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Fertigation of Plant with IoT Based System for Management and Monitoring

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Abstract

An IoT-enabled smart fertigation system integrates sensors like soil, ultrasonic, pH, DHT22, and a Pneumatic Diagraph Water Pump, connected to a NodeMCU ESP32 microcontroller. Real-time data on soil conditions is transmitted to a cloud platform like Blynk for analysis. Advanced algorithms and machine learning provide precise fertilization suggestions, optimizing water and resource use. The system allows remote monitoring and control via smartphones or PCs, promising enhanced crop development, resource efficiency, and farm management.

1. Introduction

Modern agriculture is making advances because of the incorporation of technology such as the Internet of Things (IoT), with particular focus on improving fertigation procedures. Fertigation, or the proper administration of water and nutrients to plants via irrigation systems, has traditionally depended on human beings or specified timetables, resulting in inefficiencies and imprecise nutrient delivery. The incorporation of IoT into fertigation systems provides accurate water and nutrient supply control, monitoring, and optimization. By solving difficulties associated with traditional techniques, such as overuse of water and imprecise fertilizer delivery, this integration improves crop development, saves resources, and gives economic advantages. [1] [7]

Adoption of IoT in agriculture, especially in fertigation, intends to transform the sector by providing a full understanding of present practices, demonstrating the limits of old techniques, and demonstrating the potential benefits of IoT integration. Effective water and fertilizer management is crucial given the difficulties of water shortages and the growing demand for ecologically friendly agricultural operations. Traditional fertigation practices can lead to water waste or underuse, resulting in crop waste or insufficient supply. Similarly, incorrect fertilizer supply might result in nutrient runoff, groundwater contamination, or plant nutrient issues. By highlighting the need of precise control and monitoring of water and fertilizer delivery, IoT-based fertigation systems help to sustainable agriculture and address significant business problems. [4]

Fertigation systems with IoT utilizing ESP32 have gained popularity in the field of precision agriculture because of their capacity to automate and optimize fertilizer supply based on real-time data. These systems integrate fertigation principles, which include multiple applications of water and nutrients via irrigation, with IoT technology for increased control and monitoring. Before beginning this project, considerable research was conducted to ensure that this project is better than the existing system. The research is based on journal articles, thesis, and reference books on the fertigation system and how automation is used in it. The technologies used in previous studies that are relevant to the project scope are marked as references. The topics that are reviewed are focused on fertigation system, development of fertigation system, mathematical modelling of tank reservoirs, fertigation control and mechanism, fertigation scheduling and working of sensor, centrifugal pump, and Arduino. [5][8]

Several projects in agricultural innovation focused on the design and implementation of advanced fertigation systems, employing GSM technology for higher automation. These innovations, ranging from the GSM-Based Fertigation System to the use of Internet of Things (IoT) and LoRa in fertigation, demonstrate advances toward more efficient and accurate agriculture. Furthermore, projects like the Automated Fertilizer Mixer System and the use of sensing technologies in an Automated Irrigation and Fertigation System demonstrate the many ways employed to enhance fertilization and irrigation processes in current farming practices. This overview covers a wide range of initiatives that contribute to the evolution of agricultural systems, with the goal of increasing outputs using intelligent and automated fertigation methods. [3][9]

1.1 Problem Statement

Traditional plant fertigation systems, which include human work or fixed irrigation and fertilization schedules, frequently result in poor water and nutrient management. These approaches are imprecise, resulting in excessive water use, inconsistent fertilizer delivery, and poor crop development. Furthermore, farmers' capacity to maximize resource usage and adapt to changing environmental circumstances is limited by their inability to monitor and alter fertigation operations in real time.

The issue is the lack of an effective and accurate strategy to plant fertigation that deals with the limitations of previous approaches. A system that can continuously monitor plant requirements, alter nutrient supply based on real-time data, and give farmers remote access and control over the fertigation process is required. Furthermore, the system should maximize resource usage, reduce water and nutrient waste, and encourage sustainable agriculture practices.

1.2 Objectives

i) To design an IoT-enabled fertigation system for effective plant management and real-time monitoring and provide a comparison of current IoT-based systems for simplifying user control and monitoring.
ii) To develop and assemble an IoT system for fertigation system that can help the farmer to monitor and control efficiently.
iii) To test and validate the proposed framework or method for fertigation system.

