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POWER MANAGEMENT AND WEATHER-RESILIENT IOT TECHNOLOGIES IN DATA ANALYSIS

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Abstract:

Although the application of IoT technologies in water management and agriculture offers numerous advantages, several challenges arise during their implementation. First of all, environmental conditions such as extreme temperature variations, high humidity, and dust negatively affect the operational lifetime of sensors and devices. Therefore, it is essential to develop hardware solutions with weather-resistant and robust enclosures. In addition, the lack of stable internet coverage in remote areas makes real-time data transmission difficult, which necessitates the expansion of network capabilities. Power management is also a critical issue, as sensors are often powered by batteries or solar energy. To ensure their long-term operation, efficient energy management strategies and energy harvesting technologies are required.

Keywords: IoT, sensors, weather resistance, power management, data analysis, security, energy efficiency, monitoring system.



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INTRODUCTION

In recent years, the use of digital technologies in agriculture has been developing rapidly. In particular, Internet of Things (IoT) technologies are significantly expanding the possibilities for remote monitoring of crops and environmental conditions, as well as for data collection and analysis. Through IoT devices, farmers are able to monitor in real time critical parameters for optimal plant growth, such as temperature, humidity, and soil moisture. This approach plays an important role in the efficient use of resources, increasing productivity, and automating agricultural processes.

At the same time, the widespread implementation of IoT systems in agriculture faces several challenges, including extreme weather conditions, lack of stable internet connectivity in remote areas, energy supply for devices, processing large volumes of data, and ensuring data security. To address these issues, it is necessary to develop efficient energy management strategies, weather-resistant hardware designs, secure authentication systems, and reliable data storage and analysis mechanisms.

The proposed solution in this study is aimed precisely at addressing these challenges. It incorporates a portable and weather-adaptive device architecture, Raspberry Pi Zero and low-cost sensors, a data management system based on AWS EC2 and the Django platform, as well as security mechanisms such as two-factor authentication (2FA) and JSON Web Tokens (JWT). This approach makes the system not only reliable and efficient but also economically viable.

Environmental Conditions - IoT devices and sensors used in water management and agricultural processes may experience reduced operational lifespan due to environmental factors such as extreme temperature fluctuations, high humidity,



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dust, and other ecological conditions. Under such circumstances, it is essential to develop robust and weather-resistant device enclosures to ensure continuous and reliable operation.

Connectivity Issues - In many remote rural areas, stable internet connectivity is insufficient, which makes it difficult for IoT devices to transmit data to cloud platforms or local gateways. Therefore, expanding network coverage and improving bandwidth capacity are crucial factors for ensuring continuous data exchange and real-time monitoring.

Power Management - IoT sensors used in agriculture are typically powered by batteries or solar energy sources. To ensure long-term operation and reduce the need for frequent battery replacement or maintenance services, it is necessary to implement efficient energy management strategies as well as energy harvesting technologies.

Data Management and Analysis - IoT sensors generate large volumes of data in agricultural environments. To fully utilize this data, efficient data management systems are required that enable reliable storage, processing, and visualization. This allows farmers to make informed decisions based on accurate analytical insights.

Security and Privacy - IoT systems in agriculture process sensitive information related to crop yields and resource usage within farming operations. Therefore, security measures must be implemented to protect against cyberattacks,



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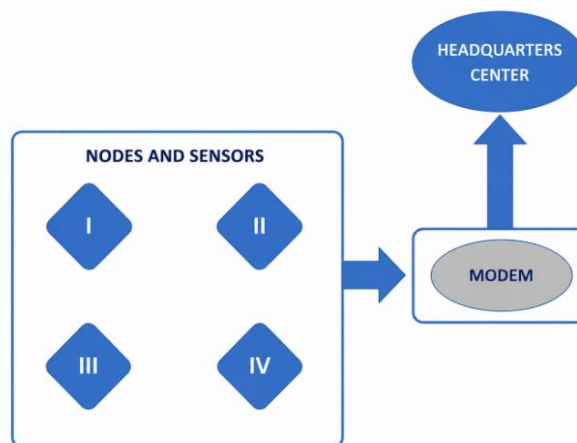
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unauthorized access, and data breaches. Special attention should also be given to data privacy during collection and usage processes.

Cost Factor - The large-scale implementation of IoT technologies in agriculture often requires significant financial investment. Ensuring economic efficiency is particularly important for small-scale farmers and resource-limited regions. Table 1. The proposed system is designed to address the key challenges in agriculture and, compared to existing solutions, stands out in terms of usability, data processing capabilities, IoT node connectivity, use of waterproof sensors, energy efficiency, security level, and user engagement capabilities.



