Ekoloji 28(108): 1029-1034 (2019)

LETTER TO THE EDITOR

Remote Monitoring Method of Eco-agricultural Soil Environment Based on Internet of Things

Yuan Sun*
Department of Mathematics and Information Engineering, Puyang Vocational and Technical College, Puyang 457000, China,
*Email: pyzysy@163.com

The Internet of Things can connect any object through sensors and the Internet, providing an effective means for remote monitoring, management and research. This technology has good application prospects in the field of agro-soil ecosystem research, but its development lags behind in China and needs further research and development. This research combines the Internet of Things technology with the monitoring of soil environmental factors in ecological agriculture. Through field installation of soil profile temperature and moisture sensors, environmental temperature and humidity sensors, wired and wireless data transmission network hardware, a remote monitoring and management software platform is customized and developed, and a remote monitoring system of soil environment in ecological agriculture based on the Internet of Things is constructed. The system utilizes interdisciplinary advantages to expand and explore the monitoring and research methods of soil ecological factors in the space-time scope, overcomes the lag and error caused by traditional in-situ sampling and testing methods, and improves the efficiency and accuracy of data acquisition. By further studying the real-time dynamic response mechanism of navel orange growth process to soil profile temperature and moisture, the measures of high-efficiency production of navel orange and improvement of water and fertilizer utilization rate can be explored, and the accuracy and reliability of the Internet of Things technology in the study of soil ecological factors can be verified. The construction and operation of the system provide scientific means for soil drought early warning, soil erosion and non-point source pollution monitoring.

1 INTRODUCTION

As an important ecological and environmental factor in soil, temperature and water play an important role in nutrient cycling process, plant rhizosphere nutrient environment and growth and development of eco-agricultural soil environment. There are many traditional and mature methods and techniques for monitoring and researching soil ecological factors. However, ecological factors such as temperature and water are susceptible to the surrounding environment and can not be easily controlled in real time. The data obtained by sampling analysis and in situ testing often lag behind and error, which results in inconsistency with the actual situation in the field. Wireless sensor network based on Internet of Things technology provides an accurate and effective means for real-time acquisition of soil information. This technology can achieve intelligent monitoring and management by means of radio frequency identification, information sensing, wireless transmission and Internet connection. The technology can monitor and control the soil ecological factors in real time, and the accuracy and efficiency of data acquisition are greatly improved. At present, the technology is still in its infancy in China, but it has not been applied in the field of monitoring soil environmental factors. In recent years, there have been a lot of research reports on soil temperature and moisture at home and abroad.

Wan et al. (2019) published an article entitled “Restoration of Cadmium Contaminated Soil Using Approaching Anode Method of Polygonal Electrode” on Issue 107 of Ekoloji. This paper aims at remediation of cadmium contaminated soil by polygonal electrode approach to anode. In order to investigate the effect of polygonal mobile anode electrodes on the remediation of cadmium-contaminated soils, cadmium-contaminated soils were prepared in the laboratory, and a conventional hexagonal electrodes electroremediation experimental device was established. The repairing effects of fixed anode method and near anode method under the condition of continuously shortening the distance between anode and cathode and the electric field intensity of $2V \cdot cm^{-1}$were compared and analyzed.

Xie and Wang (2017) designed a remote monitoring system of oil palm based on the Internet of Things. To meet the needs of intelligent monitoring of oil palm environment, a remote monitoring system of oil palm growth environment based on the Internet of Things was designed. The system consists of video surveillance, soil node, environment node, gateway node and remote control center. It can real-time online monitor soil temperature and humidity, air temperature and humidity, wind speed and direction, solar radiation and rainfall in oil palm planting base, and transmit them to the control center. The control center processes the data and displays them in various chart formats. After testing, the system can run steadily. The system has the advantages of simple operation, convenient and intuitive, flexible configuration, low power consumption and large network capacity. Zou and Bai (2017) conducted research on remote monitoring system of agricultural environment based on internet of things. With the advent of the Internet of Things era, the application of Internet of Things technology has become more and more widely. Now the Internet of Things technology is applied in industrial and agricultural production. The application of Internet of Things technology in agriculture promotes agricultural production, strengthens the scientific management of agriculture, and plays a technical guarantee for the improvement of agricultural grain production. This paper mainly elaborates the research of remote monitoring system of agricultural environment based on Internet of Things from the aspects of structure design of remote monitoring system of agricultural environment, function module design of remote monitoring system of agricultural environment, implementation and operation test of remote monitoring system of agricultural environment, hoping to provide theoretical reference for experts and scholars of remote monitoring system of agricultural environment.

