Exploration and research of laboratory construction based on Internet of Things in Agriculture

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Abstract: Focusing on the current development status of internet of things in agriculture, we combined with the urgent needs of colleges for the construction of experimental platforms, and according to the three layers of requirements for the construction of internet of things in agriculture laboratories, including the perceive, transportation and application. Through deep analysis of the three layers of demand, and specific implementation of specific construction plans in the laboratory, we will be able to the effective application and long-term development of the internet of things technology in the modern agriculture.

1. Introduction

In order to pursue scientific, environmental and efficient sustainable development of modern agriculture, it is necessary to integrate intelligent information technology and establish an integrated standardized management system for agricultural production, processing, transportation and sales. In the process of modern agriculture development, the application of Internet of Things technology is in a very important position. Through the construction of agricultural Internet of Things laboratory platform, universities can strengthen the cultivation of applied talents' innovation and practical ability, and greatly alleviate the urgent needs of the current society in this field.

The concept of Internet of Things was first proposed by MIT in 1999. As a new technology since the 21st century, it has been widely studied and developed in the world. The Internet of Things is mainly composed of three layers: perception layer, transmission layer and application layer. In the field of agricultural Internet of Things, the sensing layer is composed of agricultural-related sensors, such as soil moisture sensor, air temperature and humidity sensor, carbon dioxide sensor and so on. Multisensors can effectively perceive the external information of the Internet of Things and achieve the acquisition of the underlying data of the network. As the transmission link of the Internet of Things in agriculture, the transmission layer can transmit and receive data through appropriate communication technologies, such as Wi-Fi, ZigBee, etc. The application layer is a tool to realize the production, processing and circulation and transportation of crops. Integrative management means will ultimately ensure the complete control of the entire agricultural Internet of Things system.

Based on the in-depth analysis of the three-tier architecture of the agricultural Internet of Things system and the difficulties in the actual construction of the laboratory platform, this paper puts forward three levels of requirements for the construction of the agricultural Internet of Things laboratory, and explores the specific implementation plan, which will provide some reference for the construction of the experimental platform of the agricultural Internet of Things in domestic universities.

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2. Perception Layer of Agricultural Internet of Things

2.1 Key Technology Composition of Perception Layer

Perception technology plays a very important role in the agricultural Internet of Things system. Perception layer is usually composed of peripheral multi-sensor and sensor nodes to collect soil moisture, plant information and other data. Therefore, in the perception layer of the agricultural Internet of Things, sensors are mainly divided into two categories: agricultural environmental information sensors and agricultural animal and plant life information sensors. Agricultural environmental information sensors usually include the collection of physical and chemical information such as light intensity, air/soil temperature and humidity, rainfall, carbon dioxide concentration, soil salinity, soil pH value and dissolved oxygen in water. Agricultural animal and plant life information sensors include the collection of physical and chemical information such as crop surface temperature and humidity, stem strength, crop nitrogen, ion concentration and plant water content.

Therefore, on the basis of sensor acquisition, it is necessary to carry out comprehensive application research on optics, thermoelectricity, electronics and electromagnetics, electrochemistry and nuclear magnetic resonance, and develop agricultural sensor standards, anti-interference technology of agricultural environment, adaptive coding and decoding technology of agricultural environment, and agricultural environmental communication technology. The research needs of the direction constitute a complete technical framework of the perception layer of the agricultural Internet of Things.

2.2 Perception Layer Construction Scheme

From the analysis of the needs of the perception layer, we can see that all sensors involved in the construction of the agricultural Internet of Things laboratory must be classified effectively, and then, according to the specific experimental content, agricultural information sensors should be purchased and equipped separately. For agricultural environmental information and animal and plant life information monitoring, all sensor collection types can be divided into eight types, namely, environmental meteorology, soil instrument, plant protection instrument, plant physiology, food safety, seed detection, breeding information, crop quality. Specific equipment contained in sensor types is required. Purchase should be made according to the actual situation of the project, such as accumulated temperature meter, accumulated light meter, total radiation recorder, photosynthetic active radiometer, wind direction anemometer, temperature and humidity recorder, carbon dioxide detector and so on. Common crop quality equipment includes Kjeldahl nitrogen meter, crude fiber meter, fat meter and so on.

3. Characteristics and Key Technologies of Agricultural Internet of Things Transmission

3.1 Transmission characteristics of Agricultural Internet of things

Agricultural Internet of Things (IOT) is usually deployed in outdoor environment, so in actual transmission, it is necessary to consider that the actual deployment of sensor nodes is constrained by the following conditions [4].

(1) Energy limitation. Agricultural Internet of Things (IOT) is usually deployed in places where the environment is complex and harsh, and even difficult for staff to reach. It is very difficult to change the power supply frequently. Therefore, the energy limitation of sensor nodes exists in the agricultural Internet of Things.

(2) The transmission distance is limited. In the agricultural Internet of Things, the energy consumption of node communication is proportional to the communication distance, and the larger the communication distance, the greater the energy consumption. Therefore, short-distance transmission and multi-hop mechanism are usually combined to reduce network energy consumption.

