new rule, as shown in the following formula:

$$w_{k+1} = \left(y(t) - \frac{\sum_{k=1}^{K} \omega_{jk} F_k(t)}{\sum_{p=1}^{K} F_p(t)}\right) \times \left(\frac{\sum_{k=1}^{K} F_k(t)}{F_{K+1}}\right) \quad (11)$$

Parameter update criteria: If the prediction error is above the parameter update threshold and below the join threshold, while the spherical potential is above the novelty threshold, the parameters of the network are updated based on the t-th sample. The central rule and width of the output weight are updated based on the extended Kalman filter scheme, and the rule update condition is given by:

$$(E_L < E(t) < E_a) \quad \Psi(t) > E_s \quad (12)$$

Where EL is the adaptive parameter update threshold, its value is set in the range of [0.01, 0.04]. When the network parameters are updated, the parameter update and novelty threshold are adaptively changed according to the equation.

3) Sample reserve strategy

If the current sample does not satisfy the sample deletion or sample learning strategy, then the retention considerations are considered at different times. Adaptive networks may evolve other rules to cover these samples, otherwise the adaptive nature of automatically adding learning thresholds makes it easy to use these samples at a later point in time.

These three strategies are repeated for each sample, which helps the network to effectively learn and promote knowledge. The metacognitive interval T-S/2 type fuzzy neural inference system algorithm summarizes the McIT2FIS learning algorithm. In the process of practical application, we will use the bias of the smart greenhouse in the metacognitive interval T-S/2 fuzzy neural inference system McIT2FIS and derive its cognitive sequential learning algorithm.

3. Experiments

3.1. Experimental Environment and Data Sources

These three strategies are repeated for each sample, which helps the network to effectively learn and promote knowledge. The metacognitive interval T-S/2 type fuzzy neural inference system algorithm summarizes the McIT2FIS learning algorithm. In the process of practical application, we will use the bias of the smart greenhouse in the metacognitive interval T-S/2 fuzzy neural inference system McIT2FIS and derive its cognitive sequential learning algorithm.

3.2. Experiment Details

(1) The overall scheme of the system

The data communication of the measurement and control system is based on the data acquisition and transmission under the Modbus protocol standard. Each detection point of the greenhouse has a measurement and control system to receive important parameters such as temperature, humidity, CO2 concentration, soil temperature and humidity, and light intensity through the sensor.According to the collected data analysis and judgment, and then control the heat pump or air conditioning, water curtain, lighting, fans and irrigation equipment, the environmental data is controlled within the appropriate range to meet the environmental requirements of crop growth. The basic structure of the measurement and control system is shown in Figure 3.

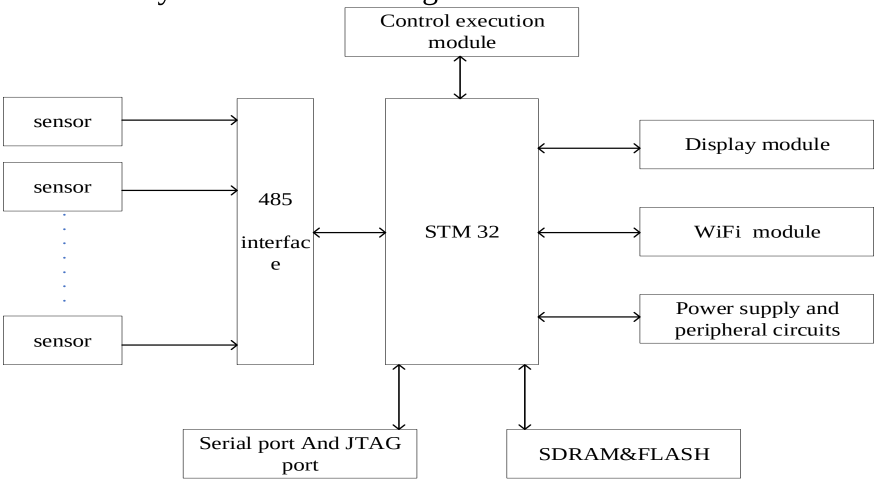

Figure 3. Basic structure of measurement and control system

The measurement and control system adopts STM32 as the core. The sensor with 485 signal is connected through 485 interface and communicates with STM32. The measurement and control system mainly includes WiFi module, control execution module and display module. The WiFi module communicates with the server, transmits and saves the data of the sensor to the database, and controls the execution module to control the equipment in the shed according to the data analysis of the system, and the display module can display the real-time data of the current environmental parameters.

