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Hydroponic Monitoring System using IoT

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Abstract: *The use of hydroponic systems for growing crops is becoming increasingly popular due to its efficiency and sustainability. However, monitoring and controlling these systems can be challenging and time-consuming. This is where the Internet of Things (IoT) comes into play, as it allows for the real-time monitoring and control of hydroponic systems from anywhere at any time. In this paper, we explore the use of IoT for monitoring and controlling hydroponic units, including sensors for measuring various parameters such as pH, temperature, and nutrient levels, and actuators for controlling water and nutrient supply. We also discuss the advantages of using IoT for hydroponic farming, such as increased yield and reduced resource usage, as well as potential challenges and future research directions. Overall, this paper provides a comprehensive overview of the use of IoT in hydroponics and its potential to revolutionize modern agriculture*

Keywords: Agriculture; Automation; Hydroponics; Arduino

I. INTRODUCTION

Agriculture, an important part of human life and economic maintenance, depends on the relationship between soil composition and nutrition. At the same time, the great impact of global warming and the increasing world has caused lands to become less suitable for agriculture. These declines pose a serious threat to the quality of many crops and increase the challenges facing agriculture. In response to this growing problem, over-reliance on chemical fertilizers and pesticides for a good harvest has become a necessary but dangerous practice. While these chemical products increase crop yields, their broader negative effects cannot be ignored. Careless use of waste and pesticides causes soil degradation, water pollution and many other negative effects on ecosystems and human health. But to these problems and environmental conflicts, a promising solution has emerged in the form of hydroponics, a new method that is changing the face of agriculture. Hydroponic systems provide stability and benefits to plants by overcoming the need for soil as a growing medium. Rooted in the use of water-soluble mineral solutions, hydroponics represents a revolution in agriculture, making plants more productive and productive.

The meaning of hydroponics comes from the verb "Hydro", meaning water and work, and represents the harmony of innovation and social thought. In this happy way, plants in the soil leave their roots in water or grow in a poor environment such as perlite or gravel. The dynamic versatility of hydroponic systems allows the use of a variety of nutrients, from organic substrates such as hatchery fish and duck cages, or carefully formulated chemical fertilizers. The basis of successful hydroponic growing is careful calibration and control of the growing medium. By controlling key factors such as moisture content, pH and precise nutrient levels, growers can achieve faster growth and yield larger yields. Good management of growth not only improves resource use, but also reduces environmental impacts, promotes sustainable agriculture and works well for future generations.

II. LITERATURE REVIEW

Hydroponics is an innovative and efficient method of growing plants in a soil-less environment. The use of IoT in hydroponic systems is gaining popularity due to its ability to automate and optimize the monitoring and controlling process. The following literature survey provides an overview of the previous research on the use of IoT in hydroponic systems.

One of the earliest works on IoT-based hydroponic systems was presented by Linares et al. (2016). The authors proposed a system that uses a Raspberry Pi and Arduino to monitor the temperature, humidity, and water level of a hydroponic unit. The system was able to regulate the nutrient solution and light exposure based on environmental conditions.

Another research paper by Cruz et al. (2017) proposed a hydroponic system that uses a wireless sensor network and IoT technologies for monitoring and controlling. The system was designed to automatically adjust the nutrient solution, pH level, and light exposure based on the real-time data collected from the sensors.

The work by Alajmi et al. (2019) introduced a hydroponic system that utilizes IoT to monitor and control the environmental conditions of the hydroponic unit. The system uses sensors to monitor the temperature, humidity, and pH levels and adjusts the nutrient solution and light exposure based on the collected data.

A recent study by Alotaibi et al. (2021) presented a hydroponic system that uses IoT and machine learning techniques for monitoring and controlling. The system uses sensors to collect data on environmental conditions and machine learning algorithms to analyze the data and adjust the nutrient solution, pH level, and light exposure.

The literature review reveals that IoT-based hydroponic systems have been extensively studied in the past few years. Most of the studies propose systems that use sensors to monitor the environmental conditions and adjust the nutrient solution and light exposure accordingly. The use of machine learning algorithms in hydroponic systems is gaining popularity as it provides an efficient way to analyze the collected data and adjust the system parameters.

III. PROPOSED WORK

The proposed system for monitoring and controlling hydroponic units using IoT will consist of various sensors, microcontrollers, and communication modules to monitor and control different parameters of the hydroponic system, such as pH levels, temperature, humidity, water level, and nutrient level. The system will collect data from the sensors and send it to a cloud-based server where it will be processed and analyzed. Based on the analysis, the system will send alerts to the user's smartphone or other devices in case of any abnormality in the system. Additionally, the user will have access to a web-based dashboard to monitor and control the hydroponic system remotely.