In China, the traditional in-situ acquisition and spot observation methods are mostly used to obtain soil temperature and moisture parameters. Compared with some foreign research sites and platforms (Chen et al. 2017, Yang et al. 2018; Liu et al. 2018), their research methods are relatively backward, and need further improvement and improvement. Soil temperature and moisture are interrelated. Accurate acquisition of the real-time dynamics of soil temperature and moisture is very important for accurate research results. This system is based on this starting point, and aims to expand and apply the research methods of soil temperature and moisture by using information technology. Real-time dynamic acquisition of soil temperature and moisture based on Internet of Things (IOT) is a combination of information technology and soil ecology research. It has a high frequency and real-time data acquisition. It can further improve the efficiency, reliability and accuracy of data acquisition on the basis of existing research. It is an in-depth expansion and exploration of previous research methods and existing achievements.

2 IDEA DESCRIPTION

2.1 Overview of remote Monitoring based on Internet of things

The Internet of Things (IOT) is an information technology that connects all items with the Internet through information sensing devices such as radio frequency identification (RFID) to realize intelligent management. Through radio frequency identification (RFID), infrared sensor, global positioning system (GPS), laser scanner and other information sensing devices, according to the agreement, any object is connected to the Internet for information exchange and communication, in order to achieve intelligent identification, location, tracking, monitoring and management of objects (Liuet al.2018). It includes three main parts (sensor network, information transmission network and information application network) which endow the Internet of Things with the characteristics of comprehensive information perception, reliable data transmission, effective optimization system and intelligent information processing.

Internet of Things (IOT) technology and its application is a new interdisciplinary subject. Domestic researchers have put forward many innovative ideas and theories in theoretical research, such as network protocol, algorithm and architecture of the Internet of Things. There are also many problems that need to be solved further, such as energy-saving optimization of the network, rational layout of network nodes, prolongation of life cycle, and improvement. Safety and reliability of data transmission, etc. (Li et al. 2018). At the same time, the technology is limited by such factors as lack of funds, backward technology and equipment, lack of professional guidance channels in various application fields, and its development lags behind and the level of intelligence is relatively low. It has not been linked with relevant control equipment, and has not really realized scientific decision-making and intelligent control. The application of Internet of Things in China's agricultural production is far from being large-scale. More work needs to be done in both scientific research and industrialization (Wang et al. 2017). Therefore, the application of Internet of Things technology in agricultural resources utilization, ecological environment monitoring, agricultural fine management and traceability of agricultural products safety is becoming a new research field, and has broad prospects for development.

2.2 Experimental Design Scheme of Monitoring system

In this study, a typical purple soil in a certain area was selected and an experimental observation plot with an area of 2 m×2 m was established. There were three treatments, CK, SW and SC, with three replicates in each treatment, and bare soil as background value reference. There were 10 real-time observation plots. The background values of soil nutrients in each plot were consistent. Newhall navel orange, the dominant local cultivar of navel orange, was selected as the test plant, and one plant was planted in each plot. Soil temperature and moisture sensors were buried in the root zone within the canopy drip line, respectively. Soil profiles of different fertilization treatments were buried at 0-20, 20-40 and 40-60 cm depths. A solar power supply system (Fig. 1) is installed near the district to supply power for sensors and data acquisition devices. At the same time, the data acquisition device is connected with remote monitoring equipment through wired and wireless transmission equipment to acquire real-time and online soil temperature and moisture data of different treatments. In order to obtain the environmental background values around the test area, soil temperature and moisture sensors were buried at the same three depths in the soil profile of the meteorological observation station, and ambient air temperature and humidity sensors were installed at the same time. The hardware facilities of the Internet of Things system in this system are mainly composed of soil temperature, moisture and environmental factors sensors, information acquisition devices, data transmission network and data management application devices.

Fig. 1 Cell where sensors and solar power supply systems are installed.

2.3 Selection and Measurement principle of Sensor

The sensors used in this study are Beijing Time Domain TDC220TH Integrated Soil Moisture and Temperature Sensor and TDC302 I Ambient Air Temperature and Humidity Sensor. Soil moisture sensor uses crystal oscillator to generate high frequency signal and transmit it to parallel metal probe. The signal generated is superimposed with the return signal, and the soil moisture content is measured by measuring the amplitude of the signal. A platinum temperature sensor is installed in one of the probe outer rings to simultaneously measure soil temperature. The integration of soil moisture and temperature sensor can avoid disturbance to soil and obtain more accurate measurement results.

3 RESULTS

From the results obtained in the initial operation of the system, the whole system has shown incomparable advantages in terms of software and hardware stability and data acquisition continuity. The differences between different processing methods are clearly reflected. The experimental data acquisition has reached a precise and efficient level, saving a lot of manpower, time and energy. In the later stage of the study, the real-time dynamic data of different processing time and frequency bands in the test area can be studied in depth.

