

IOT Role in Transforming Agriculture: A Smart Farming Revolution

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ABSTRACT

In the field of precision farming, IOT has played an essential role in revolutionizing the whole agricultural system. It not only just increases the yield and economic status of the farmer but also helps in the sustainable farming practices. It helps in different areas of agricultural practices like smart irrigation, fertilizer application by the help of drones, soil mapping etc. By integration of artificial intelligence (AI) with the Internet of things (IoT), the whole agricultural system has become more efficient, convenient and sustainable. In the conventional farming method, the farmer has to frequently visit his field throughout the crop-growing season to monitor his crop. Farmers spend most of their time analyzing and monitoring crop conditions rather than working in the field, which makes smart agriculture necessary. Beyond agronomic improvements, the Internet of Things is revolutionizing agriculture and providing real financial gains for farmers. Farmers may optimize the distribution of resources, boost profitability, and achieve notable yield increases by utilizing big data analytics and IoT-driven insights.

INTRODUCTION

In the era of modern agriculture, the application of Internet of Things (IoT) technology has revolutionized the modern agriculture system, transforming conventional farming methods into an area of efficiency and precision. The amalgamation of big data analytics, machine learning algorithms, and the Internet of Things resulted in an age of smart agriculture, wherein intelligent decision-making and sustainable agricultural methods come together to optimize environmental impact, production, and resource utilization. The fundamental component of IoT in agriculture is the installation of networked sensors and devices throughout farmlands, animals, and equipment. It enables the real-time collection of data on critical parameters like soil moisture, temperature, crop health, and weather patterns. This vast data network serves as a foundation for well-informed decision-making by providing farmers with useful insights via intuitive graphical user interfaces.[Muhammad Ayaz et al., 2019] Furthermore, drone-based aerial surveillance and monitoring is only one example of how artificial intelligence (AI) and the Internet of Things (IoT) are driving the emergence of intelligent and smart farming methods that transcend land boundaries. With the help of these unmanned aerial vehicles (UAVs) and their modern sensors, farmers can discover regions in their field that are ready for improvement, detect abnormalities, and evaluate the health of their crops by obtaining high-resolution images. In the conventional farming method, the farmer has to frequently visit his field throughout the crop-growing season to monitor his crop. Farmers spend most of their time analyzing and monitoring crop conditions rather than working in the field, which makes smart agriculture necessary. Beyond agronomic improvements, the Internet of Things is revolutionizing agriculture and providing real financial gains

for farmers. Farmers may optimize the distribution of resources, boost profitability, and achieve notable yield increases by utilizing big data analytics and IoT-driven insights.

WHAT IS IOT?

The internet of things refers to a network of interconnected smart devices fitted with sensors, and software that collect and share real time data.

Area of application

Farmers have been using traditional farming methods for centuries, but by incorporating the latest technologies like sensors and IoT, every aspect of conventional farming processes can be significantly improved. At present, smart agriculture can achieve previously unthinkable heights because of the easy integration of wireless sensors and the Internet of Things. Diverse sensing devices' data is gathered via wireless sensor networks, or WSNs. Furthermore, cloud services must be coupled with IoT in order to analyze and interpret the collected remote data, which helps in the implementation of the best solutions. IoT can assist in providing answers to many conventional farming problems, such as pest and disease forecast and control, water and nutrient management, soil health management, land compatibility, and yield optimization, by following smart agriculture principles.

How modern technologies are contributing to increased efficiency at different phases is covered below:

1. Soil Mapping and Sampling

Understanding the complexities of soil composition, fertility, and moisture levels is essential for effective agriculture. In traditional agriculture, soil mapping and sampling are time-consuming procedures that

frequently rely on estimations and subjective judgements. But in smart agriculture, farmers can extract information about the variability of various factors in soil and the health of their soil throughout their field with the help of drones and an IoT-based network of sensors. The IoT-based network of sensors buried in the soil can measure real-time soil health parameters like soil moisture level, pH, soil fertility, soil compaction, nutrient content, and temperature of the soil. After that, this data is transferred wirelessly to centralized systems for analysis and transformation into suggestions that can be put to use. Farmers may optimize crop yields while minimizing the impact on the environment by using this information to develop accurate soil maps of the field, identify nutrient-deficient areas in the field, and execute customized fertilization methods.

