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Overview of Agricultural Applications Based on the Internet of Things

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Abstract

Internet of things (iot) technology is a hot research topic in the world. In agriculture, the use of iot technology can reduce labor costs and increase productivity. This paper introduces the application of Internet of things in agriculture in detail from three aspects: perception layer, network layer and application layer.

Keywords

Internet of things; Agriculture; Perception layer; Network layer; Application layer.

1. INTRODUCTION

With the continuous development of Internet of things technology in recent years, its application has been implemented in all aspects of life and production. Nowadays, large-scale breeding and cultivation have become the new normal of modern agriculture. It has the advantages of large area, wide range and high yield, but it also has the disadvantages of difficult management and high labor cost. The application of Internet of things technology to modern agricultural production can further reduce the consumption of labor, and will more directly show the working state of each part of agricultural production, so as to realize remote control. Effectively control all aspects of the production process to achieve the production objectives of low cost, high yield and high efficiency. This paper summarizes the key parts of the application of Internet of things in agriculture by referring to relevant literatures, which is of great significance for the research of the Internet of things technology oriented to agriculture.

2. OVERVIEW OF INTERNET OF THINGS TECHNOLOGY

The Internet of things (Iot) refers to the communication between things and things through the Internet according to the specified communication protocol. It was originally applied in the military field. With the continuous development of various technologies, it is now continuously applied in medical treatment, industry, agriculture and other fields. Internet of things technology can be divided into three layers: application layer, network layer and perception layer. "Social division of labor" in the application layer is mainly oriented towards users, including mobile phone applications and PC applications. The network layer is the nerve center and the brain. The data collected by the perception layer can be processed and transmitted depending on various communication methods. The sensory layer is composed of five senses and skin sensors, which use various kinds of sensors to obtain different physical information. Its architecture is shown in figure 1.

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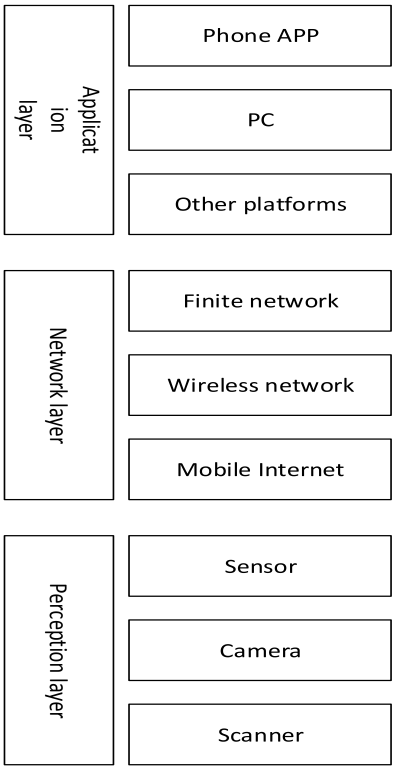

Figure 1. Iot architecture

3. INTERNET OF THINGS NETWORK LAYER

The Internet of things now USES wired, wireless and carrier networks as its main means of communication. In agricultural production, due to the complex site, may face high temperature, humidity and other severe environment. The traditional wired network transmission is through the prewiring communication, and this wiring in the complex environment of agricultural production, low reliability, high cost, difficult maintenance, so with the development of wireless network technology, wireless communication gradually replaced the traditional wired network.

3.1. Zigbee Technology

Literature [1] introduces the current popular wireless transmission mode of Internet of things and Zigbee wireless sensor technology. Zigbee network is mainly composed of terminals, coordinators and routers, and its topological structure includes network, tree and star structure. Developed by iee.802.15.4 wireless standard, it has the advantages of low complexity, short distance, low cost and low energy consumption.In transmission, each individual Zigbee module is similar to the base station, which can expand the communication distance to several hundred meters or even several hundred kilometers, greatly improving the scalability and effectively reducing the cost.Literature [2] introduces the protocol architecture of Zigbee technology. Based on IEEE 802.15.4 standard, Zigbee defines the high-level of the system, including the available network structure, security layer, application convergence layer and high-level application specifications. All devices in Zigbee networks are assigned unique 64bit IEEE dynamic addresses, which also support 16bit short addresses. 16bit local address is more convenient to process, saving power. Once the network is established, short addresses can be used to enable the network to support more than 65,000 nodes. Figure 2 shows the architecture of the Zigbee protocol.