(2) Sensor monitoring

In order to verify the correctness and practicability of the research, according to the operation process and results of the TS fuzzy neural network adaptive control system, the results of the operation process of the lower computer system and the upper computer system are compared respectively, and the temperature control system can be normal. Operation, the control system achieves the desired results. Finally, the intelligent control system is set up in the laboratory for debugging. After the commissioning is completed, it is installed in the greenhouse, and the on-site operation test is performed. The real-time detection interface of the upper computer shown in Figure 4 is performed.

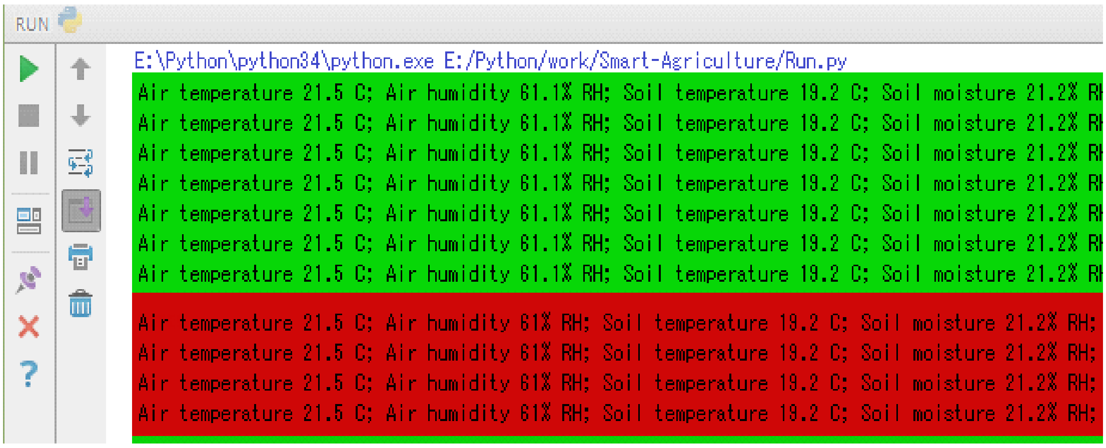

Figure 4. PC real-time monitoring interface

(3) The growth effects of tomatoes under the greenhouse intelligent control system

In this experiment, the tomatoes were placed in an open field, a steel frame greenhouse, and a smart greenhouse environment, respectively, to cultivate a mature quarter. The environment of the smart greenhouse greenhouse adopts the system designed in this paper, and the open-air and steel frame greenhouses are tested in N city.

4. Discussion

4.1. Analysis of the Output Value of Tomatoes under Different Cultivation Conditions

In the agricultural product cost-benefit accounting system, the income is generally reflected by the output value, cash income, net profit and other indicators, which reflect the income status of the agricultural products grown from three aspects. The output value refers to the sum of the income that the producer sells the main product through different channels and the income of the product closely related to the main product and the main product still retained. It does not include the cost factor, and the output value only reflects the producer. Cash income refers to the balance of the output value of the product minus all cash and in-kind expenses incurred for the production of the product, but does not deduct the portion of the self-employment rent in the household cost discount and land cost in the labor cost, which is an output value. The balance after subtracting the incomplete cost reflects the actual income of the producer. Net profit refers to the balance of the output value of the product minus the cost of all production factors such as capital, labor and land invested in the production process. The cost of labor production factors includes both the cost of labor and the discount of household labor. The cost of land production factors includes the rent of the land. It also includes self-operated land leases, which is a balance of output value minus full cost, reflecting the net return of all resources consumed in production.

Compare the changes in the output value of different greenhouses in the N city, and summarize the level and characteristics of the total cultivated tomato cultivation in the N city. The output of the wisdom greenhouse tomatoes in N city has a relatively large difference under different cultivation conditions. Compared with the cultivation of open field tomatoes, tomato production in steel greenhouses and smart greenhouses has high productivity and little seasonal variation. Advantages have now become the direction of modern agricultural development and production. Here, this paper studies the effects of tomatoes on smart greenhouses. We will compare the tomatoes grown in three different ways: smart greenhouse tomatoes, steel greenhouse tomatoes, and open tomatoes, in order to find out the difference between greenhouse tomato and open tomato production. The results of the study are shown in Table 1:

Table 1. Comparison of tomato yield under different cultivation conditions

Project	tomato		
	Land	Steel frame greenhouse	Intelligent greenhouse
Output value per mu (yuan)	9576	17867	62981
Unit price (yuan)	2.8	3.6	7
Yield per mu (kg)	3832	4988	10500

