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Application and Development of Smart Agriculture based on Internet of Things

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Abstract: Based on the Internet of Things (IoT) technology, this paper firstly analyzes the importance and value of smart agriculture in the agricultural field, starting from the concept and background of smart agriculture. Then, its key technologies, application scenarios, advantages and challenges, and future development trends are introduced in detail respectively to elaborate the development and application of smart agriculture in various aspects. The conclusion points out that the development of smart agriculture is important for promoting rural economic development, improving the quality of agricultural products and farmers' income level. This paper aims to provide references for the further promotion and application of smart agriculture.

Keywords: Internet of Things; Smart Agriculture; Sensors; Automat.

1. Introduction

With the continuous advancement of technology, people are seeking more efficiency in agricultural production. At the same time, food safety and environmental protection are also of greater concern. Smart agriculture, as a new agricultural model, is gradually becoming a hot topic in the field of agriculture. Through the application of Internet of Things (IoT) technology, smart agriculture has realized the digitalization, intelligence and precision of agricultural production. IoT technology provided a new way of thinking and means for agricultural production and management.

1.1. Background and Significance

Agriculture has long been the cornerstone of human survival and development, yet the traditional model of agricultural production faces a number of challenges and problems. Firstly, rapid population growth and urbanization have led to an increasing demand for food and agricultural products. However limited land and water resources are unable to meet this demand. Secondly, the use of large amounts of pesticides and chemical fertilizers in traditional agricultural production has put enormous pressure on the ecological environment, triggering problems such as soil degradation and water pollution. In addition, there is information asymmetry and inefficiency in agricultural production, and it is difficult to increase the income level of farmers.

Smart agriculture as an emerging agricultural model, combines sensors, wireless communication, cloud computing and other technical means in the IoT to face these problems. It has the function of monitoring the moisture temperature, carbon dioxide and nutrient status of crops from a distance. Its real-time monitoring and precise management of the whole process of agricultural production. Smart agriculture provides a more scientific and efficient solution for agricultural production. Smart agriculture can optimize the production data better, and for its structure, it can be more ecological, spatial, organizational and environmental protection[1]. It can not only improve the yield and quality of crops and reduce the waste of resources and environmental risks in agricultural production. It can also improve the income level and quality of life of agricultural workers. It has important significance to the development of agricultural modernization.

1.2. Current Status and Problems

Through the support of IoT technology, soil monitoring, weather prediction, water resources management, plant growth monitoring, pest control and other aspects of agricultural production have been greatly improved. At present, the international intelligent agriculture represented by the United States and Germany. Smart greenhouse production represented by the Netherlands. Small intelligent equipment industry represented by Japan. All of these have made great progress and have formed relatively mature technologies[2]. However, there are still some problems that need to be solved in the development and application of smart agriculture in China.

Firstly, the cost of smart agriculture technology and the high requirements for infrastructure and expertise limit its popularity in rural areas and among small-scale farmers. Secondly, the applicability of smart agriculture to different regions and crops needs further research and validation. So that it can be applied to different environmental conditions and agricultural needs according to local conditions. Finally, smart agriculture generates a large amount of agricultural data. How to effectively manage, analyze and utilize these data, as well as how to protect the security and privacy of these data, is also one of the current problems facing smart agriculture.

2. Basic Concepts and Technical Features of Smart Agriculture

2.1. Definition and Fundamentals

Smart agriculture mainly uses advanced technologies such as radio frequency identification, wireless sensors and network communication in the IoT technology to digitize. A modern agricultural model that realizes information and automation of all aspects of the agricultural production process. The basic principle of smart agriculture is through the IoT sensing and other technical means. Real-time monitoring and precise regulation of various factors in agricultural production, such as moisture, temperature, carbon dioxide, and nutritional status of crops. To achieve improved production efficiency, reduce costs, and improve product quality and safety.

2.2. Application of IoT Technology

Wireless network technology is the most common technology in human life and the most widely used. Using wireless network communication technology, information about agricultural production processes can be transmitted efficiently and at high speed. A large number of sensors actually work to accurately identify valid information and transmit data information back to the back office. It cannot be done without the strong support of wireless network technology.

Sensor technology is used to collect and process data and information within a certain range. Sensor technology is used to collect and process data and information in a certain range. Sensing and recognition in the IoT are the basis for obtaining information about the outside world. Sensors are able to scan and identify external information and related objects, and store and disseminate relevant information in the form of data. Physiological and ecological monitoring of the crop growth process is carried out through the use of various types of sensors. The parameters of crops are accurately and efficiently recorded using smart agriculture systems, which allows for real-time knowledge of crop growth. Adjustments to the monitoring can be made to achieve an efficient agricultural production process[3].

