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Design of Farmland Water Conservancy and Irrigation Management System Based on GIS

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Abstract The farmland irrigation project is an important part of China's water conservancy project. To keep abreast of the farmland water conservancy and various related environmental parameters, we can use the external sensors to acquire real-time data, employ the computer technology, networking and communication technology, database technology, geographic information system (GIS) technology, component technology and other advanced modern information technologies combined with the automated water conservancy technology, in order to build an accurate, efficient, fast, comprehensive, standardized decision support system integrating farmland water conservancy and irrigation information collection, transmission, storage, management and analysis. In this paper, we give details about the overall framework design of farmland water conservancy and irrigation management system based on GIS, information collection and data input, and information processing and data output, to provide a reference for the digital water conservancy construction in China.

Key words GIS, Farmland water conservancy, Farmland irrigation, Data information

1 Overall framework of system

Informatization is the inevitable choice of China to accelerate the modernization of water conservancy, and the information technology has been more and more widely applied in the water conservancy. The digital water conservancy technology is an important symbol of modern high technology of water conservancy in the 21st century, and also an important part of "Digital China".

The digital water conservancy, also known as precise water conservancy or information-based water conservancy, is to use the digital earth technology (including the high-tech systems of various resolutions combining the remote sensing technology, global positioning systems, computer network technology, geographic information technology (GIS)), and use the digital technology for digitization and visualization expression, design, control and management of whole water conservancy (water conservancy construction, farmland water conservancy and irrigation, water industry, *etc.*) production and management process, so that the water conservancy is developed in accordance with the goals and direction of human needs.

GIS can record the geographical data by a variety of ways and use efficient data organizational form for database management, updating, maintenance, and rapid query[1]. It has broad application prospects in the modern water conservancy management, especially the farmland water conservancy and irrigation production management. Using GIS software, combined with the modern sensor technology, automatic control technology, intelligence expert technology and other modern scientific and technological means, the geographic information data about the reservoir capacity and channel flow rate are collected for real-time monitoring and automatic management of reservoirs, channels and gates, to provide the managers with real-time data.

The overall structure of system is shown in Fig. 1.

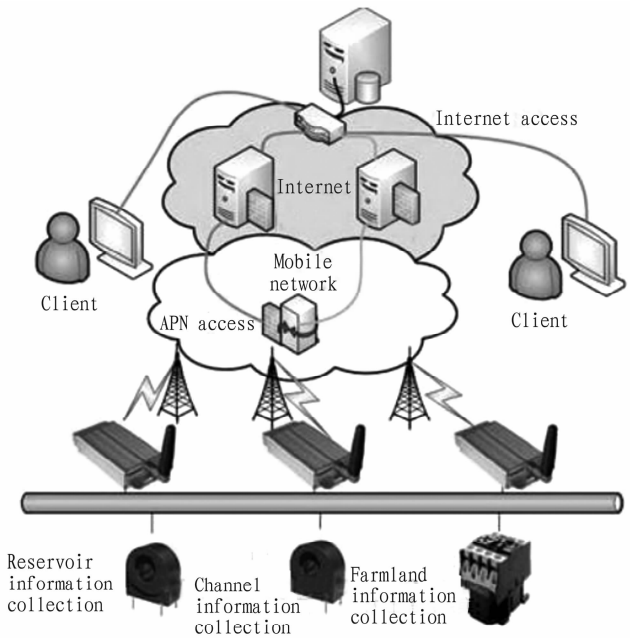

Fig. 1 The overall structure of system

2 Information collection and data input

Previously, the production managers must personally measure in order to know about the environmental status of farmland, and make summary after measurement, so that the timeliness can not be guaranteed.

After applying the remote monitoring system for the farmland water conservancy data, as long as installing a remote monitoring

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device at the monitoring point, the information about farmland soil moisture, humidity and reservoir storage, water level and channel flow rate and velocity can be transmitted back to the monitoring platform via the sensors, to help the relevant departments and irrigation managers to know something about the drought situation, temperature, humidity of each field at the same time, as well as the operating status of related reservoirs, channels and other facilities, and provide decision-making and control basis for irrigation and automatic control system.

