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The Research and Design of Intelligence Environment Monitoring and Evaluating System

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Abstract: Crop growth environment has a great influence on the yield and quality of crops. At present, environmental monitoring and evaluation system for the growth of crops is undeveloped in China. Therefore, an intelligence environment monitoring and evaluating system has been developed. This system consists of three parts, including data collection device, server-side data interaction software and web client. It achieves remote real-time monitoring and analysis for muti-indicators such as soil temperature and humidity, PH, EC and illumination. It possesses great mobility and excellent adaptability to environment. In addition, in view of the problem of crops' adaptability to planting environment, this paper proposes an evaluation method based on an improved matter-element model. According to the classic matter-element model and the practical characteristics of environmental indicators, the correlation calculation method has been optimized and the accuracy of the evaluation has been improved. Finally a great information intelligent management platform has been established.

Keywords: crop growth environment, data collection, environment monitoring, matter-element mode, evaluation method

1. Introduction

Agriculture is the basic industry of China's national economy. The goal of agricultural production is high-yield, stable production and safety. The growth environment of crops will have a significant impact on their yield and quality. Therefore, how to monitor the relevant indicators of crop growth environment in real time, has become an urgent problem to be solved in the current agricultural production.

China's agricultural production is in the stage of rapid development. Large-scale equipment used in agricultural production has been quite popular, such as planting seedlings, harvesting crops, spraying pesticides and so on. However, the monitoring of crop growth environment is still in a backward stage [1-2]. At present, the automatic monitoring of crop growth environment indicators is not fully universal. Many regions use human labor to carry out regular on-site environmental sampling and laboratory tests to produce results. Such methods are poorly timed. In recent years, some areas using Wi-Fi network base station for on-site environmental monitoring. However, this method is costly and poorly transferable [3-4]. At present, there is a lack of a rapid, accurate, migratory, adaptable crop growth environment monitoring system.

In addition, in the agricultural planting production process, also need to conduct a comprehensive evaluation of crop growth environment. But there is still a lack of a unified standard for its comprehensive evaluation. Some scholars put forward the application of statistical and intelligent methods to the evaluation on the basis of traditional multi-index comprehensive evaluation methods [5-7]. They use LVQ neural network, gray theory and matter-element model evaluation methods [8-10]. However, these methods are subjective, and ignore the impact of a single indicator on the evaluation results and other issues [11].

Aiming at the present situation, a crop growth environment intelligent monitoring and evaluation system has been developed for the agricultural planting site. The system consists of data acquisition site, server-side data exchange program and web client. The system realizes real-time monitoring of soil temperature and humidity, PH value, EC value, light intensity and so on. At the same time, a new evaluation method based on improved matter-element model is proposed in this paper. Based on the classical matter-element model, this method is optimized to evaluate the adaptability of crops in the target growth environment.

2. System Composition

2.1 System Framework and Function

Figure 1 is the crop growth environment intelligent monitoring system frame diagram:

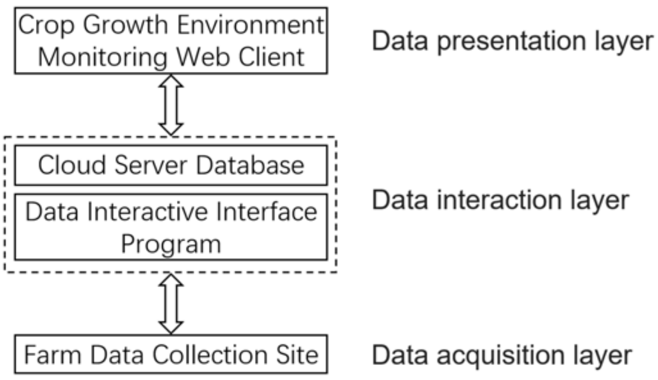

Fig.1 The research and design of intelligence environment monitoring and evaluating system frame diagram

The system mainly consists of three parts, including data acquisition layer, data interaction layer and data display layer. The data is acquired by the data acquisition layer, and then the server receives and manages the operation. Finally, the data in the database is called and applied according to the functional requirements of the web client.