2. Irrigation with IoT

Good-quality irrigation water is very limited, and its scarcity is a serious concern in my region of the world, so effective water management becomes essential for farmers. For a very long time, farmers have been using traditional irrigation practices to deliver water to their crops efficiently, and the traditional irrigation practices are primarily operated by humans and are frequently ineffective, resulting in wastage of water and lower yield. But irrigation techniques have changed drastically since the introduction of IoT technology in agriculture. The irrigation system based on IoT plays an important role in maximizing the efficiency of water use since it provides water to plant roots directly as per requirements. IoT contributes to water conservation and maximizes crop yields by eliminating the uncertainty associated with conventional irrigation techniques.

2.1. Using IoT to Advance Irrigation

2.1.1. Smart sensors for accurate monitoring: To track soil moisture levels, meteorological conditions, and other crucial variables, the smart sensors are positioned strategically throughout fields. These sensors provide real-time information to the users on how much water a crop needs by continuously gathering and transmitting data.[Dewan Md Nur Anjum Ashir et al., 2022]

2.1.2. Automated Decision-Making: IoT devices can initiate irrigation by automating decision-making processes by utilizing data from smart sensors. After analyzing the data, advanced devices turn on irrigation systems when the soil moisture drops below ideal thresholds. This preserves water resources by eliminating over-irrigation and guaranteeing timely watering.

2.2. Methods of Precision Irrigation

2.2.1. Drip Irrigation Systems: Conventional irrigation systems have been completely transformed by the IoT with the advent of precise techniques like drip irrigation. Based on real-time data, smart controls adjust the flow of water, which is delivered straight to plant roots based on requirements.

2.2.2. Variable Rate Irrigation (VRI): Another innovative use of the IoT in agriculture is variable rate irrigation, or VRI. Based on real-time data on crop requirements, topography, and soil moisture conditions, VRI systems modify the amount of water application across various zones within a field.

3. Smart fertilizer management

An important component of the modern agriculture system is fertilizer, and the highest possible yield can be ensured by applying fertilizer. But the traditional method of fertilizer application used by farmers is not accurate and not very efficient, resulting in

waste and environmental damage. Shifting to IoT-based fertilizer management helps in the smart management of fertilizers.

3.1. GPS systems: In today's modern agriculture practices, the use of Global Positioning Systems (GPS) has become an essential part. By integrating GPS into farm equipment, the farmers can precisely monitor the application of fertilizer and track the position of the equipment. GPS's real-time tracking feature helps in saving resources and time by optimizing farm operations overall.

3.2. Variable Rate Technology (VRT): The traditional method of fertilizer application used by farmers lacks precision and efficiency, which causes wastage of fertilizer. By replacing it with Variable Rate Technology (VRT), it helps farmers to tailor fertilizer applications to individual field conditions. A network of IoT sensors collects information from the field on the health of soil, moisture content, and specific requirements of crops.

Integration of IoT with VRT helps farmers deliver the exact amount of fertilizer required by the crop and at the exact location, minimizing fertilizer wastage and increasing crop yield.

CHALLENGES OF IOT IN AGRICULTURE

IoT implementation in agriculture confronts obstacles despite its potential, the implementation cost might be higher, especially for small farmers. Poor internet connectivity is a problem in rural areas, which hampers data transmission. The data stored in IoT devices is sensitive and thus susceptible to hacking, which could compromise private farm data and cause operational disruptions. Farmers lack technical knowledge of using and maintaining the Complicated IoT system. [Nizetić S, Šolić P et al., 2020]

FUTURE PROSPECTS

The future of Internet of things (IoT) in agriculture appears to be bright despite the obstacles it faces. New developments and breakthroughs have the potential to improve farming and more dependable and affordable Internet of Things solutions can be developed to cater the specific need of agriculture. More advanced data analysis and predictive modelling in agriculture will be possible with the integration of artificial intelligence (AI) and machine learning algorithms with Internet of Things platforms.

CONCLUSION

In this article we have seen how the IOT and AI can change conventional farming into highly efficient smart farming. By carefully adjusting irrigation schedules, fertilization schedules, and pest control measures to crops' individual needs, IoT-driven solutions help farmers practice sustainable farming by minimizing waste and environmental degradation. Prediction of crop pest and disease attack, evaluation of soil health, optimization of planting strategies, and reduction of yield losses by using real-time and historical data through machine learning algorithms. By implementing these technologies, we can get more yield in the same amount of land by putting less inputs. So, farmers will get more profits and there will be an increase in the socio-economic condition that directly impacts the GDP of our country.

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