

The Application of the Internet of Things Technology in Intelligent Agriculture Monitoring and Management

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Abstract:

In the wave of technology in the 21st century, the Internet of Things technology, with its unique charm and wide application prospects, is profoundly changing our way of life and production. Especially in the field of agriculture, the introduction of the Internet of Things technology has injected new vitality into traditional agriculture and promoted the development of intelligent agriculture. This paper focuses on the application of the Internet of Things technology in intelligent agricultural monitoring and management and demonstrates how it can accurately and efficiently promote the intelligent transformation of agricultural production.

Keywords:

Internet of Things technology
Intelligent agriculture
Meeting point
Monitoring and management application

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1. Introduction

With the rapid progress of information technology, the Internet of Things technology, as one of its core branches, is penetrating various industries with unprecedented depth and breadth, among which the application of intelligent monitoring and management is particularly prominent. Through its unique perception, transmission, and processing mechanism, the Internet of Things greatly improves the efficiency of monitoring and management, while effectively reducing operating costs. In agriculture, a traditional and essential industry, the introduction of the Internet of Things technology has promoted the wave of intelligent transformation.

The application of the Internet of Things technology in the agricultural field is not only limited to the real-time monitoring and adjustment of the production environment, but also expanded to many aspects such as animal identification traceability, and precise planting and breeding, realizing the precise management of the whole chain of agricultural production. This change not only significantly improves the efficiency of agricultural production, but also promotes the optimal allocation and sustainable utilization of agricultural resources, laying a solid foundation for the sustainable development of agriculture. More importantly, the application of the Internet of Things technology also effectively

guarantees the quality and safety of agricultural products and improves consumers' trust and satisfaction with agricultural products.

Therefore, an in-depth study of the Internet of Things technology application in intelligent monitoring management not only promotes agricultural modernization and improves agricultural production efficiency, but also promotes the sustainable use of agricultural resources and enhances the safe quality of agricultural products, building a harmonious society and achieving high-quality economic development.

2. The convergence of the Internet of Things and intelligent agriculture

2.1. Internet of Things technology

Internet of Things technology, as an outstanding representative of information technology in the 21st century, is subtly divided into the perception layer, network layer, and application layer. From the evolution of information technology, the Internet of Things deeply integrates computer technology and communication technology, as shown in **Figure 1**. This layered design not only promotes the seamless docking between technologies but also greatly expands the application boundary of the Internet of Things ^[1].

In the perception layer, the Internet of Things realizes the comprehensive and real-time acquisition of information in the physical world by deploying various sensors, RFID tags, and other sensing devices. These devices, like the "tentacles" of the Internet of Things,

can capture diversified information such as temperature, humidity, light, and sound in the environment, and turn them into digital signals, providing a solid foundation for subsequent data processing and analysis. The network layer bears the heavy responsibility of data transmission and communication. Through various communication methods such as wireless networks and wired networks, the Internet of Things gathers the data collected by the perception layer to the cloud or data center, realizing the long-distance transmission and sharing of data. In this process, the Internet of Things technology not only ensures the security and reliability of data transmission, but also realizes the real-time accuracy of data, which provides strong support for intelligent management and decision-making. At the application level, the Internet of Things technology demonstrates its wide potential for industrial applications. Whether it is a smart city, smart home, industrial manufacturing, or intelligent transportation, the Internet of Things plays an important role with its unique advantages. Through the construction of intelligent and automatic application scenarios, the Internet of Things not only improves the operation efficiency and management level of all walks of life, but also brings people a more convenient and comfortable life experience ^[2,3].

2.2. Intelligent agriculture

As the frontier position of modern agricultural development, the advantages of intelligent agriculture lie in multi-dimensional and deep-level reform and promotion. First of all, through real-time monitoring

