OPTIMIZATION OF AGRICULTURAL PRODUCTION CONTROL BASED ON DATA PROCESSING TECHNOLOGY OF AGRICULTURAL INTERNET OF THINGS

A. Fengwen Zhai*
School of Electronic & Information Engineering
Lanzhou Jiaotong University
Gansu
China
skyq56@163.com
B. Ming Cheng
Shanxi branch of the Internet of things Technology Co., Ltd.
Changzhi,
Shanxi
China
C. Liqiang Zhang
Shanxi branch of the Internet of things Technology Co., Ltd.
Changzhi,
Shanxi
China
D. Tong Ding
Shanxi branch of the Internet of things Technology Co., Ltd.
Changzhi,
Shanxi
China
E. Yanping Liu
School of Economics and Management
Shanxi Agricultural University
Shanxi
China

Abstract. Internet of things is an important part of a new generation of information technology and it is a big step towards modern informationization for modern agriculture for us to introduce and apply the Internet of Things technology in agriculture which will lead the development of intelligent agriculture. In order to optimize the agricultural production control ability, realize automatic production, optimization control and intelligent management, improve the crop yield and quality, this paper carries out a design study on the optimization of agricultural production and control on the basis of fully understanding the agricultural thing networking data processing technology.

*. Corresponding author

Firstly, a service framework was put forward for the analysis of different agricultural products. Secondly, an agricultural information forecasting model based on an output-input feedback mechanism was applied to effectively control the growth environment of crops. Finally, the service framework, forecasting system and other modules were integrated into an application platform, which was then tested and showed a good read and write rate and a precise retrieval accuracy rate, could effectively predict environmental factors and give feedbacks, realize real-time monitoring of the environmental parameters and control the agricultural production.

Keywords: Internet of things, agricultural production, data processing, prediction system.

1. Introduction

With the popularization and application of the computer network information technology, the importance of the Internet of Things [1] has become increasingly prominent. The application of the Internet of Things technology in agriculture takes its comprehensive perception, reliable transmission and intelligent processing technology as the support and means and is characterized by the ubiquity of the intellectualization of the whole industry and whole process of agriculture, with automated production, optimized control, intelligent management, systematic logistics and electronic trading as the main modes of production, which gradually changes the production mode of agriculture from the human-centered one which relies on machinery to the new information and software-centric one that applies electronic devices. GeWet al [2] held the view that Agricultural internet of things (Ag-IoT) is the highly integrated and comprehensive application of the new generation of information technology in agricultural field. He Qian [3] studied the theory and key technology of the structure and intelligent information processing of Internet of Things and put forward that data processing technology improved the efficiency of information processing and had excellent prospects for development. Paraforos D S et al [4] believed that agricultural production management is entering into a new era where every day farmers decisions are supported by highly sophisticated Farm Management Information Systems.

The application of the Internet of Things technology in agriculture is of great practical significance to crop production. The design of the data processing service structure of agricultural IOT can realize safer and more efficient data processing, and can then optimize the agricultural production control. The output-input feedback mechanism [5], monitoring information database module, monitoring data management module and forecasting expert module were applied for the establishment of the prediction model and the realization of the Ag-IoT application network system, which can predict environmental factors effectively, interact information data, send commands to the relevant equipment of the intelligent greenhouses and change the state of the control device. For example, if the soil moisture content is too low, the irrigation system will automatically open its watering operations to ensure a good crop production environment.

2. Theoretical research on the data processing technology of agricultural IOT

2.1 Theoretical research on Ag-IoT

Internet of things is a network constructed based on the computer internet applying the RFID and wireless data communication technologies that covers everything in the world and can realize the automatic identification of goods and information interconnection and sharing without human intervention. Ag-IoT collects realtime environmental parameters through a variety of sensors and obtains the best conditions for crop growth through wireless network measurement, so as to realize remote monitoring, automatic control and management of the whole process to achieve the purpose of improving production and quality.