Hardware Selection: The first step in building the proposed system is to select the appropriate hardware components such as sensors, microcontrollers, and communication modules. The selection should be based on the specific requirements of the hydroponic system and its environment.

Sensor Integration: The next step is to integrate the selected sensors into the hydroponic system. The sensors will collect data on different parameters of the system, such as pH levels, temperature, humidity, water level, and nutrient level.

Microcontroller Programming: After integrating the sensors, the next step is to program the microcontroller to read data from the sensors and transmit it to the cloud-based server.

Communication Module Integration: In the next step, the communication module will be integrated with the microcontroller to transmit data to the cloud-based server.

Cloud-Based Server Setup: The cloud-based server will be set up to receive data from the hydroponic system, process and analyze the data, and send alerts to the user's smartphone or other devices in case of any abnormality in the system.

User Interface Design: The user interface will be designed, which will consist of a web-based dashboard and a mobile app. The dashboard will provide real-time data monitoring and control of the hydroponic system.

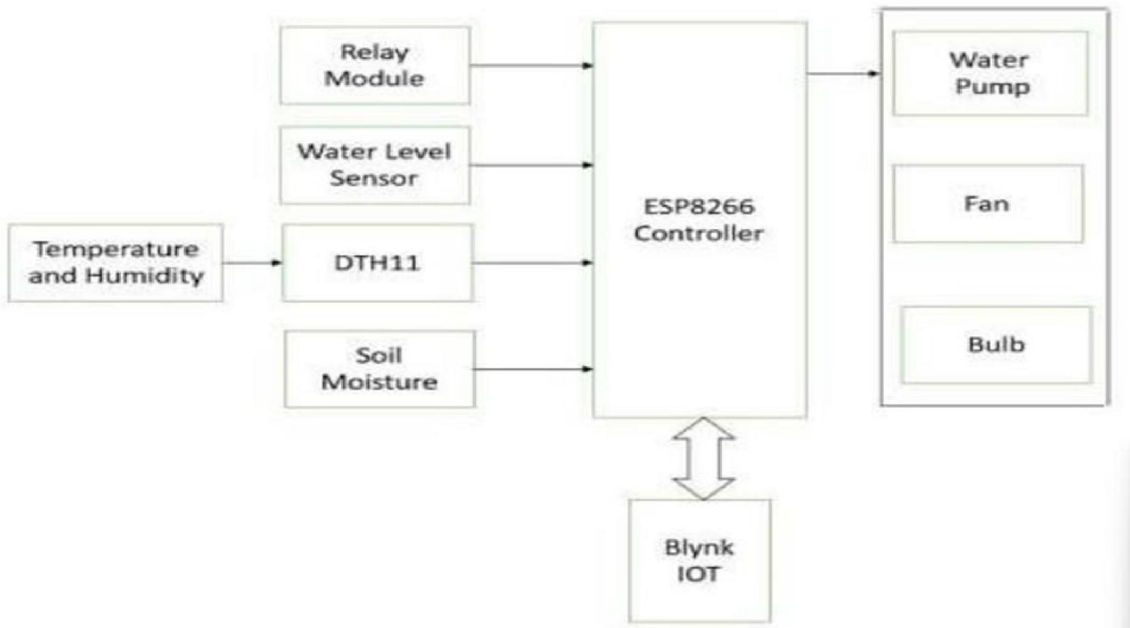
Testing and Optimization: The final step will be to test the system in a real-world environment and optimize it for better performance and reliability.

IV. METHODOLOGY

The approach to IoT-based smart hydroponic monitoring systems involves several key steps to ensure efficient operation and data collection. First of all, it is important to choose the right sensor, taking into account factors such as accuracy, reliability and compatibility with the hydroponic environment. These will include sensors to monitor pH, nutrient concentration, temperature, humidity and water level. Once the sensors are selected, the next step is to install them in the hydroponic system. This often involves setting up hardware and connecting to transfer data to a central hub or IoT gateway.

Additionally, the system needs to be configured to receive, process, and store sensor data efficiently. IoT platforms play an important role in this approach and act as the interface between sensors and end users. It should facilitate instant monitoring, data visualization and analysis capabilities. Cloud-based platforms are often preferred due to their scalability and accessibility, allowing users to access data remotely from any internet device. Finally, ensuring the security and reliability of the IoT infrastructure is critical. Overall, a clear approach to IoT-based smart hydroponic monitoring systems includes sensor selection, integration, IoT platform development, data analysis and security measures and is cyber-engineered to ensure efficient and reliable operation for efficient cultivation and production.