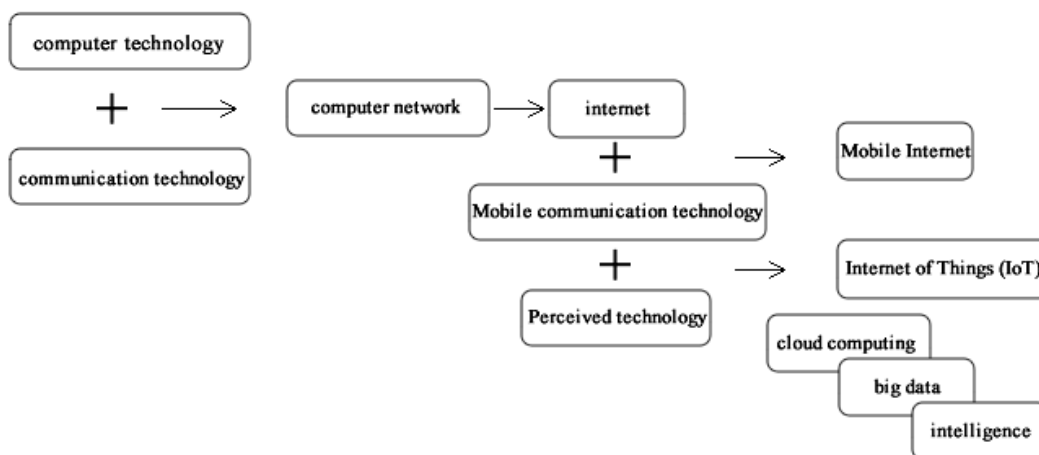


Figure 1. Physical network frame

and analysis of soil composition and humidity by high-precision sensors, intelligent agriculture realizes the accurate allocation and efficient utilization of agricultural resources, ensuring that every inch of land can grow the most suitable crops, so as to maximize production benefits and promote the sustainable utilization of agricultural resources. Secondly, intelligent agriculture realizes the fine management of the whole process of agricultural production. From sowing to harvest, every link is placed under intelligent monitoring. The application of high and new technologies such as the Internet of Things and big data enables the crop growth state to be acquired and regulated in real time, providing a scientific basis for agricultural production, and significantly improving the crop yield and quality^[4]. Moreover, intelligent agriculture also shows great potential in agricultural ecological monitoring. Through the Internet of Things and other high-tech technologies, the agricultural ecosystem has realized dynamic and comprehensive monitoring, which provides the possibility for timely discovering and solving ecological problems, and lays a solid foundation for the sustainable development of China's agriculture. Finally, the development of intelligent agriculture also promotes the process of agricultural informatization. The construction of the information system integrates a variety of sensor equipment, wireless transmission terminals, and other advanced technologies, realizes the automatic acquisition and remote sharing of equipment information, strengthens the close connection between farmers and crops, and provides strong support for the intelligence and precision of agricultural production^[5,6].

2.3. Intelligent agriculture based on the Internet of Things technology

In the wave of agricultural modernization, intelligent agriculture based on the Internet of Things technology is leading the profound change of agricultural production mode with its unique advantages. The core of the innovation mode is the diversity of sensor terminals cleverly deployed in the growing environment, including but not limited to temperature sensors, humidity sensors, CO₂ concentration detection sensors, etc. These devices act as "nerve endings" of agricultural production, capture and transmit the subtle changes of environmental parameters in real time, and build up a comprehensive

coverage, accurate, and efficient monitoring network.

The monitoring network built by the Internet of Things technology realizes the real-time collection and display of environmental data with the help of the intelligent algorithm of the network terminal, so as to accurately predict the growth state of crops and scientifically calculate the nutrients needed. On this basis, the intelligent agricultural system can automatically regulate irrigation, fertilization, temperature control, and other environmental parameters, create the most suitable growth environment for crops, and realize the refinement and intelligence of agricultural production management^[7].

In particular, it is worth mentioning that the application of the Internet of Things technology has greatly liberated the agricultural labor force, enabling managers to monitor and manage the agricultural environment remotely with the help of terminal equipment such as computers or mobile phones, which not only improves the work efficiency but also reduces the labor cost. Compared with the excessive reliance of traditional agriculture on the natural environment and the high-intensity input of human labor, intelligent agriculture, based on scientific algorithms and intelligent equipment as the means of intelligent agriculture, not only improves the accuracy and efficiency of agricultural production, but also promotes the significant improvement of agricultural economic benefits, and opens up a new path for the sustainable development of agriculture^[8].