2.2 Theoretical research on data processing technology

Data processing technology is one of the core technologies of Internet of Things, which carries out effective transmission processing of large-scale real-time data and makes prompt feedback of the analysis results to the users so as to realize intelligent control. The difficulty of data processing is the large amount, timespace correlation and dynamic variability of the data of the Internet of Things and the heterogeneity of sampling data. At present, the main processing methods are hierarchical processing and dimension reduction processing.

3. Optimization design of agricultural production control

3.1 Design of data processing service architecture for agricultural Internet of Things

The service architecture of data processing for agricultural IOTS follows the principles of demand-orientation, integrated resources and innovative pragmatism. In this paper, taking the computer and computer network as the main equipment materials, combined with related technologies, such as agricultural forecasting and early warning technology, agricultural intelligent decision-making and control technology and agricultural inference technology [6, 7], a data processing service structure for agricultural IOT based on agricultural production control process was proposed, as shown in figure 1. As shown in figure 1, the process of the data classification processing business of different agricultural products is analyzed and the users service project is decomposed and grouped using the corresponding subservices and the obtained data results are finally returned to the user. Its content is close to the application and promotion of the Internet of Things technology, including agricultural production information, agricultural ecological environment information, agricultural market information, agricultural resources information, which provides multiple information resources for the information service object.