2.2 System Hardware Design

The hardware of the system mainly includes the main controller, GPRS module, camera, and various sensors. Soil temperature and humidity sensors, soil EC sensors, soil pH sensors and small meteorological stations are used to collect atmospheric-related indicators (atmospheric temperature and humidity, atmospheric pressure and light intensity). Figure 2 is the hardware system architecture.

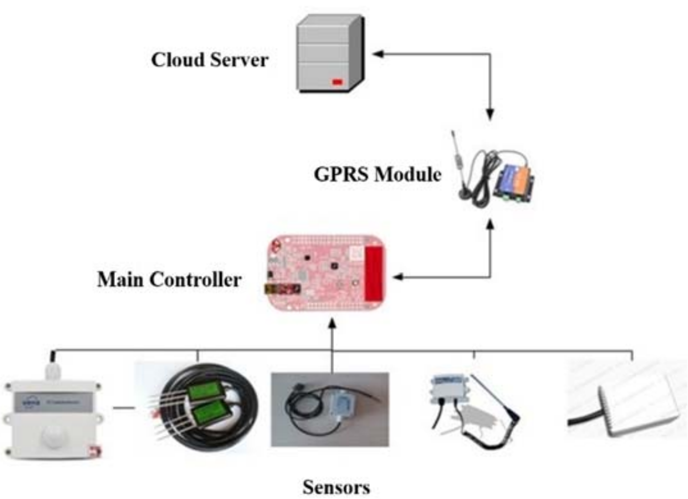

Fig.2 The hardware system architecture diagram

As shown in Figure 2, the main controller uses the ARM controller as the control core. The main controller sends data to the sensor by sending commands to the sensor and the camera at the same time, and then composing the data packet, finally sending the data packet to the cloud server through the GPRS module. The hardware is powered by a solar battery and is equipped with a waterproof housing. This design greatly improves its environmental adaptability.

2.3 System Software Design

2.3.1 Server-side Software Design

The role of the server-side data in the cloud to receive and manage, as well as the service web client calls.

Based on Socket communication technology, the system's main controller uses two independent network ports for data transmission and picture transmission. When the cloud server receives a packet from the host controller, the server program extracts the valid data in the packet. Program to the local database to add, modify, delete, query and other operations to manage data. When the cloud server receives the live photos from the host controller, the photos are stored in the specified path of the server hard disk in the specified naming format and the file path of the photos is stored in the database. Figure 3 is the main interface of the server-side software.

Fig.3 Server software interface

2.3.2 Web Client

Data display layer Web client to achieve real-time monitoring, statistical analysis, data early warning and comprehensive evaluation. Figure 4 is a Web client architecture diagram.

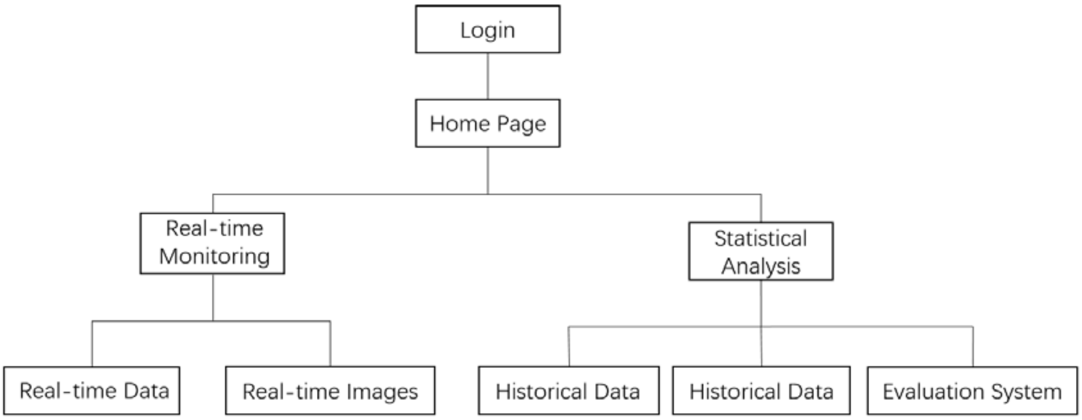

Fig.4 Web client architecture diagram

The data stored in the cloud server database, through statistical analysis and evaluation system, the results are displayed in the web page. Figure 5 for the web client data interface:

Fig.5 Web client interface

3. Improved Matter - element Model Evaluation Method

In order to evaluate the growth environment of crops, a set of evaluation methods based on improved matter-element model was proposed to evaluate the adaptability of crops in the monitored growth environment. Matter-element model was developed by Cai Wen in the early 1980s, and used the formal model to study the possibility and the rule of things development. It was used to solve the incompatible complex problem and was suitable for multi-index evaluation [12]. In recent years, some scholars have used the matter-element model to carry out a comprehensive evaluation of environmental quality, product quality and agricultural resources, etc. [13-14]. For different indicators of crop growth environment, because of the different types of indicators and the difference of dimensions, it is difficult to use the solution solve the compatibility of other indicators to solve this problem [15]. In this system, the multi-index system of crop growth environment was used to calculate the weight of each index in the comprehensive evaluation by AHP and entropy method. The method of matter-element model was improved to evaluate the adaptability of crop and growth environment. Finally, an evaluation method of crop growth environment based on improved matter - element model was proposed. The evaluation results were compared with those of experts.

3.1 The Establishment of State Matter – element

The matter element R is used to describe the object N, which we usually denote as:

$$R = \begin{vmatrix} N & c_1 & v_1 \\ & c_2 & v_2 \\ & \cdots & \cdots \\ & c_n & v_n \end{vmatrix} = \begin{vmatrix} R_1 \\ R_2 \\ \cdots \\ R_n \end{vmatrix} \tag{1}$$

c_1 *to* c_n are the eigenvectors of the object ***N***, and v_1 to v_n are the feature quantities of the object ***N***. ***R*** is an n-dimensional state matter element.

According to expert opinion, here with R_{oj} to describe the target state of the evaluation level, known as the classical model of matter-element domain, with the following formula:

$$R_{oj} = (N_{oj},\ c_i,\ v_o) = \begin{vmatrix} N_{oj} & c_1 & (a_{oj1}, b_{oj1}) \\ & c_2 & (a_{oj2}, b_{oj2}) \\ & \cdots & \cdots \\ & c_n & (a_{ojn}, b_{ojn}) \end{vmatrix} \ (j = 1,2,3,4 \ldots) \tag{2}$$

In the formula (2), ***i*** is used to distinguish a plurality of indexes to be evaluated, ***j*** represents a different evaluation level, and (a_{oji}, b_{oji}) expresses a range of values corresponding to the indicators in the corresponding ratings obtained according to experts' opinions. According to the classical domain, we can get the domain of matter-element model:

$$R_p = (N_p, \ c_i, \ v_p) = \begin{vmatrix} N_p & c_1 & (a_{p1}, b_{p1}) \\ & c_2 & (a_{p2}, b_{p2}) \\ & \cdots & \cdots \\ & c_n & (a_{pn}, b_{pn}) \end{vmatrix} \tag{3}$$

The section field is used to describe the whole range of the growth environment index, and the classical domain and the section domain are determined. The material element of the growth environment to be evaluated is denoted R_x

$$R_x = \begin{vmatrix} N_x & c_1 & v_1 \\ & c_2 & v_2 \\ & \cdots & \cdots \\ & c_8 & v_8 \end{vmatrix} \tag{4}$$

3.2 Method of Calculating Relevance

The association function is used to calculate the correlation function $K_j(c_i)$ of the index c_i for a certain evaluation level j by improving the matter-element model used in the method. The definition is:

$$K_j(c_i) = \begin{cases} \frac{-\rho(c_i, X_{oji})}{|X_{oji}|} c_i \in X_{oji} \\ \frac{\rho(c_i, X_{oji})}{\rho(c_i, X_{pi}) - \rho(c_i, X_{oji})} c_i \notin X_{oji} \end{cases} \tag{5}$$

$$\rho(c_i, X_{oji}) = |c_i - 0.5(a_{oji} + b_{oji}) - 0.5(b_{oji} - a_{oji})|$$
$$\rho(c_i, X_{pi}) = |c_i - 0.5(a_{pi} + b_{pi}) - 0.5(b_{pi} - a_{pi})| \tag{6}$$