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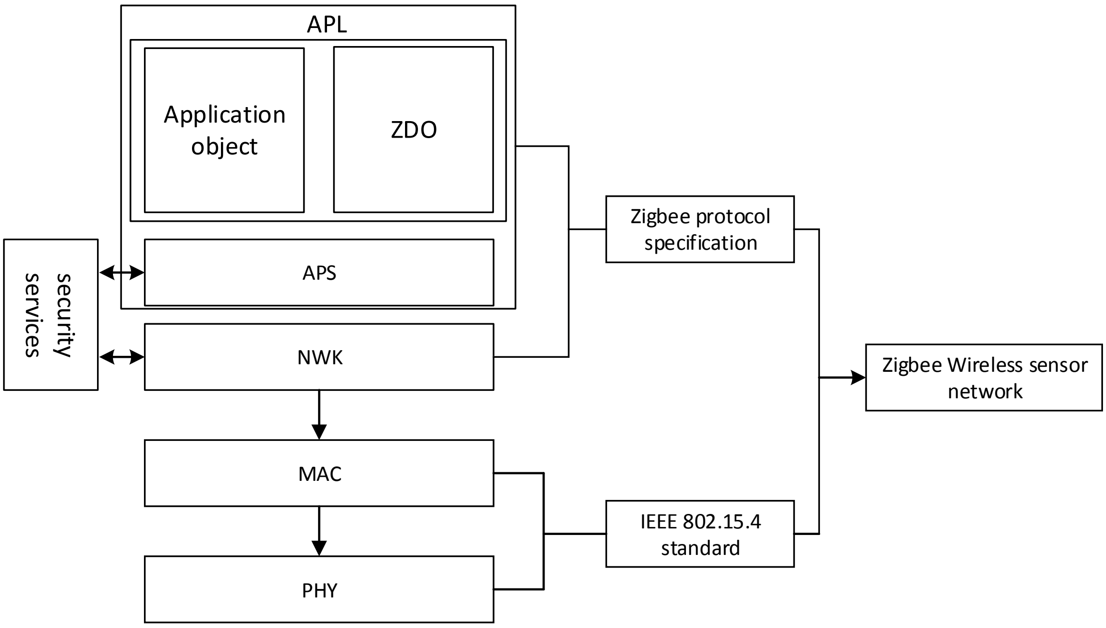

Figure 2. Architecture of Zigbee protocol

3.2. Wifi Technology

Literature [3] introduces WIFI technology. WIFI is a wireless interconnection technology and a brand of wireless network communication technology. Therefore, WIFI and wireless LAN cannot be confused. WIFI technology signal range is wide, the effective range is about 100 meters; the maximum bandwidth at ieee802.11b can reach 11Mbps, and it can also be adjusted to 5.5mbps, 2Mbps and 1Mbps. Literature [4] introduces the composition of WIFI. A complete WIFI network is mainly composed of wireless medium (WM), site (STA), distributed system (DS) and access point (AP). In a wireless network, to transmit signals more efficiently, you need to set up some bridge and the control function of the site, the site was known as the access point (AP), from a certain point of view, the AP determines the WIFI network mode, such as: point to point mode, multiple AP mode, infrastructure, wireless bridge mode and wireless relay, etc.

3.3. UWB Technology

Literature [5] introduces UWB technology, which is also known as ultra-wideband technology. The bandwidth of UWB is at least over 1GHz, and the spectrum resource reaches 10.6ghz. Under such a high bandwidth, it is widely used for high-speed data transmission. Its transmission power is small, the penetration ability is strong, the uwb base band pulse contains the low frequency component, has the very strong penetration ability, but its current in the civil field has not received the strong support. Literature [6] details the structure and composition of UWB transparent transmission module. It is mainly composed of data sending module S and data receiving module M. FPGA was selected as the main control chip and connected with DW1000 through SPI bus, and the radio frequency signal was generated by DW1000. When transmitting data, the wireless chip DW1000 conducts parameter configuration, and the control command interacts with the data frame, and finally outputs the data to the antenna end.