3. The application of the Internet of Things technology in intelligent agriculture monitoring and management

3.1. Animal identification and traceability of epidemic prevention

Today, with the vigorous development of intelligent agriculture, animal identification and epidemic prevention traceability system, as a model of in-depth application of Internet of Things technology, is gradually becoming a key link to improving the level of agricultural management and ensuring food safety and public health safety. Through high-precision, non-contact RFID tags or advanced wearable sensor technology, each animal is assigned a unique identity, realizing the whole-chain

monitoring and traceability from farm to table. These Internet of Things identification devices can not only capture and record key physiological indicators such as position changes, activity patterns, eating intake, and body temperature in real time, but also monitor the temperature, humidity, and air quality of the feeding environment combined with environmental sensors, providing a scientific basis for accurate feeding. Data is transmitted to the cloud data center in real time through wireless communication technology, and advanced technologies such as big data analysis and machine learning are used for deep mining and processing, so as to accurately predict animal health status, disease risk, and growth and development trend^[9].

In terms of epidemic prevention and traceability, the efficient response mechanism of the system is particularly critical. Once abnormal animal health or suspected signs of the epidemic are detected, the system will immediately trigger the warning mechanism, automatically send an alarm to the managers, and activate emergency plans, including isolation of suspected sick animals, tracing contact history, and adjusting feeding and management measures, so as to effectively curb the spread of the epidemic and protect the overall health of the animal community. In addition, the system also plays an irreplaceable role in the traceability of food safety. Consumers can scan the unique identification code on animals to obtain the whole chain information from breeding to processing and circulation, so as to enhance consumer confidence and promote the healthy development of the market.

3.2. Intelligent monitoring and environmental protection

The environmental monitoring network is based on the Internet of Things technology, integrating the diversified information collection capabilities of the wireless sensor network, combined with broadband communication, high-performance computing, cloud computing, and big data mining technology, and builds a comprehensive, high-precision, real-time environmental information collection and processing platform. This platform can not only fully cover key environmental parameters such as soil humidity, meteorological conditions, and air quality, but also realize in-depth integration and analysis of data,

providing strong data support for precision agricultural management^[10].

For example, in the field of intelligent agriculture, the intelligent control system of agricultural greenhouses has significantly improved the management efficiency of modern agricultural greenhouses with its highly integrated and intelligent characteristics. By integrating a variety of high-precision sensors and intelligent control units, the system realizes the remote and real-time monitoring and accurate control of multiple modern intelligent greenhouses. Specifically, it can not only carry out uninterrupted monitoring of key environmental parameters such as the greenhouse temperature, humidity, ventilation, and light intensity, but can also create the most suitable environment for crop growth according to the preset conditions or crop growth demand, intelligent regulation irrigation system, shade, ventilation equipment, etc. (**Figure 2**). This move not only greatly reduces the labor intensity and cost of greenhouse management, but also effectively improves the yield and quality of crops^[11].



Figure 2. Intelligent control system of agricultural greenhouses

Other than that, the application of intelligent monitoring systems of agricultural machinery has brought revolutionary changes to modern agricultural mechanization operations. Relying on advanced sensor technology and intelligent equipment, the system realizes the comprehensive monitoring and independent decision of the state of agricultural machinery and tools. Through real-time monitoring of the working state of agricultural machinery, fuel consumption, mechanical wear, and other key indicators of agricultural machinery, the system can accurately predict the best time for repair

and maintenance, effectively avoid the production delay caused by fault shutdown, and significantly improve the operation efficiency and the service life of the machinery (Figure 3). At the same time, the introduction of intelligent management and operation modes decreases the labor intensity of farmers, reduces production costs, and provides strong technical support for the sustainable development of modern agriculture.



Figure 3. Intelligent monitoring system of agricultural machinery

Third, the rise of livestock management technology of the Internet of Things is profoundly changing the production and management mode of animal husbandry. The technology uses advanced means of digital transformation to realize the comprehensive monitoring of the health status, activity location, and behavior mode of livestock through smart wearable devices and wireless sensors. This solution has been widely used in several key areas of livestock, including healthcare management, estrus cycle detection, calving process monitoring, precision feed feeding, and dynamic weight tracking. It not only improves the production efficiency and refinement level of animal husbandry, but also significantly enhances the ability of disease prevention and control, and injects new vitality into the sustainable development and industrial upgrading of animal husbandry.