In the formulas (5) and (6), $\rho(c_i, X_{oji})$ is the distance between the point c_i and the classical domain interval $X_{oji} = [a_{oji}, b_{oji}]$, $\rho(c_i, X_{pi})$ is the point c_i and the section interval $X_{pi} = [a_{pi}, b_{pi}]$. $|X_{oji}| = |b_{oji} - a_{oji}|$. Using the current calculation method, when c_i=$0.5(a_{oji} + b_{oji})$, the correlation value is the largest. This indicates that the optimal point position of the classical synthetic evaluation matter-element model is set to the median value of each level interval. But not all of the indicators are the median value of the best value. Therefore, the system so the use of matter-element model method at this point is different from the classical matter-element model approach. In view of the above c_4, c_8 such a decrement is excellent, or increase is excellent indicators, we propose the following calculation method:

$$\rho(c_i, X_{oji}) = |c_i - a_{oji}| - (b_{oji} - a_{oji}) \tag{7}$$

$$\rho(c_i, X_{oji}) = |c_i - b_{oji}| - (b_{oji} - a_{oji}) \tag{8}$$

3.3 Empirical Research

Combined with expert advice, we have drawn on the artificial cultivation of Atractylodes needs the scope of the growth environment indicators. According to formula (2) and formula (3) we can to the following a group of classical domain and section domain. c_i contains the following indicators: Soil temperature, soil moisture, soil pH, light intensity, atmospheric temperature, atmospheric humidity, atmospheric pressure and soil EC value. As shown in equation (9):

$$R_o = \begin{vmatrix} & \textit{Very Suitable} & \textit{Suitable} & \textit{Medium} & \textit{Unsuitable} \\ c_1 & (21.5,24.2) & (19.8,21.5) & (16.6,19.8) & (0,16.6) \\ & & (24.2,25.7) & (25.7,26.6) & (26.6,30) \\ c_2 & (17,27) & (13,17) & (9,13) & (0,9) \\ & & (27,30) & (30,32) & (32,40) \\ c_3 & (5.5,6.8) & (5.1,5.5) & (4.6,5.1) & (3.9,4.6) \\ & & (6.8,7.4) & (7.4,7.9) & (7.9,8.9) \\ c_4 & (1.68,3) & (1.42,1.68) & (0.98,1.42) & (0,0.98) \\ c_5 & (19,23.1) & (16.4,19) & (15.2,16.4) & (0,15.2) \\ & & (23.1,25.1) & (25.1,27) & (27,30) \\ c_6 & (17.6,21) & (12.5,17.6) & (9.4,12.5) & (0.9.4) \\ & & (21,23.1) & (23.1,25.5) & (25.5,27.1) \\ c_7 & (96,100) & (93,96) & (91,93) & (85,91) \\ & & (100,102) & (102,103) & \\ c_8 & (1.2,1.4) & (1.4,1.8) & (1.8,2.2) & (2.2,3) \end{vmatrix} \quad R_p = \begin{vmatrix} c_1 & (0,30) \\ c_2 & (0,40) \\ c_3 & (3.9,8.9) \\ c_4 & (0,3) \\ c_5 & (0,30) \\ c_6 & (0,27.1) \\ c_7 & (85,103) \\ c_8 & (1.2,3) \end{vmatrix} \tag{9}$$

The crop growth environment intelligence monitoring system designed in this paper selected eight groups of crop growth environment data samples in the actual test as the object to be tested to verify the evaluation method. The sample data is shown in (10).