Cloud computing and big data technologies are applied to store and process the huge amount of data generated by IoT devices. Cloud computing technology provides powerful computing and storage capabilities that can analyze and process IoT data. Big data analytics technologies can extract valuable information and insights from IoT data and support decision making and business optimization.

2.3. Advantages

(1) Real-time monitoring: the use of IoT technology to achieve real-time monitoring of the agricultural production chain, timely detection of problems and abnormalities.

(2) Precise control: Through big data analysis and intelligent decision-making, we realize precise control of agricultural production links. As a result, agricultural production efficiency and product quality can be improved.

(3) Automatic control: Using automatic control technology to realize the automatic management and operation of agricultural production and reduce human costs.

(4) Sustainable development: The new agricultural model of smart agriculture achieves the protection and sustainable development of the natural environment by optimizing the use of resources and production methods.

(5) Information management: Through digital and information management of agricultural production, operation and management, production efficiency and operational efficiency can be improved.

3. Application of Smart Agriculture

3.1. Precision Work in Large Fields

The use of sensor technology can easily achieve the crop production environment of each element of the information acquisition. At present, some agricultural production bases in China have adopted IoT technology to monitor the growth of crops. Through real-time monitoring of the atmospheric environment, the presence of harmful substances in the atmosphere, carbon dioxide concentration, and light intensity are analyzed. It can also detect the soil environment of crops, such as soil PH value and other related data.

After all aspects of the crop growth process are monitored, the data obtained can be processed and analyzed. Researchers are able to accurately determine the current crop growth status. They can then fine-tune the irrigation, pesticide spraying and fertilization of the crop based on this data. Such a refined operation can, on the one hand, save water and fertilizer and reduce the use of pesticides to a certain extent. On the other hand, it also facilitates better crop growth, thus increasing crop yield and creating higher economic value.

3.2. Fine Management of Livestock and Poultry

Smart agriculture based on IoT technology is also commonly used in aquaculture, pig farming and dairy farming. The IoT technology allows real-time monitoring of data such as breeding status, growth cycle, feeding cycle and condition of livestock and poultry[4]. Analysis of these data allows the designation of more appropriate breeding plans. It can also be combined with automated equipment to achieve automated feeding and other operations, which can save labor while better breeding livestock and poultry. In addition, IoT technology can monitor the temperature, air quality and other relevant environmental data of poultry houses. It can also achieve fine control of poultry house environment and livestock health by monitoring the body temperature of individual livestock and poultry. This is important for the prevention of major epidemics of livestock and poultry.

3.3. Agricultural Product Quality and Safety Traceability

With the improvement of people's living standard, people are now more and more concerned about the quality of agricultural products and the safety of agricultural products. IoT technology can realize the recording of the growth information of livestock and poultry as well as agricultural products. Based on RFID, QR code and other technologies, we can record all the data of the circulation of agricultural products such as picking, storage, logistics and sales[5]. Therefore, consumers can have a comprehensive and detailed understanding of the growth process information and transportation information when purchasing related livestock and agricultural products. In addition, when food safety problems occur, IoT technology can help relevant regulatory authorities identify the causes based on traceability information. The traceability of agricultural products can optimize the subsequent food safety supervision work. It can be said that the use of IoT technology is also important to improve the efficiency and level of food hygiene and safety in China.

4. Development and Problems of Smart Agriculture

4.1. Development Status Overview

Smart agriculture, as an emerging agricultural model, has been widely used and promoted worldwide. Many developed countries and regions, such as the United States, the Netherlands and Israel, have made remarkable achievements in the field of smart agriculture. Through the introduction of IoT technology and big data analysis technology. These countries have realized digital, intelligent and refined management of agricultural production, and improved agricultural production efficiency and product quality. At the local promotion level in China, smart agriculture has become

a hot spot for development everywhere. Innovative practices such as Beijing Smart Farm Park, Changsha Smart Agriculture Demonstration Zone, Jinan Smart Agriculture Pilot Zone, Guangdong 5G+ Smart Agriculture Pilot Zone, and Fujian Modern Agricultural Smart Park have been carried out[6].

The application of smart agriculture covers a wide range of crops and agricultural production in different regions. In large farms and agribusinesses, smart agriculture technologies are widely used in food crops, vegetables, fruits, and animal husbandry. In some developing countries and rural areas, the application of smart agriculture is relatively small and mainly concentrated in some demonstration projects and pilot areas.

In food crops, smart agriculture technologies are widely used in the production management of planting soybeans, corn, wheat and other crops, realizing planting density control, water and fertilizer management, and early warning of pests and diseases. In vegetables and fruits, smart agriculture technology enables greenhouse environment monitoring, irrigation regulation, and weather prediction. It can improve the yield and quality of vegetables and fruits.