V. BLOCK DIAGRAM



VI. IMPLEMENTATION

In hydroponic farming, the process begins by seeding plants in traditional soil until their roots establish themselves. Once the young plants reach a suitable stage, they are carefully transplanted into a hydroponic system. This system comprises an intricate network of pipes filled with a precise blend of nutrient solution, meticulously prepared to provide essential nutrients typically obtained from soil. These nutrients are expertly mixed into the water reservoir feeding the pipes. The strategic placement of the plants ensures their roots have direct contact with the nutrient-rich solution, allowing efficient uptake of moisture and nutrients. This innovative approach guarantees optimal nutrition for the plants, ensuring unhindered growth without deficiencies and facilitating robust photosynthesis, vital for overall health and development. The tailored environment provided by hydroponic farming exemplifies a harmonious blend of scientific precision and natural processes, offering a sustainable and efficient method for cultivating healthy, flourishing plants.

Hydroponic farming employs the Nutrient Film Technique (NFT) as its primary system. This system includes a grow charger containing essential water and nutrients, while net pots house plants and growing media. A return system guides used nutrient solution back to the source. The grow charger is set at a pitch, allowing water to flow down towards the nutrient return pipe. Any excess nutrient solution exits through this pipe, entering another channel for uninterrupted circulation. The roots of the plants pierce the shallow film of nutrient solution, absorbing vital nutrients for growth. This system also keeps the upper portion of the roots dry, providing them with oxygen for optimal development. While growing media are often used, some farmers choose to forego them in the NFT system.

VII. ADVANTAGES

- Hydroponics, used in areas with severe soil degradation, can be grown indoors.
- Used for landscaping terraces.
- Soilless agriculture.
- The plant can be grown all year round both indoors and outdoors.
- Reduce water consumption.
- Multi-level farming increases crop yield per area.
- Plants grow faster and are organic in nature.

VIII. SYSTEM REQUIREMENTS

The system for monitoring and controlling hydroponic units using IoT requires the following:

1. Sensors for monitoring different parameters of the hydroponic system such as pH levels, temperature, humidity, water level, and nutrient level.
2. A microcontroller to read data from the sensors and transmit it to the cloud-based server.
3. A communication module to transmit data from the microcontroller to the cloud-based server.
4. A cloud-based server to receive data from the hydroponic system, process and analyze the data, and send alerts to the user's smartphone or other devices.
5. A user interface that will consist of a web-based dashboard and a mobile app for real-time data monitoring and control of the hydroponic system.

IX. SENSOR REQUIRED

1. The following sensors are required for monitoring and controlling hydroponic units using IoT:
2. pH sensor to measure the acidity or alkalinity of the nutrient solution.
3. Temperature sensor to measure the temperature of the hydroponic system.
4. Humidity sensor to measure the moisture content

X. CONCLUSION

The implementation of a system for monitoring and controlling hydroponic units using IoT offers numerous benefits to growers, including increased productivity, improved resource management, and reduced labor costs. The use of sensors, microcontrollers, and communication modules allows for real-time monitoring and control of various parameters of the hydroponic system, providing growers with valuable insights into the system's performance. The cloud-based server enables the processing and analysis of data, allowing for quick detection and correction of any abnormalities in the system. The user interface, which includes a web-based dashboard and a mobile app, provides easy access to real-time data, enabling growers to make informed decisions and take necessary actions. Overall, the implementation of such a system can revolutionize the way hydroponic farming is done, leading to more sustainable and efficient production of crops.

XI. FUTURE SCOPE

Many hydroponic farms enabled by IoT technology, including rooftop, vertical, and green buildings, can strategically position themselves near urban areas. This placement not only reduces transportation costs but also ensures the safe transport of IoT plants. To efficiently manage these farms, developers can create a user-friendly standard website. This website would collect sensor data and present it through visually appealing graphs, aiding farmers in gaining valuable insights and making informed decisions about their crops. Moreover, integrating IoT technology in these farms will open avenues for research, turning each farm into a hub for innovative agricultural studies. Given the challenges of limited arable land, water scarcity, rising costs, climate change, and a growing population, it is expected that both government entities and large corporations will increasingly invest in hydroponic farming solutions. This shift toward hydroponics is motivated by the urgent need to address these complex challenges with sustainable and technologically advanced agricultural practices.

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