$$R_x = \begin{vmatrix} & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\ c_1 & 22.3 & 21.5 & 26.5 & 18.6 & 21.4 & 17.5 & 24.1 & 18.1 \\ c_2 & 18.4 & 13.9 & 21.4 & 15.5 & 18.5 & 21.6 & 25.9 & 27 \\ c_3 & 6.4 & 5.8 & 7.9 & 6.8 & 4.9 & 7.2 & 4.4 & 6.1 \\ c_4 & 0.37 & 1.44 & 1.38 & 1.7 & 0.43 & 1.55 & 1.54 & 1.95 \\ c_5 & 24.6 & 24.3 & 27.9 & 19.9 & 23.9 & 18.9 & 26.9 & 19.2 \\ c_6 & 26.6 & 9.8 & 22.7 & 10.5 & 17.3 & 21.4 & 26.8 & 21.9 \\ c_7 & 100 & 93 & 100 & 101 & 101 & 92 & 102 & 103 \\ c_8 & 1.4 & 1.6 & 2.3 & 2.4 & 1.2 & 1.2 & 1.3 & 1.8 \end{vmatrix} \tag{10}$$

Eight sets of sample data were calculated by the correlation function calculation method. Obviously, the most relevant rating is the corresponding indicator of the attribution rating. The matter - element to be evaluated is introduced into the matter - element model, and the corresponding calculation result can be obtained. Taking the index c_1 of the growth environment of the first group of crops as an example, the calculation process is briefly introduced. Bringing $v_1 = 22.3$ into the above formula, the index can be obtained in the evaluation of the degree of relevance. $K_1(v_1) = 0.2963$; $K_2(v_1) = -0.1979$; $K_3(v_1) = -0.306$; $K_4(v_1) = -0.425$. It can be concluded that the c_1 index of the growth environment samples of the first group belongs to level I, that is, the "superior" level. Similarly, the correlation of other indicators can be obtained, as shown in Table 1.

Tab.1 evaluation index correlation of the first set of soil sample

Relevancy	***Level I***	***Level II***	***Level III***	***Level IV***	***Evaluation***
$K_j(v_1)$	0.2963	-0.198	-0.306	-0.425	**superior**
$K_j(v_2)$	-0.0001	-0.241	-0.331	-0.375	**Good**
$K_j(v_3)$	-0.3966	-0.588	0.111	-0.738	**medium**
$K_j(v_4)$	-0.2028	-0.3294	0.375	-0.4124	**medium**
$K_j(v_5)$	-0.0115	0.0588	-0.333	-0.3768	**Good**
$K_j(v_6)$	-0.2424	-0.3489	0.2813	-0.4213	**medium**
$K_j(v_7)$	0.037	-0.3058	-0.4216	-0.5597	**superior**
$K_j(v_8)$	-0.222	-0.3389	0.4687	-0.4167	**medium**

Based on 8 different indexes, we separately evaluated the growth environment from the standpoint of each independent index. But we still need to integrate the evaluation results of each index, and get a comprehensive evaluation result. Using the Analytic Hierarchy Process (AHP), we obtain the weight of each index in the comprehensive evaluation results (see Table 2).

Tab.2 Analytic hierarchy process (AHP) empowerment results

Index weight	***Indicator***	***Weighted Value***
w_1	**soil temperature**	0.10
w_2	**soil humidity**	0.19
w_3	**PH value**	0.28
w_4	**illumination**	0.12
w_5	**atmospheric temperature**	0.04
w_6	**atmospheric humidity**	0.05
w_7	**atmospheric pressure**	0.02
w_8	**EC value**	0.20

The indicators in Table 1 on each level of relevance and weight (Table 2) into the weighting formula:

$$K_j(N_x) = \sum_{i=1}^{n} w_i K_j(c_i) \tag{11}$$

The comprehensive correlation degree of the growth environment samples of the first group was calculated as: $K_1 = -0.1620$;$K_2 = -0.3587$;$K_3 = 0.6864$;$K_4 = -0.5005$. It can be analyzed that the skin level of this volunteer is the maximum comprehensive correlation degree K_3 corresponding to of Class III. Similarly, the other volunteers can determine the skin status level, see Table 3.

