INTERNET OF THINGS IN AGRICULTURE

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Abstract

The Internet of Things (IoT) in agriculture has changed agricultural output in new ways. It may successfully raise the quality of agricultural products, lower labor costs, boost farmers' incomes, and genuinely achieve agricultural intelligence and modernization in addition to increasing agricultural output. The current state of agricultural IoT research is methodically compiled in this report. First, a summary and illustration of the current state of agricultural IoT's system architecture are provided. The five main agricultural IoT technologies are then thoroughly examined. Applications of IoT in agriculture are then presented in five typical domains. Lastly, the issues with agricultural IoT are examined, and a prediction for its future growth is provided.

Keywords;Agricultural IoT,System architecture**,**Typical application**,**Key technology

1. Introduction

The term "Agricultural Internet of Things" (I oT) describes a network in which physical el ements of the agricultural system, including plants and animals, production tools, enviro nmental factors, and various virtual "objects, " are connected to the internet through agric ultural information perception equipment usi ng specific protocols to facilitate communic ation and information exchange.

It aims to make agricultural objects and proc esses intelligently identifiable, positioned, tr acked, monitored, and managed.

Agricultural IoT's "human-machine-things" connectivity can assist people in ide ntifying, controlling, and managing a variety of agricultural components, systems, and pr ocesses in a more sophisticated and dynamic manner.

Additionally, it can significantly improve hu man comprehension of the vital aspects of a gricultural animals' and plants' lives, aid in managing agricultural crises. Agricultural IoT technology is currently the subject of intense and extensive global research, but most applications are still in the experimental demonstration stage. The current state of agricultural IoT research is methodically compiled in this paper. First, a summary of the agricultural IoT's system architecture and current state are provided. The five main agricultural IoT technologies are then thoroughly examined. Applications of IoT in agriculture are then presented in five representative domains. Lastly, the issues facing agricultural IoT are examined, and a prediction regarding its future growth is provided.

2. Agricultural IoT development and system architecture

2.1. Creation of IoT sensors for agriculture

Due to the extensive use of IoT technology in agriculture, which is fueled by advancements in digital technology, the Internet, and sensing technology, sensors created with new technologies are continuously emerging and moving toward becoming embedded, intelligent, integrated, and smaller. The United States, Japan, and Germany currently hold a dominant position and are ahead of other nations in sensor technology and manufacturing processes (He et al., 2009). Soil sensors, weather sensors, water sensors, and plant sensors are just a few of the increasingly varied agricultural sensor applications. These sensors, which can detect a variety of objects, offer strong assistance in gathering data on agricultural production.

2.2. Use of IoT in agriculture

Wireless self-organized data transmission is made possible by the Zigbee wireless network of the agricultural Internet of things. It guarantees stable and convenient remote data transmission by integrating well with wired data transmission. IoT microprocessor research and development has advanced significantly in terms of intelligent control. Data processing, communication, control, and wireless sensing are all integrated into the microprocessor. In terms of real-time agricultural production monitoring, satellites have been used by both European and American nations to precisely operate and monitor field cultivation as well as intelligently monitor fertilizer and water. Complete production procedures have already been established in the interim. The advancement of information technology encourages developed nations to optimize the use of agricultural IoT. Technology for artificial intelligence (AI) can be incorporated based on observation and clever administration, which enhances the use of the sensor data. When paired with expert systems, agricultural IoT enables planters to manage crops precisely and enhance their planting experience (Liu, 2016). Numerous facets of agricultural production in China have benefited from the use of IoT, including farmland irrigation, environmental monitoring in agricultural production, traceability of agricultural product safety, and applications in aquaculture, animal husbandry, and farmland planting. Additionally, China has produced high-precision diagnostic and information monitoring tools, which has encouraged the use of IoT in agriculture. Equipment for gathering information about crops and plants, tracking environmental data, and observing animal behavior are currently the most developed and utilized types of equipment (Shan, 2019).