The proposed solution consists of a portable and weather-adaptive hardware architecture, optimized power management, and sensors equipped with low-cost yet reliable components such as the Raspberry Pi Zero. For data management, AWS EC2 servers and the Django platform are utilized, ensuring efficient data storage and analysis.



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From a security perspective, two-factor authentication (2FA) and JSON Web Token (JWT) mechanisms are implemented to protect sensitive information. The system's simplicity, scalability, and reliable access mechanisms make it an effective solution for agricultural applications—particularly for communication in remote areas, improving energy efficiency, and supporting water resource conservation.

Yig'ilgan ma'lumotlar	Harorat, namlik va tuproq namligi	Harorat va barglarning namligi	Harorat, tuproq namligi, yorug'lik intensivligi va namlik	Harorat, namlik va yorug'lik ta'siri	Harorat, namlik va tuproq namligi	Harorat, namlik, tuproq namligi va o'simlik fotosuratlari
Ma'lumotlarni boshqarish	Thingsboard	Shaxsiy kompyuter	IoT bulutli platformasi	AWS	ThingSpeak	AWS
IoT tugunlari	ESP32	IRIS parchasi	Arduino	ESP32	NodeMCU ESP8266 va Raspberry Pi	Raspberry Pi Zero
Ulanish	Wi-fi	Zigbi	Wi-fi	MQTT	MQTT	Wi-Fi va GSM
Suv o'tkazmaydigan sensor	Yo'q	Yo'q	Yo'q	Yo'q	Yo'q	Ha
Quvvat samaradorligi	Yo'q	Yo'q	Yo'q	Yo'q	Yo'q	Quvvatni boshqarish
Xavfsizlik	Yo'q	Yo'q	Blokcheyn yordamida xavfsiz kirish	Blokcheyn yordamida xavfsiz kirish	Expeditious Cipher (X-chipher) yordamida xavfsiz kanal	2FA va JWT yordamida xavfsiz autentifikatsiya
Foydalanuvchini jalb qilish	Veb-ga asoslangan	Ish stoliga asoslangan	Android ilovasi	Veb-ga asoslangan	Veb-ga asoslangan	Android ilovasi



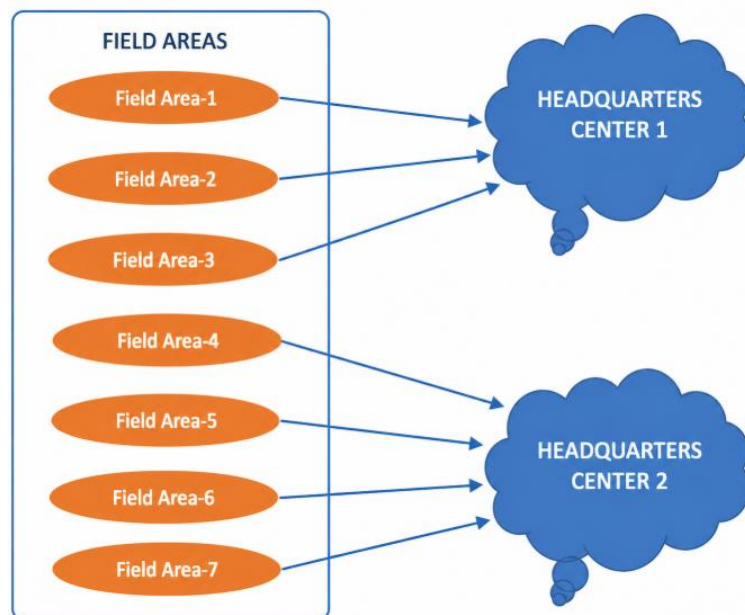
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The table presents an overall view of the proposed system architecture. The developed system is designed to provide real-time information on plant growth and health, incorporating waterproof enclosures, optimized power management, and secure authentication mechanisms. It consists of three main components: a power supply unit, a sensor module, and an Android application for user monitoring.



The smart monitoring system utilizes IoT sensors, machine learning algorithms, and automated irrigation technologies to monitor soil moisture, temperature, and salinity levels in real time. This approach enables early detection of potential issues, generation of automatic alerts, and efficient use of water resources. As a result, farmers can better monitor crop health and improve overall productivity.



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The proposed IoT-based plant health monitoring system offers several advantages over traditional methods, including reduced labor costs, optimized resource utilization, and more accurate decision-making based on data-driven insights. In addition, the system is designed to be user-friendly, providing the ability to monitor individual agricultural areas through a web-based interface.

By implementing IoT principles, the collected visual and sensor data play a crucial role in intelligent plant health monitoring, anomaly detection, and the development of sustainable agricultural practices.

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