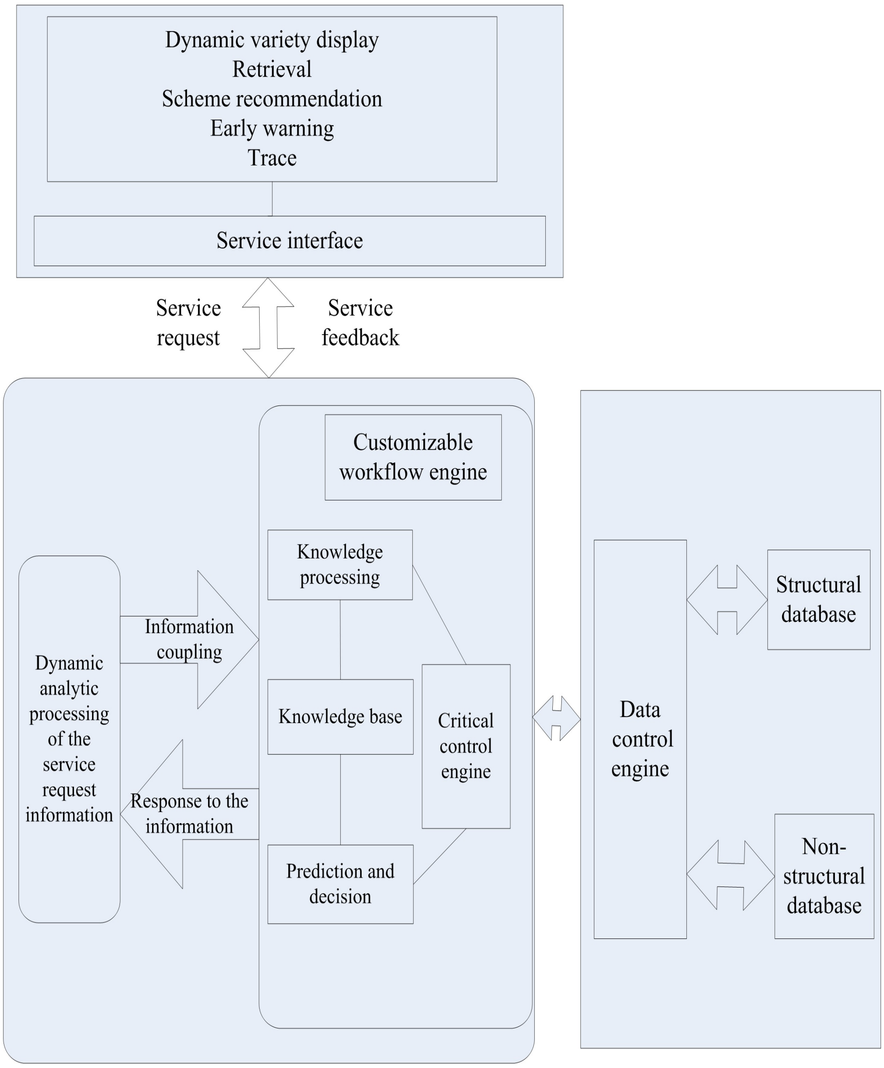

Figure 1: Data processing service architecture of agricultural IoT

3.2 Design of the agricultural information forecasting system

Agricultural information prediction system is mainly used to avoid adverse weather, pests and other environmental factors, with two function s of monitoring and early warning. Based on the output - input feedback mechanism of agricultural information forecasting system, the Elman neural network model was improved. Based on the feed-forward network [8], an additional layer is added to the middle layer of the feed-forward network to make the system change in real time. It has storage and memory functions. Generally, there are four layers: input layer, intermediate layer or hidden layer, continuing layer and output layer. In the design, the feedback of the output layer and the period before the output layer is increased by using the computer networks, and the simulation is carried out by the MATLAB software [9]. Combining with the traditional dynamic theory, statistical theory and mathematical calculation technology as well as integrating the distributed, parallel-style features, the prediction system simulates human nervous system, enhances the sensitivity of the system to historical data, and thus improves the accuracy of prediction, effectively controls the growth environment of crops and improves crop yield and quality.

3.3 Design of application platform of agricultural Internet of Things

The construction of the application platform of agricultural IOT consists of service architecture, forecasting system and other functional modules mentioned above. It mainly includes six major applications: item information, system management, warehouse management, remote automatic control, real-time video monitoring and environmental monitoring. The real-time monitoring of environmental parameters is realized through installing wireless lighting, temperature and humidity sensors in intelligent greenhouses. Data acquisition, analysis, archiving and storage of the sensors are completed by the data software. The data is transmitted to the gateway through the ZigBee protocol [10]. The gateway then sends the sensor data to the data platform server via the data routing node or GPRS directly. The user can access the data platform to monitor real-time intelligent greenhouses onsite environmental parameters and control the field device through the integrated controller. The core of the platform is

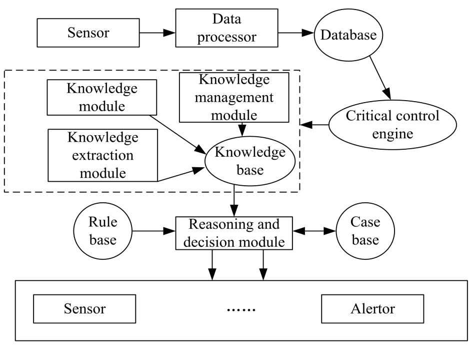

Figure 2: Structure chart of the agricultural knowledge processing and decision - making model

knowledge processing and decision-making, as shown in Figure 2, including data acquisition, knowledge processing, reasoning decision and practical application. Aiming at the key control points of the HACCP system and the GAP system, classes, frameworks and production rules are defined as knowledge representation and storage strategy. Stereotyped keywords and quantitative keywords are used to express knowledge representation and storage. The K-Neighbor algorithm is used to calculate the similarity in the knowledge entry module to ensure the matching degree between the modules.

4. Test on the results of the optimization of agricultural production control

4.1 Test on the results of data processing service architecture of agricultural Internet of Things

In order to ensure the practical operability of the design results, the performance of the data processing service architecture for agricultural IOT is tested. The real-time monitoring test system data transmission stream is set to continue for 1000 minutes in order to test its accuracy of reading and writing and retrieval rate [11]. As shown in Fig. 3 and Fig. 4, the precision of the search decreases as the data transmission time increases. When the transmission time is about 500 min, the read / write time per second is the highest, and the data processing system has reliability. A reasonable service architecture ensures the read and write rate and retrieval accuracy rate, and the application of workflow engine can improve the versatility and reuse rate of the system.