3.4. Bluetooth Technology

Literature [7] introduces bluetooth technology, which, due to its low cost, low power consumption and simple networking, has become the standard configuration of many mobile phones or smart terminals. Bluetooth protocol defines synchronous connection-oriented link and asynchronous connection less link. Nowadays, bluetooth specification has been increased from 1.0, 2.0 and so on to 4.0. Bluetooth technology works in the 2.4Ghz ISM band, which is free, so it will inevitably be interfered with by other wireless signals. Bluetooth adopts frequency-

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hopping technology, and communication can only be conducted through frequency-hopping. Therefore, in the absence of communication, the inter-connection of devices will consume a lot of time. Literature [8] USES bluetooth 4.0 rf module, and the effective indoor transmission distance can reach 60m. Bluetooth is not only the data acquisition terminal, but also the infrared emitter that drives the execution equipment. And the combination of mobile phone client to achieve the chicken house environment monitoring.

4. INTERNET OF THINGS PERCEPTION LAYER

Sensors belong to the perception layer among the three layers of the Internet of things, and the perception layer is the most direct means for the Internet of things system to obtain external information. Due to its unique monitoring objects, the sensors required by the agricultural Internet of things are different from those in other fields. The monitoring objects mainly include: soil, temperature and humidity, air, animal and plant characteristics, etc. (sensor cameras, environmental monitoring sensors, soil sensors)

Literature [9], through multi-spectral image analysis of nutrient element detection and diagnosis of cucumber leaves in greenhouse, CCD camera and filter were used to select threshold values of near-infrared light wave breaking images respectively by genetic algorithm and watershed algorithm, and an obvious linear relationship between NDVI and leaf area and nitrogen content of leaves could be obtained. The experimental data show that it is feasible to use CCD camera to collect multi-spectral images of crops and then diagnose the nutrients and growth of crops. Literature [10] used multi-spectral camera to process images in three channels of green light, red light and near-infrared, and ls-svm to establish a fitting model between vegetation index and leaf nitrogen content and leaf area index. The fitting correlation coefficients between vegetation index and leaf nitrogen content and leaf area index were 0.8665 and 0.8553, respectively, indicating that leaf nitrogen content and leaf area index were closely correlated. Literature [11] used a small number of wavelengths in the near-infrared spectrum of fresh meat to predict its PH value, and established a simple multiple linear regression model (spa-mlr) by continuous projection algorithm (SPA) to select the characteristic wavelength. The selected characteristic wavelength was fixed, and the selected variables were mostly the absorption peak of hydrogen-containing groups, which had practical physical characterization significance. Literature [8] adopted the combined treatment method of direct orthogonal signal correction and continuous projection algorithm (dosc-spa) to realize the rapid and accurate diagnosis of rice leaf blast by visible/near-infrared spectroscopy. The spectral data of rice canopy were processed by direct orthogonalization, and the effective wavelength was extracted by continuous projection algorithm. Literature [12] proposed a direct orthogonal signal correction algorithm (DOSC) for spectral data preprocessing, established a quantitative analysis model for each group of gases using partial least squares regression method, and carried out ergodic optimization to select the optimal analysis model for the number of principal elements, derivative step size and the number of orthogonal components. The results show that DOSC algorithm USES the concentration array in data processing, which improves the loss of useful information in useful spectral data, and the baseline drift is effectively corrected. Literature [13] proposed a method for direct quantitative analysis of PAHs pollutants in soil based on two-dimensional fluorescence spectroscopy. Based on the synchronous two-dimensional correlated fluorescence spectral matrix and the mathematical model of ananthene and phenanthrene concentration, cross-validation root mean square errors under different principal component Numbers were calculated respectively, and the optimal principal component number was selected.

