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Construction of GIS-based Agricultural Machinery IoT Service Platform

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ABSTRACT

In recent years, as the information technology becomes mature gradually and the modernized agriculture develops rapidly, the important role of agricultural mechanization in the development of the Internet era has gradually become prominent. As an important part of modernized agriculture development, the agricultural mechanization is also facing management problems caused by the information technology in the Internet era. The information shows new characteristics in the development of agricultural mechanization in the Internet era, such as rapid increase in the amount of information, faster data transmission and processing, more diverse data acquisition and processing methods, more and more complex technologies involved in information processing, and more and more extensive fields. As the information becomes diversified, complex and massive, the traditional agricultural machinery service management model shows greater limitations, such as low management efficiency, backward management methods, and low quality levels, etc.. The GIS technology has brought unprecedented development opportunities for the development of agricultural informatization. It plays an important role in promoting the improvement of agricultural machinery informatization to develop the agricultural machinery IoT service system by using the GIS technology.

Keywords: agricultural mechanization; IoT; GIS; service platform

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Introduction

With the support of emerging technologies such as cloud computing, IoT and GIS systems, many Western countries have shifted their agricultural development focus to the digital level, by which agricultural production methods, production technologies and production depth are integrated with the informatization on the basis of IoT technology to promote the rapid development of Agricultural IoT technology [1]. In addition, the intelligentization and informatization of agriculture has become an important way to promote the upgrading and transformation of agricultural machinery and the development of “whole-process, comprehensive, high quality and efficient” agricultural mechanization. Up to now, agricultural machinery production has shown many problems, such as non-standard resource management, imperfect information processing and transmission, unreasonable resource allocation, etc., which are all called obstacles to the efficient development of agricultural machinery. China has attached increasing importance to the development of agricultural informatization and modernization, and has formulated a number of policies for supporting agriculture and benefiting farmers to promote agricultural production, thereby accelerating the rapid integration of agricultural informatization and mechanization. China has established an agricultural machinery IoT service system integrated with the IoT technology, which is not only conducive to the timely sharing and transmission of agricultural machinery information, but also helps provide correct guidance for agricultural development.

1. IoT and GIS

The IoT is a network that connects objects on the network using the technologies such as wireless sensing, radio frequency identification, global positioning system, smart services, remote sensing and Internet communication according to relevant protocols to perform information exchange, communication, positioning, monitoring and management [1]. The IoT technology is an emerging information technology, which has become an important feature of the development in the information age. The IoT is developed on the basis of the Internet and is an extension of Internet technology, which extends the functions of clients to information sharing and exchange between people and things and between things. The IoT is actually business and application. The structure of the IoT is complex. The IoT architecture can be divided into application layer, sensing layer and network layer by the principles of data processing [2]. See Figure 1 for details.

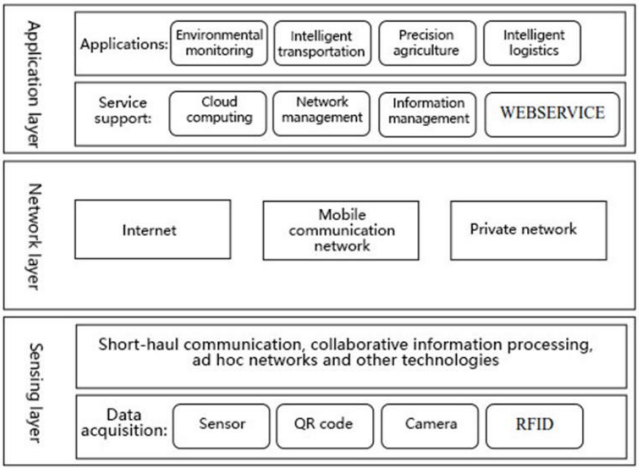

Figure 1 Basic Architecture Diagram of the IoT

(1) Sensing layer. It is composed of data acquisition equipment, short-distance communication, collaborative information processing and AD hoc network technology. Data collectors include a variety of sensors, such as RFID, infrared devices, temperature and humidity sensors, cameras, 2D barcode readers, GPS and other terminal devices. These sensing devices can obtain the geographical position of the objects. As the key content of the IoT, the sensing technology is a bridge connecting the information with the objects. The key technologies of the sensing layer include wireless communication technology, RFID technology, sensor technology, etc., which are the basis for obtaining the data and identifying the objects.