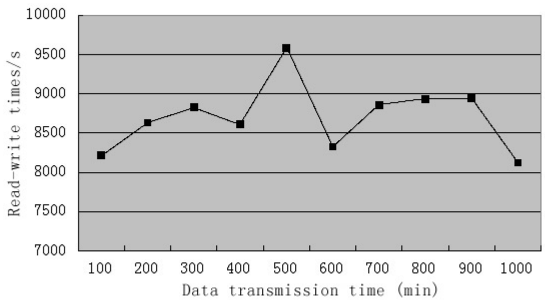

Figure 3: Read-write ability of the data processing system

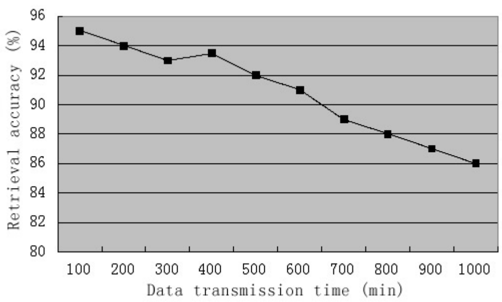

Figure 4: Retrieval accuracy of the data processing system

4.2 Test on the results of agricultural information prediction system

Taking the pest and disease prediction in agricultural production control as an example, the forecasting accuracy of the agricultural information forecasting system is tested. In this experiment, the related factors affecting the activity of rice pests were selected and the related data were collected. The six-month data from 2013 to 2015 were processed by Premnmx in the Matlab software.

Year	Month	Average temperature	Minimum temperature	Rainfall capacity	Illumination time	Degree of insect attack
2013	5	-0.4727	-0.6234	-0.5623	0.7823	Level 1
	6	0.8912	0.2315	-0.4865	0.89	Level 2
	7	0.5892	0.0000	0.0553	0.4582	Level 4
	8	0.6859	0.5968	-0.2969	0.2654	Level 4
	9	-0.0381	-0.1239	-0.3618	0.1688	Level 4
	10	-0.8265	-1.0056	-0.6214	-0.3236	Level 1
2014	5	0.1123	-0.2358	-0.5019	0.5599	Level 1
	6	0.2136	-0.0583	-0.5168	0.2458	Level 2
	7	0.5890	0.2368	0.3257	-0.1258	Level 2
	8	0.9812	0.5415	-0.0025	-0.0589	Level 4
	9	-0.0025	-0.1023	-0.5689	-0.4136	Level 3
	10	-0.6581	-0.8924	-0.1384	-0.1580	Level 3
2015	5	0.0059	-0.0036	-0.0856	-0.0985	Level 1
	6	0.2584	0.1254	0.9926	-0.5469	Level 2
	7	0.2154	0.0026	0.5812	-0.1528	Level 2
	8	-0.1235	-0.2588	-0.2589	0.5833	Level 4
	9	0.2589	-0.0254	-0.8521	-0.0539	Level 1
	10	-0.2158	-0.4586	-0.3265	-0.1247	Level 1

Table 1: Factors influencing the activities of pests in rice during the six month from 2013 to 2015

As shown in table 1, the data from 2013 to 2014 are taken as learning samples and the data in 2015 are taken as prediction samples. In the prediction system (using the IOIF-Elman neural network prediction model), there are 9 neurons in the middle layer and the S-type tangent function is taken as the transfer function; there are 4 neurons in the output layer and the S-type logarithm is taken as the transfer function. A network is built using the same data samples and simulation and comparison are made between the agricultural information prediction system, the Elman neural network and the BP network. Based on the data in table 2, the precision formula

$$p = 1 - \frac{\sum_{i=1}^{n} |y(x_i) - \widehat{y}(x_i)|}{\sum_{i-1}^{n} y(x_i)}$$

is used to calculate the data results of the three network models. The results found that the prediction precision of agricultural information forecasting system is obviously higher than that of the other two systems, which shows that it is more powerful, stable and predictive to deal with dynamic information, and can forecast environmental factors effectively, and make feedback to remind users to adjust accordingly so as to improve the control on agricultural production.