1.3 Project Scopes

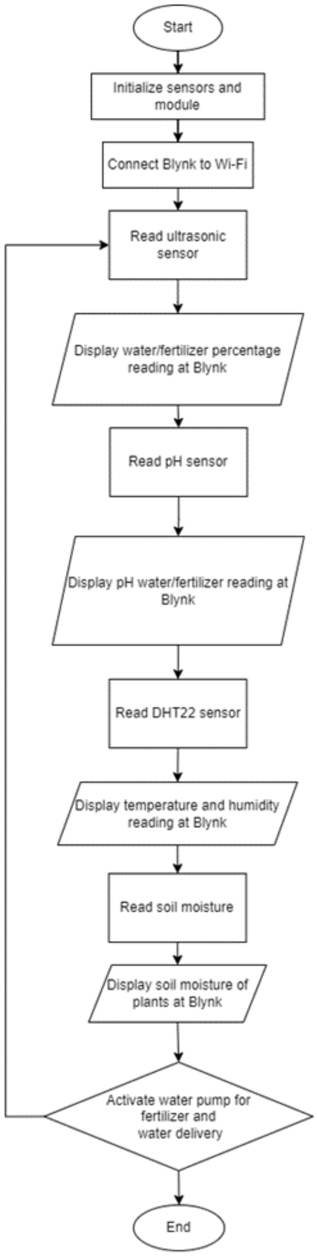
i)Design and compare a complete model for the IoT-based fertigation system, including a summary of the design, components, and connections.
ii)Develop and assemble an effective Internet of Things device with sensors for soil and crop monitoring and motors for irrigation management, then apply it into a combined fertigation system.
iii)Validate sensor accuracy in controlled conditions, evaluate real-world performance in agriculture, and simulate real-time monitoring and control situations to guarantee IoT system responsiveness.

2. Methodology

This chapter outlines research approaches, including system flowchart, block diagram, and design architecture. The smart plant fertigation implementation involves IoT devices, emphasizing data-driven decisions, automation, and continuous improvement, revolutionizing agriculture with sensor tech, analytics, and remote control for enhanced crop output, resource conservation, and sustainable practices.

2.1 Flowchart of the System

Flowchart that includes sensors that include DHT22, pH, soil moisture, and ultrasonic for collecting environment and tank data. Using Blynk, ESP32 processes and shows the results, improving plant care and decreasing resource waste. The DHT22, pH sensor, soil moisture sensor, and ultrasonic sensor collect data on temperature, humidity, pH level, soil moisture, and water or fertilizer levels in the tanks. The ESP32 microcontroller then processes the data and analyses the sensor readings by displaying the data at Blynk apps. The microprocessor controls the relay to activate or deactivate the water pump based on the assessed data. Based on the demands of the plants, users can use the water pump to supplies the right amount of water or nutritional solution. Furthermore, the system is linked to the Blynk app, which allows users to remotely monitor and operate the system. Users may monitor real-time sensor data, change settings, and control the water pump via the app. This integrated and automated system delivers accurate and efficient fertigation, improving plant development and reducing resource waste. [2][6]