Tab.3 8 sets of soil sample evaluation level

	Level I	***Level II***	***Level III***	***Level IV***	***Result***
Sample 1	-0.1620	-0.3587	0.6864	-0.5005	Level III
Sample 2	-0.1322	0.1548	0.0009	-0.0005	Level III
Sample 3	0.2007	0.0511	-0.1186	-0.007	Level I
Sample 4	-0.1144	0.1426	0.00289	-0.6885	Level II
Sample 5	-0.3357	-0.0064	0.0497	0.0006	Level III
Sample 6	-0.5579	0.0135	0.0168	0.10598	Level IV
Sample 7	-0.4655	-0.3368	-0.0025	0.21	Level IV
Sample 8	0.0446	0.0986	-0.0765	-0.1688	Level II

Similarly, using the same sample data and applying the traditional matter-element model method, we simulate the evaluation by simulation program. Combined with the evaluation results given by experts. In Table 4, we compare the three evaluation results for eight groups of samples.

Tab.4 Improved matter-element model evaluation result

	Expert	***Improved matter element***	***Traditional matter element***
Sample 1	**Level III**	**Level III**	**Level II**
Sample 2	**Level III**	**Level III**	**Level III**
Sample 3	**Level I**	**Level I**	**Level II**
Sample 4	**Level II**	**Level II**	**Level II**
Sample 5	**Level III**	**Level III**	**Level III**
Sample 6	**Level IV**	**Level IV**	**Level IV**
Sample 7	**Level III**	**Level IV**	**Level III**
Sample 8	**Level II**	**Level II**	**Level II**

It can be seen that the accuracy of the results obtained using the improved metamodel method is about 82%. While the classical matter-element model method is only 75% of the evaluation results. Analysis of the actual situation of comparative samples. Sample 2 and Sample 7 show a certain degree of deviation in the evaluation results obtained by the evaluation method. Mainly because the sampling site in the sampling time and the experts on-site assessment of the weather is different, so the evaluation results have a certain impact. However, from the overall evaluation results, the use of improved material element model evaluation method significantly improved the accuracy of the evaluation results, reflecting the evaluation method has a good reference value.

Figure 6 is the system server-side software evaluation system interface, combined with the data collected the same day, we have a correlation of the results of a hundred percent, intuitive to provide the score and evaluation results.

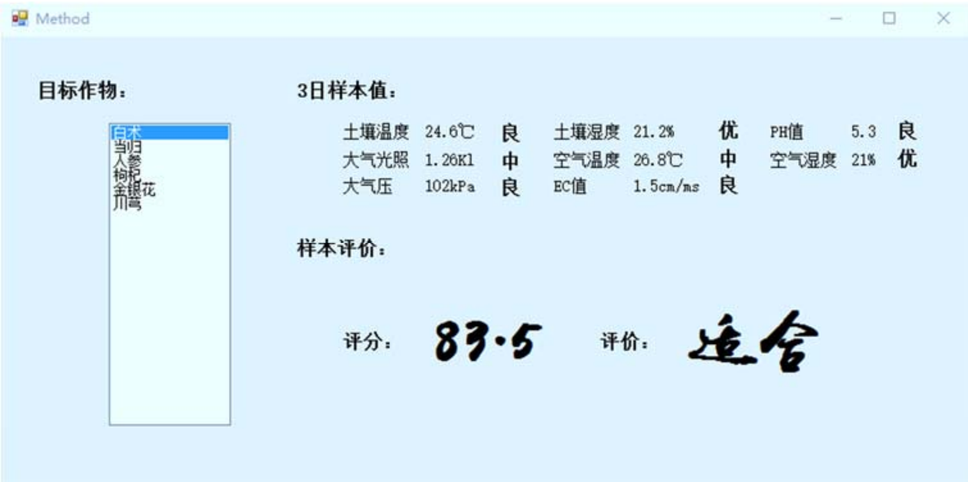

Fig.6 The server software evaluation system interface

4. Conclusion

In this paper, an intelligent monitoring and evaluation system for crop growth environment is designed, which integrates serial communication technology and cloud service technology. It realizes real-time and accurate acquisition of many indicators of crop growth environment, and provides an intuitive and convenient data display platform. Aiming at the problem of crop adaptability in growing environment, this paper proposes an improved metamodel method to improve the classical matter-element model according to the practical application characteristics of the index to be evaluated, and to adapt the crop to the growing environment Sex to make an objective evaluation, so as to provide a scientific and effective crop planting guide the basis.

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