5. IOT APPLICATION LAYER

In agricultural production, iot is mainly applied to traditional projects such as planting industry, animal husbandry and aquaculture. Users can get timely feedback of production status through iot devices and make corresponding adjustments according to the running status. The application layer of the Internet of things mainly includes mobile terminals and cloud service platforms.

5.1. Application of Greenhouse Planting

As a big agricultural country, China's current farming mode has changed from small-scale cultivation to large-scale greenhouses. Large-scale greenhouse planting has the advantages of high yield and low economic cost, but it is accompanied by large labor consumption and high time cost. Therefore, greenhouse planting must be transformed into intelligence and information, and help agricultural personnel to carry out greenhouse planting activities through advanced Internet of things technology. Literature [14] USES the Internet of things technology to achieve real-time collection of greenhouse environmental information, such as air temperature, air humidity, soil humidity, soil temperature and carbon dioxide concentration, for real-time monitoring of the growing environment of crops. Cameras are used to monitor the growth of crops, diseases and insect pests, ultrasonic sensors are used to automatically detect the height of crops, and plot the growth curve of crops. Through the detection data, the remote PC or mobile phone APP can be used for control, or the threshold can be set for automatic control. Literature [15] designed and implemented a greenhouse intelligent monitoring system based on the Internet of things. The system can achieve automatic collection of greenhouse environmental parameters, real-time display, visual data query and analysis, and can also apply the intelligent control algorithm of greenhouse temperature system based on hybrid automata model in practical operation. The image recognition technology based on Zernike moment is applied to the detection of device state to realize automatic calibration of the device, and make full use of Ajax technology to realize real-time update and synchronization of environment data and device state. Literature [16] implemented an identification system in the cultivation of Internet of things greenhouses: the RFID technology was used to clearly display the personal information of users on the computer, and the system allowed users to conduct relevant operations after card registration. Automatic alarm function: a large number of smoke in the greenhouses, open fire and other fire hazards, can be notified through wireless network or GPRS users and related departments. Remote monitoring function: real-time monitoring of environmental parameters in the greenhouse from the web side.

5.2. Application in Orchard Planting

Traditional orchards have large planting area, high labor cost and difficult management, which can be improved in combination with the Internet of things. The first is environmental monitoring: literature [17] designs and implements an orchard environmental information monitoring system that USES Zigbee protocol to transmit environmental data. The system adopts zigbee-supporting and low-power infinite sensor nodes to form a tree-like infinite sensor network. The front-end sensor node collects soil humidity and temperature, temperature and humidity of fruit tree leaves, and light intensity information data and sends them to the zigbee-supporting coordinator, and then the coordinator uploadesthem to the management server to realize environmental information monitoring. The second is production management: literature [18] has designed a set of expert system based on Internet of things technology, which consists of sensors, remote sensing, RFID, etc., and the power is supplied by solar cells and batteries. The data returned by the sensor will be summarized in the comprehensive database, and the characteristics of diseases and pests built in the database will be matched to determine whether the fruit tree suffers from diseases and pests. The third is traceability source system: literature [19] developed a traceability orchard production process management system using RFID technology. Farmers in the process of fruit tree growth, mainly for fertilizer, spraying, irrigation, farming operation such as pruning, to import the important parameters, such as farming information to orchard web servers, and through the corresponding RFID chips for each batch of agricultural products are marked with information input, solve the fruit product information opaque, transportation timeliness is not high.

5.3. Applications in Aquaculture

Literature [20] used Zigbee technology, GPRS technology and mobile client development technology to design a remote aquaculture monitoring system based on cloud service platform. Temperature sensor module, PH sensor module and oxygen content sensor module are adopted in the monitoring node, and data are gathered to the OneNET cloud platform through Zigbee wireless communication to realize real-time monitoring and storage of data. Then send the data to the mobile phone client through the cloud platform, the client can monitor the production data of the farm in real time. Literature [21] adopts temperature sensor, pressure sensor, wind speed sensor and rainfall sensor to arrange a wireless AD hoc network in each aquaculture farm and upload data to the meteorological disaster monitoring and warning service center server of aquaculture through wireless network. After obtaining meteorological information, the model was established to make prediction according to historical data, and to timely warn of possible meteorological disasters and make disaster prevention and reduction response. Literature [22] system based on Java platform for the whole development of the stack, the main role in the whole process of aquatic feed back, adopt the unified coding bar code batch marking scheme for raw materials, based on the Java platform SDK secondary development function of qr code printer online code assigned to each link to upload to the cloud database, aquatic feed implement end-to-end traceability.

