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Precision Water and Fertilizer Management System Based on IoT Smart Agriculture

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Abstract

The intelligent water and fertilizer control system platform is a data-oriented, comprehensive planting service platform based on intelligent equipment. The underlying process control uses various intelligent equipment as the carrier to realize various planting processes that meet the needs of crop growth and ensure crop quality and yield.The whole system is divided into three levels from bottom to top: control level, local management level and remote decision-making level. The control layer is the layer that directly supervises the growth status of crops at the planting layer. It is mainly composed of several types of intelligent equipment to complete process information collection and process control tasks, real-time monitoring of crop growth and development and crop yield estimation. The local management layer is responsible for connecting the remote decision-making layer and the control layer: On the one hand, it obtains the supervision information of the planting layer from the control layer, uniformly manages the working status of several local intelligent equipment, and uploads the supervision information to the remote database server through the network; On the other hand, different types of decision-making information are obtained from the remote decision-making layer and act on the control layer to realize the decision-making content of the planting process. The remote decision-making layer aims to provide an open, interconnected and interoperable platform for the application of various expert knowledge and the management of the planting process, and to provide a convenient space for data analysis, information fusion, fault diagnosis, and control decision-making. The management method and access operation method of each layer of data are the main issues that need to be paid attention to in the design of the platform architecture.

Keywords

Intelligent control; Data interaction; Database; Internet of things.

1. Basic situation of the test base

The experimental site is located in Dongchengfang Town, ten kilometers west of Zhuozhou City, Hebei Province, with a total area of more than 21,600 acres. The experimental site for this investigation is located in the southeast of the entire site, covering an area of about 260 acres, of which the planting site is about 160 acres and the breeding site is about 100 acres. It is preliminarily determined that the planting site is corn and the breeding site is a pig farm with a scale of more than 10,000 heads.

Carry out simple contour measurement of the plot and mark of attachments in the plot that cannot be changed. Through brief measurement, the plot is a square plot, with a length of 390 m from north to south and a width of 257 m from east to west, with a total area of approximately 160 mu. At the same time, there are two high-voltage transmission towers in the plot, one is located in the northwest, 115 m from the north wall and 68 m from the west wall, covering an area of 370 m2; the other is located in the southeast, 57 meters from the east wall. m, 125 m from the south wall, covering an area of 40 m2.

The site is a square plot with a length of 223 m from north to south and a width of 284 m from east to west, with a total area of approximately 100 mu. The existing pig farms no longer have the breeding conditions, most of the original breeding facilities have been abandoned, and only one pig house is in good condition, but it also does not have the breeding conditions. Facilities for the separation, fermentation, precipitation, filtration and dilution of pig manure and other excrement have not been constructed.

2. Data management method

Under the entire system platform architecture, the storage and use of data at each level has its own specific forms and permissions. On the one hand, each layer of data is used by the system or equipment at this level, and on the other hand, it can communicate with adjacent layers through interfaces. Interact with the data. Each layer of the system can work independently without relying on other layers [1-2]. The perception layer collects the planting data at the bottom of the entire platform, that is, the operating data formed during the crop production process. These data are collected by the intelligent equipment and stored in the embedded database inside the equipment, and stored in the local management layer. In the local database. Production management personnel generate local decision-making data by operating the system and store it in a local database, and send the local decision-making data to specific intelligent equipment through a bus. The local management layer will build up a local WEB server, which has a fixed IP and mapped port, and publishes a WEB program that can be accessed remotely. Park management personnel can access the data of the local management layer by means of a browser through mobile or remote clients. At the same time, the data of this layer can be uploaded to the remote database through the wide area network. The remote database is used to support various data mining, expert decision-making, fault diagnosis and other data processing and decision-making tasks. Its remote access authority is limited to designated agricultural experts and technical service personnel [3].

3. Access Operation Method

Agricultural experts, technical service personnel, park managers, production managers and production operators are the main participants of the entire system platform. The role of agricultural experts and technical service personnel is based on various decision analysis requests, using the remote database to provide a series of auxiliary analysis of the upper-level production data and the intelligent expert system to make targeted expert decisions. Their access rights are in the remote database. related information. The roles of park managers, production managers, and production operators are to jointly manage the production and planting process of the park [4]. Park managers mainly monitor the production status of the park through remote means, and production managers perform daily production management within the park. Users, the access rights of these two types of users are related services provided in the local database, and the production operator is the user who directly manages the planting process, and the operation rights of this type of user are all kinds of intelligent equipment in the control layer [5].

The data access operations within each layer are implemented through database interfaces, and the data access methods between the layers include active sending and request-response methods. The data uplink process adopts active sending mode [6]. The control layer data is actively sent to the local management layer through the bus, and the application program of the local monitoring station is responsible for data reception and storage; the local management layer data is actively sent to the remote decision-making layer through the WAN, and the remote WEB The service application is responsible for receiving and storing. The request-response method is mainly used for remote decision-making requests, that is, the remote WEB service application receives the decision-making request from the local end, and feeds back the decision content to the local end through the response method, and the local monitoring station user controls the specific process through the operating system interface The content of the decision is actively sent to each intelligent equipment through the bus [7].