To explore the accuracy, reliability and safety of remote real-time data acquired by wireless sensor network technology based on Internet of Things, this project sets up the traditional manual recording and sampling analysis mode, which is partially processed, and compares the manual measured data with the real-time monitoring data. Data aggregation and reliability analysis. The comparison and analysis with the artificial observation data and the accuracy test show that the accuracy of the remote monitoring data is much higher than that of the artificial observation data. The change trend of soil temperature and environmental temperature is consistent, and the dynamic state of soil moisture is also related to the natural precipitation. The remote monitoring data meet the accuracy requirements of the measured data, and can meet the daily monitoring and research needs of field test sites.

4 DISCUSSION

A customized monitoring system software platform is installed in the data server and terminal computer to realize remote control, remote data acquisition, database management, data analysis, instruction control and other functions. Its structure is shown in Fig. 2.

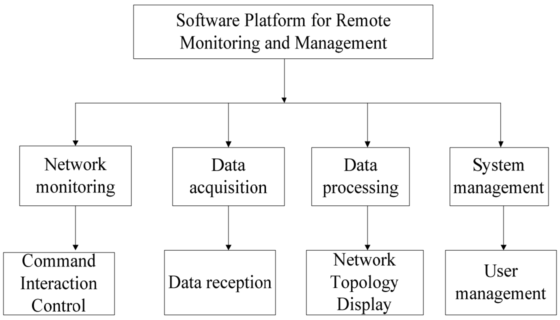

Fig.2 Structure Diagram of remote Monitoring and Management platform

The monitoring platform software has many monitoring functions, such as real-time monitoring, statistical reports, historical curve display, real-time curve display and alarm, etc. It has a good man-machine interface and is easy to operate. It is equipped with a powerful real-time database, which can store collected data according to actual needs, such as timing storage, change storage and so on, so as to ensure the reliability of data while reducing the storage. Spatial requirements; software automatic command control, intelligent decision-making function based on background database and setting values of relevant indicators, automatic control of the operation status of hardware devices; good openness, support for data storage as Excel and other commonly used software formats, easy for subsequent use of data; good scalability, without changing the premise of software system structure Under this condition, only a small amount of configuration development is needed to increase the monitoring of other data, which provides the possibility for the expansion of the whole system. At the same time, real-time correction of data is provided to ensure the accuracy and reliability of monitoring results.

5 CONCLUSION

The remote monitoring system of soil environment built in this study is a field scientific research and monitoring platform with remote real-time monitoring and control function based on the combination of software and hardware of Internet of Things technology. It can be used as a model for other field tests and monitoring sites in this research area. The combination of Internet of Things technology and monitoring and research of soil ecological environment factors is the exploration and practice of research methods based on cross-disciplinary advantages. The application of advanced information technology in traditional soil ecology research can expand the space-time scope of research. The construction and application of remote monitoring system for soil environment based on Internet of Things will help to overcome the lag and error caused by traditional soil sampling analysis and in-situ testing methods, and greatly improve the efficiency and accuracy of data acquisition. After the completion and stable operation of the system, the accuracy and reliability of the Internet of Things technology in monitoring and researching soil ecological factors can be further verified. The Internet of Things monitoring system is in the initial stage of operation, and the real-time data acquired need further accumulation, testing and system analysis. According to the characteristics of geography and ecological environment, the construction and application of the system will provide scientific means for early warning of agricultural soil drought, soil erosion and non-point source pollution control.

REFERENCES

Chen GP, Qin WJ, Ding J, et al. (2017) Designing and Validation of the Remote Monitoring System for Pigs' Survival Based on IoT Technology. Scientia Agricultura Sinica 50(5): 942-950.

Li SX, Xu SP, Liu Y, et al. (2018) Design and implementation of remote monitoring system for soil environment in field based on 4G WSN. Acta Agriculturae Shanghai 34(5):110-115.

Liu F, Liu Y, Jin D et al (2018) Research on Workshop-Based Positioning Technology Based on Internet of Things in Big Data Background. Complexity: 7875460.

Liu YC, Li JQ, Zuo QK. (2018) Design of Remote Monitoring and Control System for Agriculture Drip Irrigation Based on Internet of Things. Automation & Instrumentation 33(4):82-86.

Wan Y, Wang A, Shen M (2019) Restoration of cadmium contaminated soil using approaching anode method of polygonal electrode. Ekoloji 28(UNSP e107123107): 1041-1047.

Wang YY, Chen SG, Wang XJ. (2017) Design of flower greenhouses environment detection system based on internet of things. XianDai NongYe KeJi (10):166-170.

Xie ZH, Wang LL (2017) Design of Oil Palm Remote Monitoring System Based on the Internet of Things. Tropical Agricultural Engineering 41(5):44-47.

Yang A, Li Y, Kong F et al (2018) Security control redundancy allocation technology and security keys based on internet of things. IEEE Access 6: 50187-50196.

Zou CZ, Bai N. (2017) Research on remote monitoring system of agricultural environment based on Internet of things. Electronic Test (9): 64-65.