(2) Network layer. The network layer is mainly composed of radio and television networks, cloud computing, private networks, and the Internet, etc. As the core of the IoT, it adopts the Internet technology to process the information collected by the sensing layer and securely transmit the information to the application layer so as to realize information communication. The important technologies used for the network layer include network convergence technology, wireless communication technology, network transmission technology, etc.

(3) Application layer. The application layer can be divided into an application service layer and an application support layer. As an important interface connecting users with the IoT, it is used for the conversion, analysis and processing of information transmitted by the network layer. Intelligent applications can be realized by combining the application layer with actual business needs. This layer can perform network communication through the information system interface, and its key technologies include data mining, cloud computing and data storage.

The IoT involves a wide range of technologies, including cloud computing, GIS, RFID, embedded technology, GPS, wireless communication and other technologies. Using the RFID technology to attach barcodes to the objects or install mobile terminals, the objects can become more intelligent. Using the wireless communication technology and information security mechanisms, the IoT can perform the functions such as remote monitoring, real-time positioning, updating data, decision support, etc. to achieve comprehensive control of the objects [3]. As one of the important technologies for the development of the IoT, the GIS can perform the functions such as spatial positioning and visual analysis of the objects, and can also provide complete system supports. The GIS system can incorporate all the IoT objects into the platform and perform quick positioning, query, management and tracking of the IoT objects. The GPS technology in the GIS system can not only find targets, but also track, locate, identify and monitor the objects in real time.

Using the IoT and GIS systems in the agricultural field, China has accelerated the development of modern agriculture to establish an intelligent agriculture supported by GIS systems and the IoT. Its greatest advantage lies in giving full play to the role of information technology to save resources and provide a more efficient and convenient way for the development of modern agriculture. In the agricultural field, the agricultural production information and parameters can be acquired and monitored using the sensors. The realization of GIS spatial analysis technology, GPS positioning, information management, visual analysis and other functions can provide a scientific basis for agricultural production management and control, improve agricultural production efficiency and production input-output

rate and reduce resource consumption to eliminate the extensive agricultural production management model.

2. Framework Design and Demand Analysis of GIS-based Agricultural Machinery IoT Platform

(1) Overall framework design of the system

In this paper, WebGIS technology in GIS, corresponding development platform and relevant software development technology are used to build a GIS-based agricultural machinery IoT service system, thus bringing the agricultural machinery, agricultural skilled-workers, farmer households and agricultural machinery management departments into a unified platform. Using cloud computing, Web services and other technical means, the system can call the data from different places and servers and the different map service functions on the Internet to serve as the data source of the system. The users can use their own service systems to quickly and accurately view the detailed information of agricultural machinery service or planting service on the electronic map, select the required agricultural machinery service, and fill in and submit service orders. Through the system, the agricultural skilled-workers can manage dispatching orders, view the status of agricultural machinery and service progress, and query the status of engine and related information, etc. In addition, the track position and operation situation of agricultural machinery can be viewed so that the agricultural skilled-workers and the agricultural machinery management departments can timely and intuitively grasp the dynamic position information and the operating condition information of agricultural machinery. Using this system, the agricultural machinery management departments can quickly view relevant data and information and manage all agricultural machinery services online. Data sharing of multi-users and multi-application platforms can be realized by means of the GIS technology to provide fast and convenient service management methods for agricultural production. The specific framework diagram is shown in Figure 2.