3. Important agricultural IoT technologies

3.1. Technology for sensor perception

Numerous sensors are the primary source of information in agricultural IoT. Sensors are primarily used in agriculture for quality safety and traceability, animal and plant life perception, and environmental information monitoring. Physical property sensors, biosensors, and micro electro-mechanical sensors are currently the three types of sensors that are most frequently utilized in agriculture (You and Tang, 2013). Micro electro-mechanical sensors are new technology products with great qualities like low power consumption and high reliability; biosensors use biologically sensitive components to transmit information based on the response to the outside world; and physical property sensors realize signal conversion through sensor-sensitive physical changes (Li et al., 2015). Electrochemical, optical, electrical, and remote sensing are all part of the sensor's information sensing mechanism. Optical the fluorescence quenching effect and spectrophotometry are the two primary sensing mechanisms used for soil examination and the measurement of chlorophyll content (Li et al., 2017). Electrical sensors come in a variety of forms, including capacitive, resistive, inductive, and eddy current, and are employed in agricultural IoT to measure greenhouse temperature and soil moisture, according to application principles. Crop planting and transplanting, pesticide application, terrain monitoring, soil structure analysis, and other applications all make use of photoelectric sensors. Crop growth and development, soil chemical composition, and other topics can be analyzed using the electrochemical method, which is based on the electrochemical characteristics of the substances in the solution and their change rules (Adamchuk et al., 2004).IoT. Pesticides and crop planting and transplanting both use photoelectric sensors.

3.2. Technology for information transmission

3.2.1. Location technology for nodes

Through restricted communication between nearby nodes and a specific positioning mechanism, node location technology uses a small number of nodes with known locations in the WSN to ascertain the locations of all unknown nodes. The location data of nodes is crucial to the sensor network's monitoring operations in agricultural WSNs. Without location information, monitoring data usually has no purpose. It is crucial to identify the problem's location by identifying the node in order to stop agricultural diseases and disasters from happening. WSN node positioning algorithms fall into one of two categories based on whether the distance between nodes needs to be measured: Range-based positioning algorithms, such as TOA, TDOA, AOA, and RSSI, are one type; range-free algorithms are another. such as the DV-Hop positioning algorithm, centroid positioning algorithm, and convex programming positioning algorithm (Qin, 2016). Chang et al. enhanced the conventional genetic algorithm and suggested a new forestry WSN node positioning algorithm in response to the traditional genetic algorithm's premature convergence issue (Chang et al., 2018). In order to improve sensor performance, positioning accuracy, and crop planning, Chen et al. also used the genetic algorithm to position sensor nodes in crop areas (Chen et al., 2015). Liu et al. [20] developed a weighted centroid location algorithm and enhanced the sensor location algorithm for forest fire monitoring. In addition to preventing and minimizing forest fires and their damages to the greatest extent possible, it offered a solid positioning basis for fire monitoring location

4. Issues

It is clear from the aforementioned agricultural IoT system architecture, technology, and application that agricultural IoT has produced some impressive outcomes in recent years. To overcome some challenges, though, relentless work is necessary.

The perception layer, the transport layer, and the application layer are the three general layers into which IoT is currently separated. Research on a single layer is fairly extensive, but there isn't much discussion or study of the IoT system structure as a whole. This lowers the timeliness of data transmission by IoT by causing unstable data transmission, challenges with data sharing, possible safety hazards during transmission, and poor positioning accuracy and stability.

• (2) There are numerous sensor types with disparate communication interfaces and incompatible protocols, necessitating a large amount of software and Research on monitoring and perception of agricultural IoT mainly focus on data acquisition and single-machine processing, while research hardware and hinder future growth. The majority of them are still in the experimental stage, and there is a lack of research and implementation of embedded gateway middleware at the heart of the Internet of Things.

While there is a dearth of research on full application systems, studies on agricultural IoT monitoring and perception primarily concentrate on data collection and single-machine processing. The optimization of a few single technologies has been the main focus of research and application for IoT-enabled intelligent agricultural machinery.

High-speed wireless WAN is necessary for data transmission in the agricultural IOT. However, high-speed data transmission is not feasible in the remote agricultural environment due to the weak wireless communication signal. Thus, the only way to guarantee the real-time performance of data coding is to increase its efficiency.

Conclusion

Research is required on the deployment and management of perception nodes and the structure of agricultural IoT systems. The architecture ought to be open, distributed, and able to share resources and services. It is necessary to design multi-protocol conversion gateways, conduct additional research on embedded gateways, and create comprehensive information perception standards. The goal is to resolve issues with inconsistent device interfaces and protocols, resulting in a faster, more convenient connection that can process and analyze multiple data sets. Create an integrated network system integrating agricultural machinery by fully utilizing 5G communication technology, virtual reality technology, and augmented reality technology. The digital twin of the entire production process is realized by agronomy, crops, and farmers, and it enables multi-factor intelligent traceability, process monitoring, and intelligent decision-making.

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