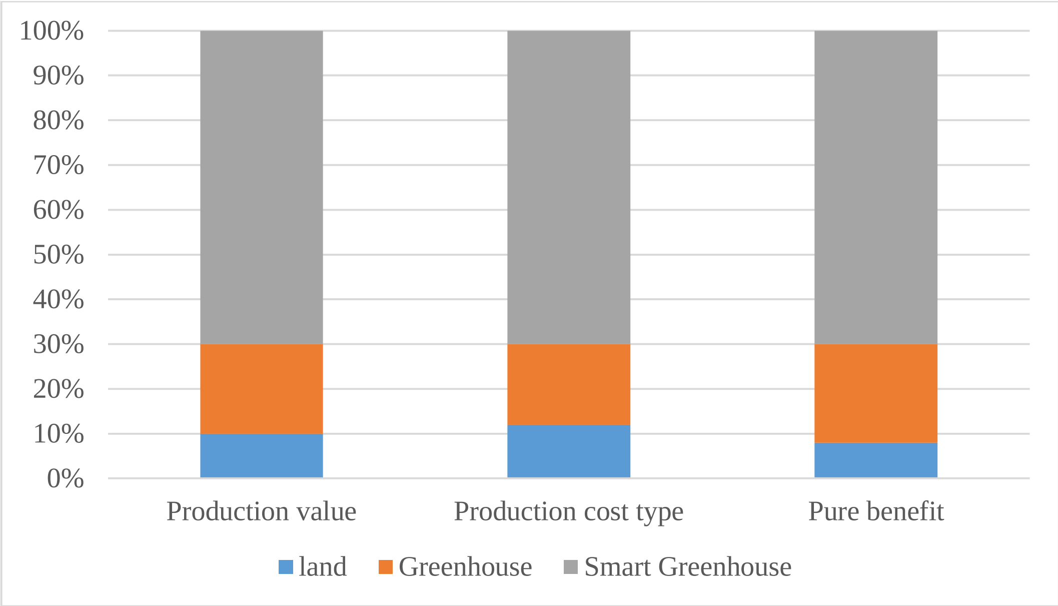

Figure 5. Output value and net income of tomato production under different cultivation conditions

It can be seen from Figure 5 that the comparison of the output value per acre of tomatoes in open field cultivation and facility cultivation in N city shows that the yield of tomatoes in the steel greenhouse is 127% of the tomatoes in the open field, and the unit price is 125% of the tomatoes in the open field. The output value is 166% of the tomatoes in the open field. The tomato production in the smart greenhouse is 277% of the tomatoes in the open field. The unit price is 230% of the tomatoes in the open field, and the output value is 640% of the tomatoes in the open field. It can be seen that the economic benefits of facility cultivation are significant, and the high output value of the smart greenhouse is due to the substantial increase in production and the price.

4.2. Analysis of Cash Yield of Tomato under Different Cultivation Conditions

Describe the level of cash income under different cultivation conditions of N city tomatoes and compare them, summarize the level and change characteristics of cash income of tomato planting in N city and make judgments, as shown in Figure 6:

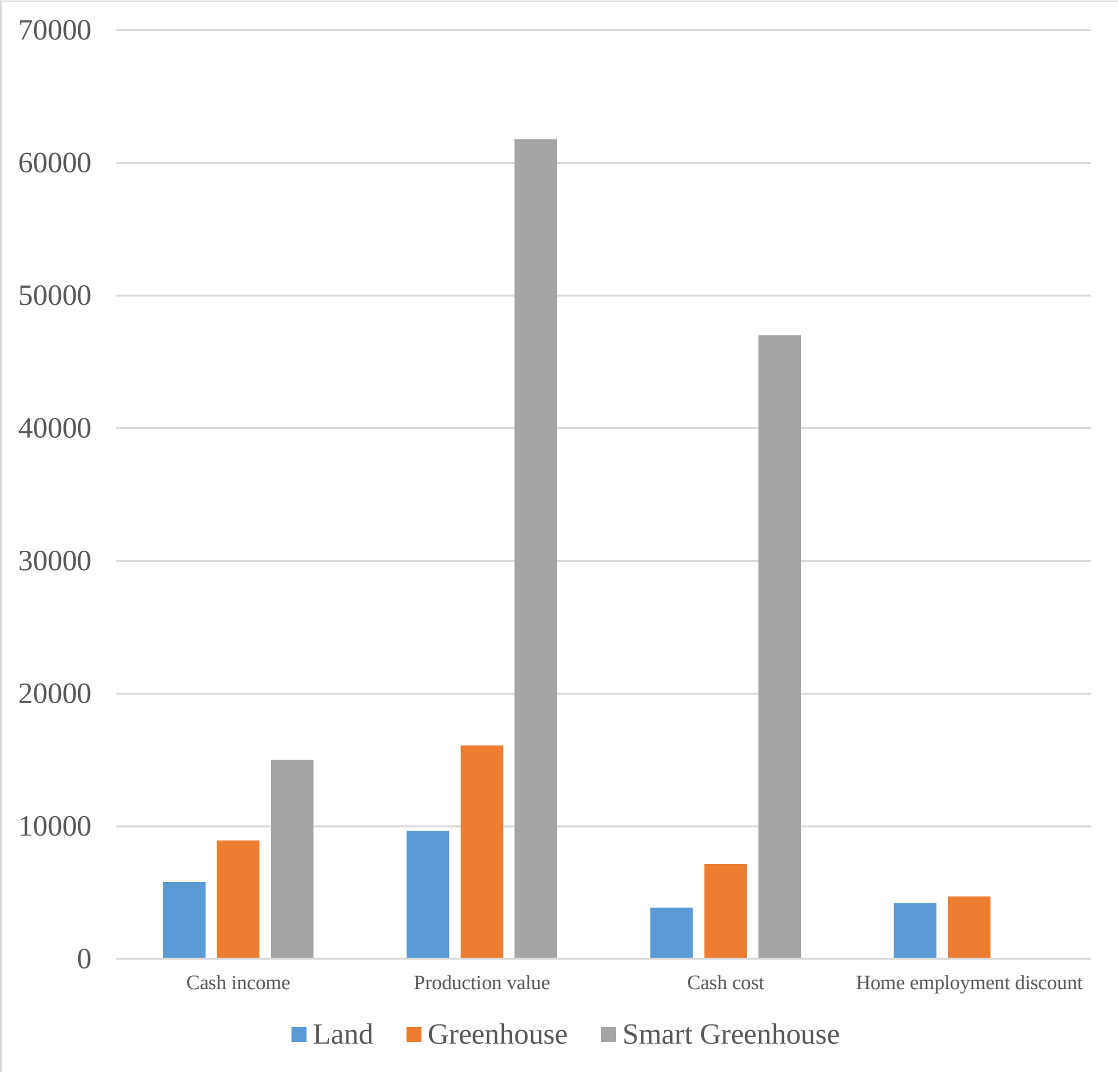

Figure 6. Tomato cash income situation map

Table 2. Wisdom greenhouse tomato cash income statement table

National large and medium cities	average	A	B	C	D	E	F	G
9131	9524	11063	11031	12356	8108	8231	7303	10061

Source of data: (National Agricultural Product Cost-benefit Data Collection)

The cash income of smart greenhouse tomatoes is shown in Table 2. In the study of tomatoes, it was found that the cash yield per acre of tomatoes grown in steel greenhouses was 8,923 yuan per mu, which was 154% of the tomatoes in the open field. The cash income per mu in the intelligent greenhouse was 15012 yuan, which was 258% per mu of cash income from tomatoes in the open field. The cash income of tomatoes grown through facility cultivation has been greatly improved. It shows that tomatoes are more suitable for facility cultivation. In the comparison of cash income, it is found that the cash income of N city wisdom greenhouse tomatoes is compared with D city, the cash income is 146% of D city, which is the average level of D city, which is 145% of E city, which is F city. 164% is 97% of B City. Compared with the cash income of tomatoes in large and medium-sized cities across the country, the cash income of openland tomatoes only accounts for 74% of the national total. The cash income of smart greenhouse tomatoes is compared with that of large and medium-sized cities across the country. For 130%, the average level of tomatoes in large and medium-sized cities across the country indicates that N cities are more suitable for planting smart greenhouse tomatoes.