4.3 Test on the results of the agricultural Internet of Things application platform

After the user enters the agricultural Internet of Things application platform and clicks the corresponding green house number, he or she can enter the green

Month	Degree of the actual plant disease and pests	BP prediction value	Elman prediction value	Prediction value of the agricultural prediction system	BP prediction precision	Elman prediction precision	Prediction precision of the agricultural prediction system
5	0	0.0000	0.0000	0.0000	0.9855	0.9714	0.9985
	0	0.0000	0.0206	0.0015			
	0	0.0145	0.0008	0.0000			
	1	1.0000	1.0000	1.0000			
6	0	0.0002	0.0012	0.0001	0.0023	0.6826	0.9362
	0	0.0000	0.1256	0.0035			
	1	0.9998	0.9986	0.9998			
	0	0.9957	0.1893	0.0600			
7	0	0.0000	0.0025	0.0000	0.2323	0.8953	0.9235
	0	0.0053	0.0045	0.0697			
	1	0.9997	0.9954	0.9932			
	0	0.7621	0.0931	0.0000			
8	1	0.9988	0.9888	0.9998	0.9923	0.9985	0.8532
	0	0.0000	0.0097	0.0156			
	0	0.0065	0.0000	0.1059			
	0	0.0000	0.0000	0.0251			
9	0	0.0000	0.1022	0.1084	0.6235	0.7265	0.7123
	0	0.01245	0.0244	0.0000			
	0	0.1240	0.0005	0.0412			
	1	0.8720	0.8536	0.8619			
10	0	0.0587	0.0000	0.0049	0.9236	0.9500	0.9887
	0	0.0000	0.0495	0.0059			
	0	0.0175	0.0001	0.0002			
	1	0.9998	0.9996	0.9997			
Prediction precision					0.62658	0.87072	0.90207

Table 2: simulation comparison between the agricultural prediction system, the Elman neural network and the BP network

house and observe the data. Besides, by clicking the view historical data item, the user can observe the change trends of the temperature, humidity, light, carbon dioxide concentration at different time points on various dates, which are presented in an Excel sheet by the program. As shown in figure 5, by clicking the the third green house item, the user can view the historical data of the green house. And by selecting the date of October 15, 2015, the change trend of the average temperature at each time point on that day can be viewed. Similarly, the data of the other sensors can be viewed. After testing, the application platform can monitor the environmental parameters in the greenhouses in real time, and has strong feasibility and practicability.

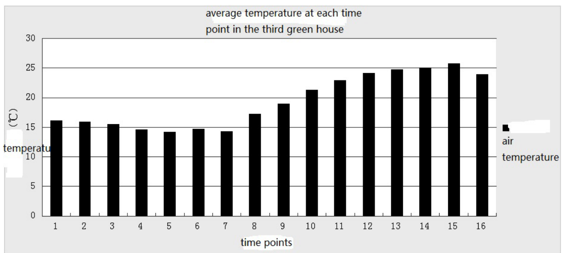

Figure 5: Average temperature at each time point in the third green house

5. Discussion

Due to the application of agricultural IoT technology, a large amount of data is generated in the process of agricultural production. If not taken advantage of, these data will go to waste. In order to solve the agricultural water and land resource use rate problem, domestic scholars F Li et al [12] designed a farmland intelligent irrigation management system and achieved the precise irrigation of farmland through the computer integrated management. Fuping et al [13] through the GPRS and ZigBee technology designed an intelligent irrigation monitoring system, which solved the problem of low utilization rate of agricultural water resources and low efficiency of land management in China.