(3) Transmission scheduling. There are many nodes in the Agricultural Internet of Things. In the

process of data transmission, there are frequent contention for channel resources. Because of the huge number of nodes and the large amount of data transmitted in the channel, the channel will be extremely crowded when the channel resources are limited, so the corresponding transmission scheduling protocol is needed to implement it.

(4)The working environment is bad. Because the agricultural environment is susceptible to seasonal climate regulation, if sensor monitoring network is deployed outdoors, the interference of abrupt environmental factors such as weather, wind and temperature on network communication must be considered.

3.2 Key Technology Composition of Transport Layer

In view of the above deployment constraints, many solutions have been derived from industry, and the networking communication mode in the agricultural Internet of Things has become a hot research topic. At present, the wireless communication technologies used in the transport layer of the agricultural Internet of Things mainly include ZigBee, Wi-Fi, GPRS, NB-IoT and Bluetooth.

(1) ZigBee has a long communication distance, with a single hop of nearly 70m and low energy consumption of node modules. ZigBee works in ISM 2.4 GHz band. The network supports AES-128 encryption and has relatively high security. ZigBee network has a large capacity and can accommodate 65536 nodes.

(2) The communication distance of Wi-Fi is about 150 m to 200 m. Among them, 802.11b type works in the ISM band of 2.4 GHz, and the transmission speed is very fast. The real-time transmission rate can reach 12 Mbps, but the security is weak. In terms of the number of connected devices, the maximum number of accessible devices is 50.

(3) GPRS communicates with server in GSM frequency band. Its communication distance and number of nodes are limited by base station equipment, and the real-time transmission rate can reach 115 kbps. It has high security but high power consumption.

(4) NB-IoT has a long communication distance, up to 20 km. GSM and LTE authorized bands are adopted. The energy consumption of the module is also relatively low, and the normal power supply can work continuously for more than 10 years. It supports double-layer encryption mode of non-access layer and wireless resource control layer, and has high security. Data transmission rate is high, up to 200 kbps. NB-IoT can support access of 100,000 nodes.

(5)The communication distance of Bluetooth varies with the power of receiving and receiving, up to 100m. Its operating frequency is 2.4 GHz ISM band and its transmission rate is as high as 1 MBps. It can be used for 8 to 20 months with relatively low power consumption under normal battery power supply. In terms of the number of connected devices, it can support seven device connections at the same time.

3.3 Transport Layer Construction Scheme

From the requirement analysis of the transport layer, it is very important to select an effective and appropriate wireless communication technology. For example, if the agricultural Internet of Things is deployed in the extreme outdoor environment, the communication mode must satisfy the long transmission distance and relatively low power consumption. At this time, Wi-Fi cannot meet the energy demand, because Wi-Fi needs to use stable power supply and high energy consumption, more suitable for deployment in a fixed agricultural environment, such as greenhouse. For example, Bluetooth technology can only support seven device connections at the same time in the number of connected devices. If there are more sensor nodes in the network, then Bluetooth technology cannot meet the actual needs.

In the construction of the Agricultural Internet of Things Laboratory, we mainly use NB-IoT and ZigBee combined with GPRS technology. NB-IoT uses low-speed for long-distance communication, and can easily achieve network coverage of several kilometers or even tens of kilometers. Because of its wide network coverage and low terminal power consumption, it is very suitable for large-scale outdoor network deployment. In the technical scheme of combining ZigBee with GPRS, ZigBee has the disadvantage of limited single hop transmission distance and can only be deployed in a single area.

Long-distance data transmission can be realized by accessing GPRS at the sink node.

4. Application Layer of Agricultural Internet of Things

4.1 Application Field of Agricultural Internet of Things

At present, the main application fields of agricultural Internet of Things are field planting, facility agriculture, aquaculture and so on. In the above areas, domestic scholars have launched targeted research, which can provide effective reference for agricultural production and the application of the Internet of Things. For field planting, Zang He Zang et al. [5] Accurate monitoring of key environmental factors and growth status of field grain crops is achieved by video surveillance and Internet of Things sensors. For facility agriculture, Sun Zhigui and other experts based on Internet data mining and expert knowledge decision-making technology, to achieve early monitoring, early warning and intelligent decision-making push for agricultural meteorological disasters in major facilities in northern China, such as cold wave, snowstorm and gale [6]. For the aquaculture industry, Liu Yuqing and others used STC15F2K60S2 embedded microcontroller, and collected sensor data through RS485 protocol to monitor the water quality and meteorological parameters of crab breeding base [7].

4.2 Construction Plan of Application Layer

Based on the application research of domestic scholars in the field of agricultural Internet of Things and the current development trend in this field, we can see that the construction of agricultural Internet of Things laboratory should start from sensor technology, focus on new sensors with low energy consumption, low cost and high performance, and effectively integrate the agricultural Internet of Things and modern agricultural machinery. In order to meet the needs of different levels of equipment, relying on school scientific research projects, we provide laboratory hardware equipment, software resources, engineering experiments, so that the Internet of Things technology runs through the entire scientific research process, and ultimately complete the teaching and research tasks.

5. Summary

In this paper, three levels of Internet of Things are analyzed, and the application scheme is discussed, which can provide effective reference for the construction of agricultural Internet of Things laboratory.

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