4.3. Analysis of Net Profit of Tomatoes under Different Cultivation conditions

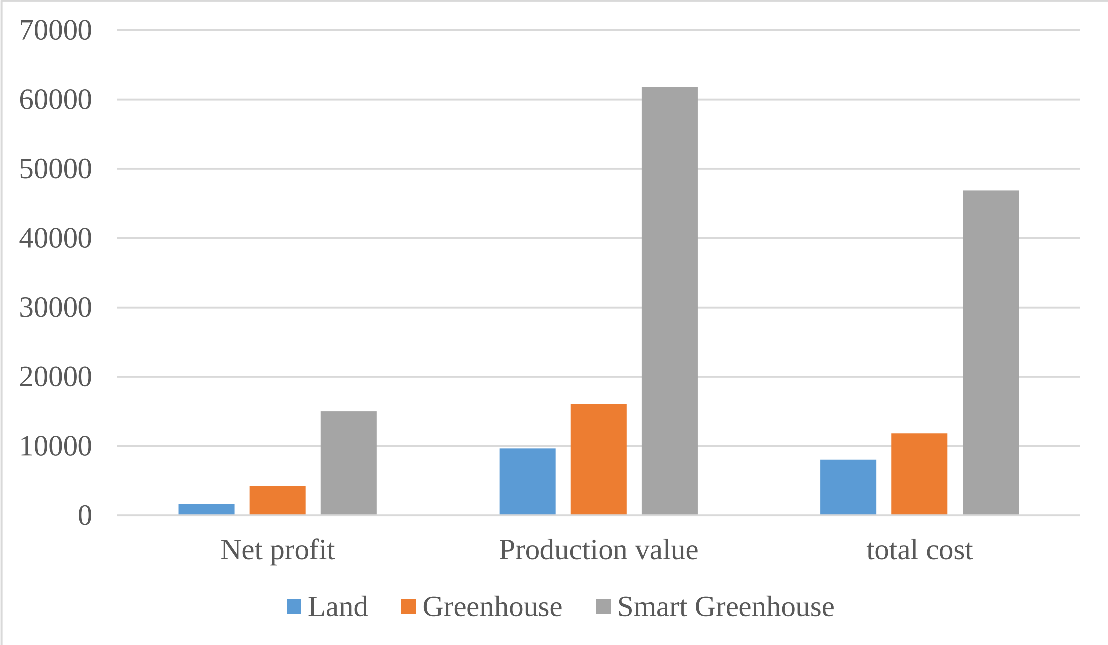

Figure 7. Tomato net profit situation map

Table 3. Wisdom greenhouse tomato net profit situation table

National large and medium cities	average	A	B	C	D	E	F	G
5501	5461	8012	7203	7811	4333	4311	3811	5121

Source of data: (National Agricultural Product Cost-benefit Data Collection)

The net profit of tomatoes is shown in Figure 7, and the statistical table is shown in Table 3. In the study of the net profit per acre of tomatoes in open field and wisdom greenhouse, it was found that the net profit of tomato cultivation in smart greenhouse was 9.13 times that of open field planting, indicating that it is more suitable to plant tomatoes in the N city by means of facility cultivation. At the same time, when comparing the net profit per mu, it is found that the net profit per mu of the N city wisdom greenhouse tomatoes is 175% of the national average, 122% of the B city, 224% of the E city, and the net profit of the N city wisdom greenhouse tomatoes. High, mainly in the large-scale production of intelligent greenhouses, high output, and significant economic benefits of smart greenhouses. The net profit per mu of N-city wisdom greenhouse tomatoes is 175% of the net profit of the wisdom greenhouse tomatoes in large and medium-sized cities across the country. However, open field tomatoes account for only 35% of the net profit of openland tomatoes in large and medium cities across the country. Compared with the whole country, the advantage of no-planting tomatoes in N city is lower in the country, so N city is more suitable for planting tomatoes by means of facility cultivation.

This chapter studies the yields of tomatoes under different cultivation conditions from three aspects of production value, cash income and net profit. It is found that the production, output value and net profit of tomato planting in N city are much higher than those in open field, indicating the adoption of facilities. Cultivation methods have obvious advantages. When analyzing cash income, the main influencing factors are product output value and cash cost. The output value of tomato planted in steel greenhouse is 187.5% of open greenhouse, the cash income is 188% of open greenhouse, and the output value of intelligent greenhouse tomato is open greenhouse. The cash income is only 221% of the open greenhouse, slightly higher than the steel frame greenhouse, because the cash cost of the smart greenhouse is very large, is 626% of the steel frame greenhouse, mainly from the investment in the previous greenhouse construction and greenhouse depreciation expense. It has a negative effect on cash income. Statistics show that the cash income from planting tomatoes in greenhouses in N city is 133% of the cash income of D-market smart greenhouse tomatoes, which is higher than the average of D city. From the above data, it is indicated that steel frame greenhouses are more suitable for growing tomatoes.