In this design, the sensor data collected are transmitted to the application platform after data processing. When the data are obviously different from the preset values, the alarm will be triggered, which will make the prediction system send feedbacks of the information to the user and start the relevant equipment through remote control so as to ensure that the environmental factors are controlled within standard. RFID technology [14] will record the crop data at all stages, which is a combination of radio frequency technology and embedded technology that can trace the whole process of crop production. Nevertheless, the design has its own deficiencies. For example, many types of data storage management have not been covered; the initial programming can only complete the key functions of the platform, and many features need to be improved; the algorithm applied is simple and its cost, versatility, flexibility also need to be further improved.

6. Conclusions

In summary, through the design of the service architecture, forecasting system and application platform as well as the result test, it is found that the application platform of agricultural IOT can realize long-range monitoring, automatic control and intelligent management of agricultural products, improve production efficiency, save investment capital, further optimize agricultural production control, build intelligent agriculture, and produce enormous economic and social benefits.

References

[1] S. Li, L.D. Xu, S. Zhao, *The internet of things: a survey*, Information Systems Frontiers, 17 (2) (2015), 243-259.

[2] W. Ge, C. Zhao, *State-of-the-art and developing strategies of agricultural internet of things*, Transactions of the Chinese Society of Agricultural Machinery, 45 (7) (2014), 222-230+277.

[3] Qian He, *Theory and Key Technology of Internet of Things Architecture and Intelligent Information Processing*, Communications World, (19) (2015),

32-32.

[4] W. Ge, C. Zhao, *State-of-the-art and developing strategies of agricultural internet of things*, Transactions of the Chinese Society of Agricultural Machinery, 45 (7) (2014), 222-230+277.

[5] W. Guo, F. Liu, *Research on Parallel Algorithm Based On Hadoop Distributed Computing Platform*, International Journal of Grid & Distributed Computing, (2015).

[6] L. Zhao, W. Wang, Y. Wu, *Implementation of Ajax asynchronous communication technology and GWT-EXT client in agricultural macroscopic decision-making system WebGIS publish*, International Conference on Photonics and Image in Agriculture Engineering, (2013), 98C101.

[7] H.L. Yue, Y.P. Zhu, Y. Xue et al., *Study on Counties Agricultural Economic Intelligent Decision-Making Support System (IDSS) Based on GIS and Knowledge*, dvanced Materials Research, (2014), 889-890:1319-1322.

[8] J. Pradeep, E. Srinivasan, S. Himavathi, *An investigation on the per- formance of hybrid features for feed forward neural network based English handwritten character recognition system*, Wseas Transactions on Signal Processing, 10(1) (2014),21-29.

[9] S.S. Mohammed, *Modeling and Simulation of Photovoltaic Module using MATLAB/Simulink,* MATEC Web of Conferences, 11 (5) (2014),03018.

[10] T. Kim, S.H. Kim, J. Yang, et al., *Neighbor Table Based Shortcut Tree Routing in ZigBee Wireless Networks*, Parallel & Distributed Systems IEEE Transactions on, 25 (3) (2014), 706-716.

[11] S.K. Vipparthi, S.K. Nagar, *Color Directional Local Quinary Patterns for Content Based Indexing and Retrieval*, Human-centric Computing and Information Sciences, 4 (1) (2014), 1-13.

[12] F. Li, B. Wang, Y. Huang, et al., it Study on the Management System of Farmland Intelligent Irrigation, Computer and Computing Technologies in Agriculture IV -, Ifip Tc 12 Conference, Ccta 2010, Nanchang, China, October 22-25, 2010, Selected Papers. DBLP,(2010),682-690.

[13] Fuping, Wang, Panpan, et al., *Design of Intelligent Irrigation Moni- toring System Based on GPRS and Zigbee*, Asian Agricultural Research, (6) (2015),97-100.

[14] Zhang Hao, Xu Shen-si, Liu Rui, *Application of Radio Frequency Identification Technology in Vegetable Cold Chain Logistics Management*, Logistics Technology, 33 (7) (2014), 348-353.

Accepted: 27.02.2017