4.2. Problems

Although smart agriculture is widely used worldwide, the following problems and challenges remain:

The diffusion and dissemination of smart agriculture technologies still face certain difficulties. The high cost of smart agriculture technology and the high requirements for infrastructure and expertise have made the popularity of smart agriculture in some rural areas and developing countries relatively low.

The development of smart agriculture in China is at a fledgling stage, and there are still limitations in the application of smart agriculture technologies. Most of today's agriculture is still at the stage of traditional agriculture, and the agricultural infrastructure in most areas is still backward and the acceptance of smart agriculture is relatively low. At present, smart agriculture is mainly concentrated in large farms and agribusinesses, and small-scale farmers are often unable to afford the technology costs of smart agriculture due to resource and economic conditions. In addition, the characteristics and needs of different regions and different crops also have an impact on the applicability of smart agriculture technologies. And further research and verification of their feasibility under different environmental conditions are needed.

Smart agriculture generates a large amount of agricultural data, and the management and security of the data are also issues that need to be addressed. Including soil moisture, meteorological information, crop growth data, etc., how to effectively manage, analyze and utilize these data is crucial to improve agricultural production efficiency and decision-making. At the same time, smart agriculture involves key information and data of agricultural production. How to protect the security and privacy of these data and prevent data leakage and misuse is one of the current challenges facing smart agriculture.

Due to the complexity and novelty of smart agriculture technology, its promotion also faces the problems of technical training and talent support. Farmers and practitioners need to receive relevant technical training to improve their ability and level to use smart agriculture technologies. Also training and attracting talents with specialized technical knowledge and skills are key factors in promoting the development of smart agriculture.

4.3. Trends and Outlook

As an innovative agricultural model, smart agriculture has broad development prospects. In the future, wisdom agriculture will show the following development trends:

(1) Intelligence and automation: With the development of technologies such as artificial intelligence, machine learning and machine vision, smart agriculture will become more intelligent and automated. Operations such as planting, feeding, irrigation and fertilization in agricultural production and management will be more often done by intelligent equipment and robots, improving production efficiency and reducing labor costs.

(2) Diversified agricultural applications: Smart agriculture will be widely used in diverse agricultural industries such as different crops, farming and aquaculture to meet different agricultural needs.

(3) Refined management and personalized services: Through big data analysis and intelligent decision-making models, smart agriculture will achieve more refined management and personalized services. According to the characteristics and needs of each piece of land and crop, precise fertilization, irrigation and pest control will be implemented to improve production efficiency and product quality.

(4) Application of blockchain technology: Blockchain technology will be widely used in smart agriculture. Through blockchain technology, traceability, quality tracing and transaction trustworthiness of agricultural products can be realized to improve the credibility of products and market competitiveness.

As an important direction of agricultural development, smart agriculture has great potential and broad prospects. With the continuous advancement of technology and expansion of applications, smart agriculture will bring far-reaching impact to agricultural production and rural development. It will help achieve the goals of food security, rural revitalization and sustainable agricultural development.

5. Conclusion

As an innovative agricultural model based on IoT technology, smart agriculture has important significance and broad application prospects. Through the application of smart devices, sensors, data analysis and intelligent decision-making and other technical means. Smart agriculture can improve agricultural production efficiency, optimize resource utilization, improve the quality of agricultural products, and promote rural economic development and increase farmers' income.

This paper describes the concept, development background and research significance of smart agriculture. Then it introduces the key technologies and application scenarios of smart agriculture, and analyzes the advantages and challenges of smart agriculture. From a global perspective, smart agriculture has been widely applied in many countries and regions and has achieved certain achievements.

However, the promotion and application of smart agriculture still faces some problems and challenges, including technology cost, applicability, data management and security, technical training and talent support. Addressing these issues will require collaboration and innovation among government, business, and research institutions. Technology development and diffusion, cost reduction, training and

support, and enhanced data management and security measures are needed.

In the future, smart agriculture will show the development trends of intelligence and automation, diversified agricultural applications, refined management and personalized services, and blockchain technology applications. The development of smart agriculture will promote agricultural modernization, rural economic development and farmers' income growth.

It also reduces resource waste and environmental impact, and promotes digitalization and informatization of rural areas.

Therefore, we should strengthen international cooperation and technology exchange. Jointly promote the development and application of smart agriculture. Achieve the goals of sustainable agricultural development, food security and rural revitalization. Only by giving full play to the advantages of intelligent agriculture can we realize the transformation and upgrading of the agricultural industry. Then, we can create a more prosperous, sustainable and better agricultural future for mankind.

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