The main information collected comprises farmland water content, capacity of the reservoirs, water level, channel flow, flow rate, *etc.* ; the system can facilitate the monitoring of irrigation system running information and farmland information, use text and figures to display the information to the users, and offer many kinds of sound and light alarms according to the farmland information and irrigation operation demand.

The system can monitor the capacity of the reservoir and channel, flow velocity, farmland water content and other parameters, keep records of changes of the parameters and store the information in its memory. At the same time, through the first serial communication port, the data are transmitted to the computer, and through the second serial communication port, the data are transmitted to the display screen.

The system can be linked up with the computer to form the embedded biological and environmental information collection system. The channel flow rate measuring sensor (Fig. 2), humidity sensor (Fig. 3) and smart gate control device (Fig. 4) are mainly connected with the farmland irrigation system information collection sensors and intelligent controllers.

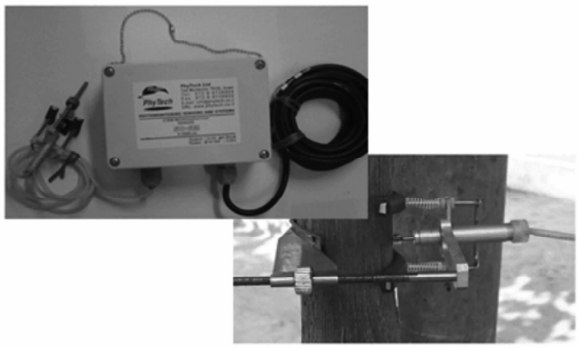

Fig. 2 Channel flow rate measuring sensor

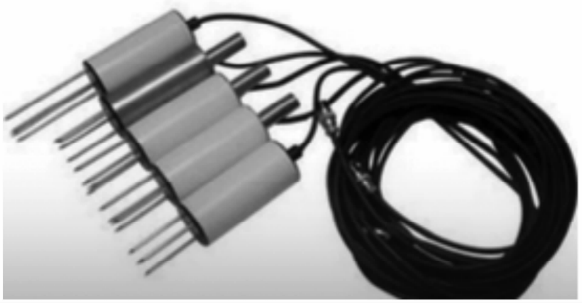

Fig. 3 Humidity sensor

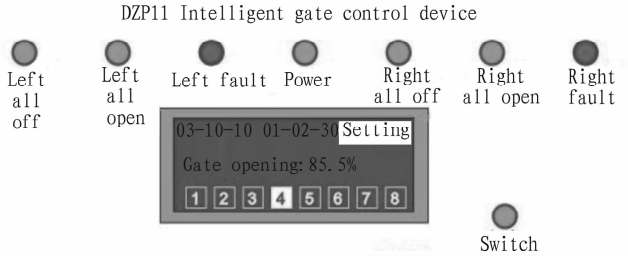

Fig. 4 The intelligent gate control device

In addition to the connection with the irrigation system sensors, it is also lined with farmland soil water content, temperature, humidity, wind direction sensors for real-time collection and transmission of environmental data including outdoor temperature, humidity, wind speed, wind direction and rain, *etc.*

The irrigation system data include storage capacity of reservoir, water level, channel flow, flow rate, *etc.* , and the intelligence, advanced control strategies and algorithms are employed to perform the automatic control of intelligent irrigation system. Through the broadband network technology, it realizes the remote real-time monitoring and remote video transmission on the farmland water and fertilizer information and environmental information, as well as the remote control of main irrigation system equipments.

3 Information processing and data output

The data processing uses the structured and modular design methods, which makes it easy to maintain, expand and improve the system. The object-oriented design methods are used for modular program and configuration so as to improve the expansion and flexible setting of system[2]. The operation is simple, and the users only need to enter the number and installation site of data collectors while other data are generated automatically. The vast majority of users do not need to modify other settings and individual users with special requirements only need to make simple setting.

The system does not classify the data and build a database, and it establishes contacts between various types of data through fields, namely making form about the farmland and environmental information for different regions, respectively, and the keyword is used to connect the forms. The database and and the database storing the data from various sensors constitute the distributed database, and the data can be updated in a timely manner, to achieve the "dynamic database" function.