4.4. Analysis of Yield Profit Rate of Tomato under Different Cultivation Conditions

The output value profit rate refers to the profit per unit of output value, indicating the relationship between output value and profit; the output value profit rate reflects whether it is high-yield and efficient, and increases production and efficiency. The high profit margin of output value indicates high production and high efficiency; The decrease indicates that the increase in production is not effective. The profit rate situation is shown in Table 4:

Table 4. Wisdom greenhouse tomato yield profit rate table (%)

National large and medium cities	average	A	B	C	D	E	F	G
42.22%	40.91%	47.35 %	56.16 %	49.11 %	36.41%	37.23 %	37.01%	36.91 %

Source of data: (National Agricultural Product Cost-benefit Data Collection)

In the year, the profit rate per mu of tomato planting in the N city was 17.03%, and the profit margin per plantage of the tomato planted in the greenhouse was 25.91%. It can be seen that the profit margin of the output of the steel frame greenhouse> the profit of the output value of the intelligent greenhouse Rate> the profit margin of the output value of open field cultivation indicates that the planting of tomatoes in greenhouses is more productive and efficient. However, by comparing with the data of D city and the large and medium-sized cities in the country, the profit rate of the output value of tomatoes per mu in the N-city through the steel frame greenhouse is equivalent to 71.98% of the average level of the D city in the year, and the profit per mu of the tomato planted through the numerical control greenhouse. The rate is equivalent to 66% of the D city average. Compared with the output value profit rate of smart greenhouse tomatoes in large and medium-sized cities across the country, the profit value of tomato planting in greenhouses is equivalent to 62.31% of the national average of large and medium-sized cities. The profit margin of smart greenhouse planting tomatoes is equivalent to the average of large and medium-sized cities nationwide. 57.13%, at a lower-middle level.

5. Conclusion

In recent years, with the continuous growth of the domestic economy and the continuous improvement of the living standards of the Chinese people, the people's requirements for vegetable products are getting higher and higher (for example, the demand for more varieties of vegetables, higher quality vegetables, and more fresh Vegetables), invisibly put forward higher requirements for the production, guarantee and distribution of domestic agricultural products. "People eat food for the sky", China's population continues to increase, and only in the limited planting space can only develop smart greenhouse greenhouse industry to ensure the balanced supply of agricultural products, reduce the limitations of traditional agriculture, and meet the increasing consumption of agricultural products by the people. Growing demand. At the same time, the development of the smart greenhouse greenhouse industry can effectively solve the rural labor force, greatly promote the development of the rural economy and supporting (such as: warehousing, rough processing, transportation), which can produce extremely high economic and social benefits.

This paper starts with the tomato vegetable and studies the growth impact of the greenhouse environment on the tomato, so as to explore the potential economic benefits of the smart greenhouse. My main work process is as follows: 1) I studied the specific design of the smart greenhouse system, proposed and planned the system architecture, and related technologies used in the system. 2) Innovatively proposed a metacognitive interval TS/2 type nerve Sequential learning algorithm for network inference systems. The algorithm can quickly reduce the system calculation interval and metacognition order to achieve higher economic benefits. 3) Use tomatoes to study the growth and production of tomatoes in smart greenhouses in N city. The tomatoes were placed in the three environments of open field, steel frame greenhouse and smart greenhouse environment for a comparative study of maturity. Then, the detailed research records of the output value, cash income, net profit and output value of tomato in three different environments were carried out to reveal the input-output relationship of greenhouse cultivation in the greenhouse of N city. Finally, the conclusion was drawn that the greenhouse greenhouse Compared with the other two traditional cultivation methods, it can greatly increase the yield and profitability of tomatoes, and can generate greater economic benefits.

Agriculture is the backbone of China's national economy, and its sustainable development has received much attention. At present, many scholars at home and abroad have evaluated the smart greenhouse system from the perspective of sustainable development. For the N city, although the rise of smart greenhouses is relatively late, in terms of the current situation, it has initially shown great vitality. Through the on-site answers, media publicity, and various smart greenhouse training classes and other initiatives to promote the wisdom of the greenhouse, so that the city's top-down government units can raise awareness of the importance of the wisdom of the greenhouse, the development of wisdom. As one of the important contents of practicing the important principles and policies of the party and the state, the greenhouse creates a better atmosphere for the development of the wisdom shed of the N city, and organizes the leadership and wisdom shed to continue to develop in the direction of truly serving the peasants.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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