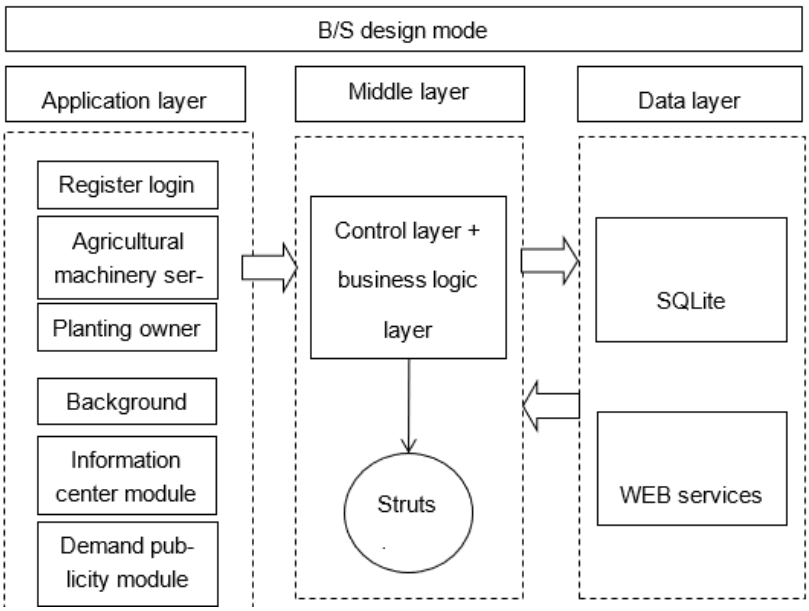

Figure 2 Framework of GIS-based Agricultural Machinery IoT Service Platform

(2) Analysis of overall system requirements

The GIS-based agricultural machinery IoT service system is used by three user groups: agricultural machinery owners, planting owners

and agricultural machinery management departments. The planting owners can register and log into the system in the busy farming season in the general term for summer and autumn harvesting, to search and locate agricultural machinery service organizations, view the detailed information of agricultural machinery types and idle machinery quantity under the agricultural machinery organizations, and fill in and submit demand service orders. After the orders are generated, the planting owners can perform the operations such as add, delete, modify and query of the orders to re-allocate operators for the orders, thus improving the opportunity for the farmers to choose the agricultural machinery and reducing the cost for the farmers to obtain agricultural machinery services. Using the system, the agricultural machinery management departments can perform order management and operation scheduling and monitor and manage the agricultural machinery and operators, understand the operation status, maintenance records and refueling information of agricultural machinery, issue relevant standards and regulations of agricultural machinery management, and realize standardized and digital management of information resources for personnel and property in the service organizations to improve work efficiency. The agricultural machinery owners can use this system to release agricultural machinery services, add the agricultural machinery, manage the service progress, realize the management of agricultural machinery services, and quote different types of agricultural machinery services. In addition, they can view the working status, progress and location of the agricultural machinery, and submit agricultural machinery maintenance requirements to ensure timely maintenance of the agricultural machinery [4]. The system provides good role access control permission and grants different functional permissions to different user roles. The users can log into different systems according to different role categories. After the users log into the system, the system can display functional modules according to the user's authority. The users cannot view and operate any module without corresponding permissions.

3. Detailed Design of System Functions

(1) Design of user register and login module

Except the system administrator, all personnel need to use a registered account for login to enter the service information platform. The users including individuals and organizations can be successfully registered as members of the platform by performing simple settings, providing corresponding information and submitting it to the background for approval.

The registered users can enter their own login information first, confirm the information in the window provided to the users on the interface, and then operate the "Login" button below the window. The interface program will analyze whether the user information is available and verify the identity of its users. If the test shows that the login information operation is wrong, the interface of wrong information will appear and the system cannot be logged in. If the verification is completed, the system will check whether the it is logged in by the account at the server. If the system has been logged in by the account, it will inform the users that the account has been used for login and cannot be repeated. If no login, the system will be logged into by the account to open the main interface of the agricultural machinery IoT service platform. For the sake of user account security, an account can only log on to the platform on one device at the same time, that is, an account is not allowed to log into the system in multiple clients at the same time. Login of the

same account on multiple mobile clients is likely to cause password disclosure. All participants in the system can log into the system using this use case and must enter a valid user name and password.

The users can modify the login password through the clients. The login password is extremely important personal information, so it cannot be changed directly. Before changing the password, the users need to obtain the authentication code sent by the system server through the mobile phone number bound to the account for registration and then enter the correct code to complete the password change.

The users can view and modify personal information. They can view or modify personal information such as profile photo, nickname, real name, location, crops, etc. in the system, and browse the general situation of relevant businesses in the system, such as received notices, published or collected agricultural technology exchange articles, comment articles, and published or accepted service information.

(2) Design of background management module

The background management mainly provides user management, data management, information auditing, information release, log management and other functions. User permissions can be allocated according to different operations. The accessible content and ranges depend on the permissions. In the user management, the user information can be modified, added and deleted. After logging in, the administrator can set the user's permissions and view the user's login status. After successfully logging in, the users can modify or delete their own name, view or delete their own permissions and history records, and also can cancel their own account. The administrator can set a user's system operation permissions. For example, the administrator can view, modify and delete the permissions of farm machinery owners or farmer households, while the users only have the permissions to view. After logging into the system, the system administrator can import, backup and restore the system data, review the application information submitted by the users and release relevant information. In addition, the administrator can turn on and off log monitoring in the system log management and monitor the operating conditions of all users at any time, and the users can view platform information and logs.