5.4. Application in Livestock Breeding

Literature [23] designed a set of automatic feeding control system for pigsty, including service management platform, communication machine and feed station master controller. STM32 chip is mainly used to transmit the collected pig's body temperature, weight and ear number to the communicator, which transmits the data to the server for processing and reading the control command. The static and dynamic models of the feed system were established by using the recursive least square method of forgetting factor. Literature [24] mainly monitored the environmental parameters of the pigsty, and sensors were set up in several pigsty houses, such as the farrowing room, the faring room and the sow room, and the collected data were taken as the information source. The system includes data acquisition layer, data transmission interaction layer and application service layer. The network communication adopts relatively mature GPRS technology at present to ensure the stability of data transmission. The upper computer saves the data to Sql Server database and can monitor the parameters of pigsty environment in real time. Literature [25] introduces the application of machine vision technology in intelligent pig raising, which can recognize the characteristics of the pig's body shape, appearance, face and other details, and extract the characteristics of each pig. Pig behavior can also be monitored, including feeding, drinking water, excretion, maternal, abnormal, etc. Pork quality evaluation is also used, including color, marbling, tenderness, juiciness.

5.4.1. Intelligent control of livestock breeding

The literature [26] adopts the integral separated PID algorithm, and obtains the PID algorithm mode (discrete and integral separated) output feedback regulation quantity to start and stop the breeding equipment by comparing the real time value with the deviation of user value and the safety threshold, so as to complete the automatic pig breeding. In literature [27],

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temperature, humidity and light intensity, three parameters with strong coupling in poultry house, were taken as the controlled objects. The coupling of the three parameters would be greatly different with different feeding scale, control equipment and other configuration conditions. The system adjusts the controlled objects through fan, curtain and gas discharge lamp, and adopts the open closed-loop PID learning rate in the iterative learning algorithm to learn the three controlled objects at any initial value. At the same time, the current output error and the previous output error are used to form the current control input, and the control quantity when controlling temperature, humidity and light intensity is studied, and the optimal control is recorded to achieve the expected control. Literature [28] applies PID fuzzy controller to poultry house environment and proposes a parameter adaptive fuzzy PID control system. In order to meet the requirements of PID parameter self-adjustment, according to different errors and errors of different rate of change, the PID parameters are modified online through fuzzy control rules. Literature [29] used CFD software to simulate real-time temperature field information of the pigsty by measuring wind speed in the tuyere, temperature and wind speed in the tuyere, combined with the humidity information in the pigsty, and used fuzzy control technology to stabilize the temperature and humidity of the pigsty within the range suitable for the survival of pigs with the fan and the wet curtain as the actuator.

5.4.2. Intelligent evaluation of livestock breeding

Literature [30] by using fuzzy theory as the foundation, established over piggery environmental factors of fuzzy comprehensive evaluation model and evaluation model is based on inner environment control standards, to establish a temperature and humidity in piggery, ammonia concentration, concentration of carbon dioxide and hydrogen sulfide concentration of membership function, based on the analytic hierarchy process (ahp), set up the weight vector of fuzzy evaluation, for each environmental factor fuzzy transform, the subordinate relations according to the maximum membership degree principle, piggery environmental suitability evaluation results are obtained. Literature [31] from the practical, economical, site location, piggery management and innovative five aspects such as evaluation of piggery health multilevel comprehensive evaluation index system, this paper proposes a combination of qualitative and quantitative piggery health multilevel comprehensive evaluation method, based on the comprehensive index membership degree and weight, fuzzy comprehensive evaluation and eigenvalue calculation steps to get the evaluation results objectively, it can effectively evaluate the piggery health status and tracking according to the results of the evaluation factors influencing the health status of piggery.

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