4. Remote Decision Making

Model-based decision support system and knowledge base-based expert system are important components of the remote WEB service platform. Its purpose is to guide and help production managers and operators of facility agriculture to rationally irrigate, rationally fertilize, and reduce disease during the production process. To improve soil continuous cropping ability, etc. The application of WEB technology to decision support and expert systems is an important direction for future development, while data warehouse, data mining, model technology, etc. are the key technologies that support expert decision-making. The platform of the remote decision-making layer designed in this paper is mainly composed of a database platform, a WEB service platform and a client [8].

The database platform is mainly composed of model database, expert knowledge base, process database, basic database, decision database, application database, etc. The model library stores crop growth models related to "soil-water and fertilizer-crops-climate", such as irrigation and fertilization decision models, yield estimation models, crop growth models, soil fertility evaluation models, etc., to determine the final target yield for users, The best irrigation system, the best water and fertilizer management methods, etc. provide a basis for decision-making [9]. The data in the process database includes crop variety information, soil moisture information, meteorological information, sensor information, system equipment operating status information, alarm information, etc., all of which are dynamically generated data information along with crop growth and water and fertilizer production management processes. The basic database stores geographic information (GIS) data of each local end, including the latitude and longitude coordinates of the planting area, grid information, topographic and landform features, climate types, climate conditions, water quality status, soil texture types, soil nutrient status, and planting management Level and other information. The decision-making database stores expert decision-making information, including drip irrigation fertilization recommendation, irrigation system recommendation, control target recommendation, disease diagnosis information, and soil fertility evaluation. The data stored in the application database is the data needed by the WEB application, such as user authority information, user management information, and data source management information [10].

The WEB service platform adopts a front-end and back-end separation architecture. React realizes front-end page display, and SpringBoot provides back-end services. The program includes six main sub-applications: multi-source data interactive application, database management application, WEB service application, data mining and analysis application, model library management application, knowledge base management application, etc.

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5. Local Management

The structure of the local management layer is shown in Figure 3. The local monitoring station and various intelligent equipment on the control layer together form a distributed control system based on the CAN bus. The web server built by this system uses Apache server, and the local database uses My SQL. Run the distributed intelligent water and fertilizer control system with B/S structure on the local monitoring station. The system allows multiple local clients to access the local database server through the local area network. The GIS acquisition system generates local geographic information data, and the video surveillance system generates monitoring image data. The remote client accesses the local database through a browser, and the GSM/GPRS module provides communication services for remote access of mobile devices such as mobile phones and PADs [11].

The core of the local monitoring station is to monitor the status of intelligent equipment in each community. The user sets water treatment strategy, irrigation strategy, fertilization strategy and other water and fertilizer process decision-making goals through the human-computer interaction interface, and monitors the operating status of the equipment online..

6. Data Control

The control layer is an important layer connecting the local management and the planting layer. The design of this layer directly affects the crop planting. The control layer is a collection of the perception layer and the execution layer with a number of intelligent equipment as the core. The two main types of intelligent equipment in the control layer include an intelligent water and fertilizer integrated machine and an automatic backwash filter. In the process of crop water and fertilizer integration, irrigation, fertilization and water treatment are the three key contents. The intelligent water and fertilizer integrated machine is responsible for the control of the irrigation and fertilization process level, and the automatic backwash filter is responsible for the process control of the irrigation water treatment[12]. Both types of equipment are installed in the irrigation head. The perception layer is the most primitive source of all data of the entire intelligent water and fertilizer control system platform, which is mainly composed of the following three types of sensors:

(1) Outdoor weather station: monitor the external climate factors of the greenhouse, including outdoor temperature, outdoor humidity, outdoor radiation, outdoor illuminance, outdoor wind direction, outdoor wind speed, outdoor rainfall, etc. These sensors and the acquisition module form an outdoor weather station. The module uploads outdoor weather information to the intelligent water and fertilizer integrated machine through the RS-485 bus.

(2) Indoor sensors: monitor water, fertilizer and climatic factors that affect the planting conditions inside the greenhouse, including environmental temperature, environmental humidity, soil temperature, soil moisture, soil EC value, soil pH value, etc. These sensors are uniformly collected by the collection module, and then the indoor sensor data are uploaded to the intelligent water and fertilizer integrated machine through the RS-485 bus.

(3) Intelligent equipment sensors: The first equipment for irrigation mainly includes intelligent water and fertilizer integrated machines and automatic backwash filters. The main control objects of intelligent water and fertilizer integrated machines are irrigation volume, fertilizer liquid concentration and pH value of fertilizer liquid, so the corresponding sensors Including EC sensors, pH sensors, flow meters, water temperature gauges, etc.; automatic backwash filters mainly rely on the pressure difference between the inlet and outlet of the filter to determine the backwash conditions, so the corresponding sensor is a differential pressure sensor.

In the process of crop production, the above-mentioned sensors will generate process data again and again. These data are exchanged through the inter-layer interfaces of each layer, and finally shared with various end users.

The executive layer is the various actuators that control the process of crop water and fertilizer, mainly composed of various pumps and valves, including solenoid valves for controlling irrigation in the irrigation area, pulse solenoid valves for controlling the fertilization process, backwashing valves for controlling the backwashing process, and control Centrifugal water pump for irrigation and fertilization process, circulating pump for controlling water circulation process, etc. The actions of these actuators are ultimately controlled by intelligent equipment to make control decisions and commands to achieve various control goals set by the upper level.

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