Fourth, unmanned aerial vehicle technology is gradually becoming an indispensable auxiliary tool for modern agriculture, and its application range widely covers many fields such as crop health assessment, precision irrigation, field environment analysis, efficient crop spraying, and precision planting^[12]. The introduction of this technology has brought many significant advantages to farmers: a significant reduction

in labor demand, a profound improvement in production efficiency, and the optimal allocation and efficient use of agricultural resources. Globally, remotely operated drones show great potential in agricultural crop spraying operations. In the Republic of Korea, for example, up to 30% of agricultural spraying missions have been completed by drones (Figure 4).



Figure 4. Unmanned aerial vehicle

In the practice of precision agriculture, the Internet of Things technology has helped farmers realize the transformation from “empirical” to “data-based” management. Through real-time monitoring of soil moisture, the system can accurately guide irrigation operations and avoid waste of water resources. Combined with meteorological monitoring data, farmers can adjust agricultural activities in advance to effectively avoid natural disasters, and the application of air quality sensors provides a scientific basis for early warning and control of diseases and insect pests, reduces the use of chemical pesticides, and guarantees the quality safety of agricultural products and the health of the ecological environment.

In terms of environmental protection, the Internet of Things technology has shown its unique advantages and value. By monitoring the use of pesticides and chemical fertilizers, the system can guide farmers to implement precise fertilization and green prevention and control strategies for diseases and insect pests, reduce agricultural non-point source pollution from the source, and protect the ecological balance between soil and water resources. At the same time, the Internet of Things technology is also widely used in farmland water quality monitoring, waste treatment, and other links, through intelligent

management means, to promote the resource utilization and harmless treatment of agricultural waste, providing solid technical support for the sustainable development of agricultural production.

3.3. Intelligent security system

In the process of agricultural modernization, intelligent security systems, as an important application field of Internet of Things technology, are gradually building a comprehensive protective network for agricultural production safety. The system integrates sensor monitoring, data transmission, intelligent decision-making, actuator control, and security prevention, to realize real-time and accurate monitoring of the farm environment. In the agricultural production site, the intelligent security system relies on high-definition cameras, infrared sensors, and other advanced equipment to build an invisible safety net^[13]. These devices can not only monitor human activities, animal behaviors, and abnormal conditions inside and outside the farm around the clock and without blind spots, but also quickly identify potential security risks through intelligent analysis algorithms. Once the system detects any abnormality or potential threat, the alarm mechanism will be immediately triggered, and the farm management will be notified in various ways to ensure that they can respond immediately, effectively prevent and contain the occurrence of accidents, so as to ensure the safety of the farm assets and personnel.

In addition, in the management of agricultural facilities, the intelligent security system also plays an irreplaceable role. Through the real-time monitoring of greenhouse internal environmental parameters, such as temperature, humidity, light, etc., the system can accurately regulate the greenhouse environment, provide

the best conditions for crop growth, and ensure its healthy growth, high yield, and high quality. At the same time, the system can also remotely monitor the operation of agricultural machinery and equipment, timely detection and early warning of equipment failure, provide strong support for the timely maintenance of equipment, and ensure the continuity and efficiency of agricultural production activities. To sum up, the intelligent security system, with its strong monitoring, early warning, and emergency response capabilities, provides a solid technical guarantee for agricultural production safety^[14].

4. Conclusion

To conclude, the application of the Internet of Things technology in intelligent agricultural monitoring and management shows its great potential and value. Through accurate data collection and analysis, the Internet of Things technology not only improves the efficiency and output of agricultural production, but also strengthens the traceability of the quality and safety of agricultural products, and promotes the rational allocation of agricultural resources and environmental protection. In the future, with the continuous maturity and popularization of the Internet of Things technology, intelligent agriculture will usher in a broader development prospect, providing strong technical support for the realization of strategic goals such as sustainable agricultural development and rural revitalization. Therefore, further increasing the research and development and application of the Internet of Things technology in intelligent agriculture is the key to promoting the transformation and upgrading of modern agriculture and enhancing international competitiveness.

Disclosure statement

The authors declare no conflict of interest.

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