The system is divided into several large modules, namely geographic information publishing module, digital production sub-module, reservoir and channel running sub-module, soil moisture sub-module, irrigation sub-module, integrated query sub-module, report submission sub-module, and system setting sub-module. In the development process, the programmers develop different modules, implement development of each module and finally integrate all the modules.

3.1 Geographic information publishing module The function of geographic information publishing module is to publish the geographic information through the relevant geographic information system software.

By the map navigation, we can enter various water conser-

vancy geographical information release pages for map scaling and roaming, search the farmland attributes, routes and area in each geographical area, use the map to have access to the information about location of farmland, sensors and internal farmland monitors, and perform the real-time monitoring on the farmland irrigation, for example, the system will sound the alarm if exceeding the specified threshold.

3.2 Digital production sub-module and reservoir and channel running sub-module The digital production sub-module uses the fertilizer, temperature, moisture and humidity sensors to collect information, and transmit the information collected into the database for analysis of fertilizer, moisture, temperature and humidity of different agricultural land, and it is regarded as the basis of production management and basic data for automatic control. The automatic control of irrigation, fertilizer application warning is realized according to the threshold set in the computer.

The function of the reservoir and channel running sub-module is to establish the expert model for the irrigation system management (reservoir, channel gate control), and submit the real-time data from various sensors into the expert model for data analysis of irrigation system parameters, to grasp the operation status of irrigation systems, and timely adjust the channel flow, flow rate, gate opening and closing and so on. By encoding, the operation information of a variety of equipments is recorded to form the irrigation system expert database.

3.3 Soil moisture sub-module It includes the moisture management analysis and field micro-irrigation systems. The moisture management analysis system uses the GIS geographic information system technology based on Web, to realize the online graphical management and analysis of soil moisture, and perform the collection, display, query, statistical analysis and output of graphical and attribute data of the facility production base.

Based on the soil moisture measurement data, it analyzes the soil moisture conditions and provides irrigation programs[3], diagnose the moisture disorders based on symptoms provided by the users and offer the reasonable proposals. By the precise management of the facility farmland soil moisture, it aims to achieve the goal of conserving resources, improving the quality of crops and soil environment.

3.4 Irrigation sub-module, integrated query sub-module and report submission sub-module The report submission sub-module submits various parameters about the farmland irrigation system through the client's web page, including the reservoir storage capacity, remaining water, channel flow, *etc.*, to the application layer, and then the application layer submits them to the database. By sorting the database data, it forms various kinds of farmland and irrigation system file modules.

The integrated query sub-module submits the farmland and irrigation system code names, to form the report about various kinds of farmland irrigation conditions for reference.

3.5 System setting sub-module The module can submit the new farmland, sensor, user and alarm threshold value to the database. The system uses the sensors for real-time data acquisition, and uses the Internet technology to promptly enter the data into various sub-databases. After the data processing, the data are finally transmitted into the server database.

The real-time input of data solves the data updating problems in the irrigation system, and the users can make a timely analysis of environmental information on farmland irrigation system and crops, to detect anomalies and solve problems.

4 Conclusions

Informatization is the inevitable choice of China to accelerate the modernization of farmland irrigation, and the information technology is more and more widely applied in the water conservancy, and will play an important role in the development of farmland water conservancy. The GIS (Geographic Information System) technology can be used to enter the geographic data in a variety of ways, and perform the database management, updating, maintenance, rapid query and retrieval in an efficient form of organization, which has broad application prospects in the current modern water conservancy management.

Using GIS software, combined with the modern sensor technology, automatic control technology, intelligence experts technology and other modern means of science and technology, it collects farmland temperature, humidity, soil conditions, reservoir, channel irrigation parameters and other geographic information data, to conduct the real-time monitoring and automated management of farmland water conservancy and irrigation, so as to provide a real-time data reference for the managers, improve the efficiency of production management, and lay a good foundation for realizing truly digital water conservancy.

To realize the digital water conservancy, it also needs the mutual collaboration among computer technology, automatic control technology and other related disciplines, and under the systematic and scientific guidance, it is necessary to use the advantages of various relevant disciplines to complete the informatization and automated design and construction of this production management system.

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