(3) Design of agricultural machinery service module

The agricultural machinery service module is capable of agricultural machinery information management, agricultural machinery service information release, maintenance requirement management, personal information management and other functions. After successfully logging into the system, the agricultural machinery owners can manage agricultural machinery information, add the agricultural machinery, fill in the type, brand, model and quantity of agricultural machinery, and also can modify, delete and view the agricultural machinery to realize the management function of agricultural machinery. Using this system, the agricultural machinery owners can release agricultural machinery service information, select the agricultural machinery service type, service price, agricultural machinery consistent with farming type) and location, and fill in the name, gender and contact number of the operator. They can describe their own advantages by short text and pictures to promote the signing of contract. After confirming that the information is correct, the owners can click the "Submit" button. After successfully publishing the agricultural machinery service information, the owners can manage the information

submitted for the view, modification or deletion of detailed information. The agricultural machinery owners can also modify, delete or add the personal information, such as nicknames, gender, location, occupation, etc. For the machinery beyond the warranty period, the agricultural machinery owners can submit agricultural machinery repair demand to agricultural machinery maintenance enterprises through the system, fill in the information such as machinery name, fault description, machinery location, contact person, contact number, etc., select a service type (visiting service or repair) and expected repair time, and pay the maintenance deposit. After the repair demand is submitted, the owners can view, modify and delete the repair demand information. After the repair is completed, the owners can give comments on the repair service. The system administrator can review the demand information submitted by the agricultural machinery owners, and release the agricultural machinery service information after confirming compliance with the requirements. Otherwise, the system administrator will feed back the failure message to the agricultural machinery owners and require them to fill in again. The agricultural machinery management departments can perform view and statistics of the quantity, status, demand information and farm work progress of agricultural machinery through the system.

(4) Design of planting owner module

The planting owner module is capable of planting demand release, demand information management, farm work progress viewing and other functions. The farmers can release the planting demand through the system, fill in the demand information (demand type and expected working date), land information (land location, area, quantity of agricultural machinery required, farm work price and land picture), and farmer information (contact person, contact number and deposit), and select a demand type from six major categories such as tillage, corn, wheat, soybean, rice, sorghum, etc. The farmers need to select the corresponding services under the major categories according to their actual needs, who can select automatic or manual input of land location. For the automatic input, the positioning software is activated to perform automatic positioning. The farmers can choose to pay or not to pay the deposit. If choosing to pay the deposit, the deposit will be directly paid to the corresponding account (the account information will be displayed after clicking, and no online payment is available). The deposit payment is similar to the user registration process, which is manually completed by the farmers. It needs to be submitted to the system background for review. After releasing the planting demand information, the farmers can view, modify and delete the information, and also can view the farm work progress through the system. The system administrator can review the demand information submitted by the farmers, and release the planting demand after confirming compliance with the requirements. Otherwise, the system administrator will feed back the failure message to the farmers and require them to fill in again.

(5) Design of information center module

The information center module is capable of the functions such as technical content release, policy and regulation release, notice display, etc. This module is only the responsibility of the system administrator. The agricultural machinery management departments and the system administrator can release the technical information related to agricultural planting and agricultural machinery as well as relevant policies, regulations and important notices through the background of the system. After releasing, the

information can be added, modified, viewed or deleted. The farmers and agricultural machinery owners can view the information details and learn relevant planting knowledge and technology through the system.

(6) Design of demand publicity module

The demand publicity module is capable of the functions such as demand information display, progress view, order grabbing view, etc. The module can repeatedly display the demands which have been released but not met, thus improving the success rate of signing contracts. It also can display the demand information which has been submitted for review. The users can grab orders after viewing the demand information, and can view the progress information after the order grabbing is completed. This module is managed by the system administrator who can release the demand information through the background system and monitor the demand transaction and progress.

4. Conclusion

Up to now, the agricultural mechanization has become an important feature of agricultural development. Using the information technology to build an agricultural machinery IoT service system that meets the development of the times plays an important role in improving the level of agricultural machinery informatization in China, and can also promote the rapid development of China's agricultural informatization and mechanization.

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