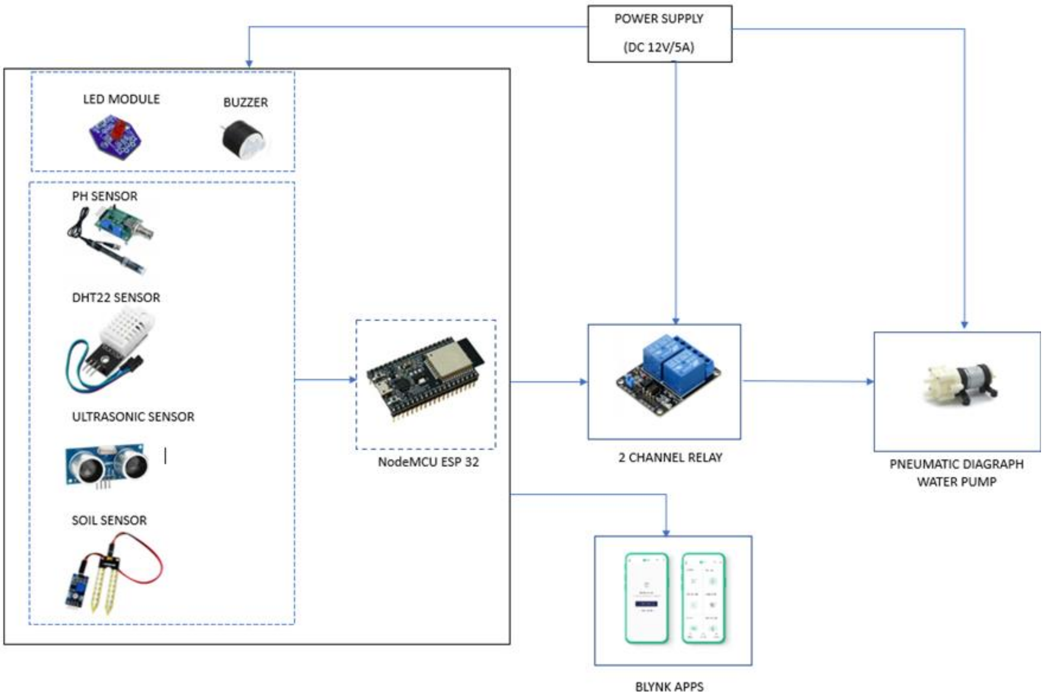


(a)

Fig. 1 *a) Flowchart system of the Fertigation of Plant with IoT Based System for Management and Monitoring*

2.2 Pictograph Block Diagram

The Pictograph Block Diagram represents every part of the fertigation system, offering a visual picture of their functions and interactions. It shows the pictograph block diagram of the project that includes power supply, LED module, buzzer, pH sensor, DHT22 sensor, ultrasonic sensor, soil sensor, NodeMCU ESP32, 2 channel relay, motor pump and the Blynk application. Each element performs an independent task in providing optimal plant care and utilization of resources.



(a)

Fig. 2 *(a) Pictograph block diagram of the project*

3. Results and Analysis

In this chapter, the purpose is to achieve the objective of this project which is to design an IoT-enabled fertigation system for effective plant management and real-time monitoring and provide a comparison of current IoT-based systems for simplifying user control and monitoring, to develop and assemble an IoT system for fertigation system that can help the farmer to monitor and control efficiently, and to test and validate the proposed framework or method for fertigation system, it will include necessary sensors such as pH, DHT22, soil moisture, and ultrasonic along with an ESP32 microcontroller and 12V power source. By trial and error, the system proved to be an efficient real-time monitoring tool that could optimize water and fertilizer supply. The accuracy of the pH sensor in measuring acidity or alkalinity in water and fertilizer, the DHT22's function in monitoring environmental conditions, and the ability of soil moisture sensors to provide information about hydration levels are all highlighted by the results. The ultrasonic sensor provides an in-depth understanding of the plant's surrounds by measuring the amounts of water and nutrients. The data gathered is analyzed in this research project, which highlights the system's potential to improve agricultural sustainability and efficiency.

3.1 Result

Related to the first objective of this project which is to design an IoT-enabled fertigation system for effective plant management and real-time monitoring, an actual prototype has been done according to the 3D design sketch.

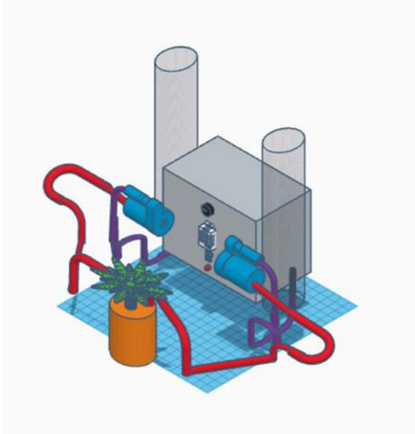


Fig. 3 *3D design using Tinkercad.*

Through a rough sketch of 3D design, an innovation in IoT integration for effective plant fertigation has been successfully developed. This prototype includes a PVC 50mm pipe functioning as reservoirs and an ESP32 microcontroller (inside the PVC box) linking sensors (pH, temperature, humidity, soil moisture, and distance) to a Blynk application. The technology provides real-time monitoring and remote control of irrigation motors, paving the way for precision agriculture and the future of resource-efficient plant cultivation at the intersection of conventional techniques and IoT technologies.

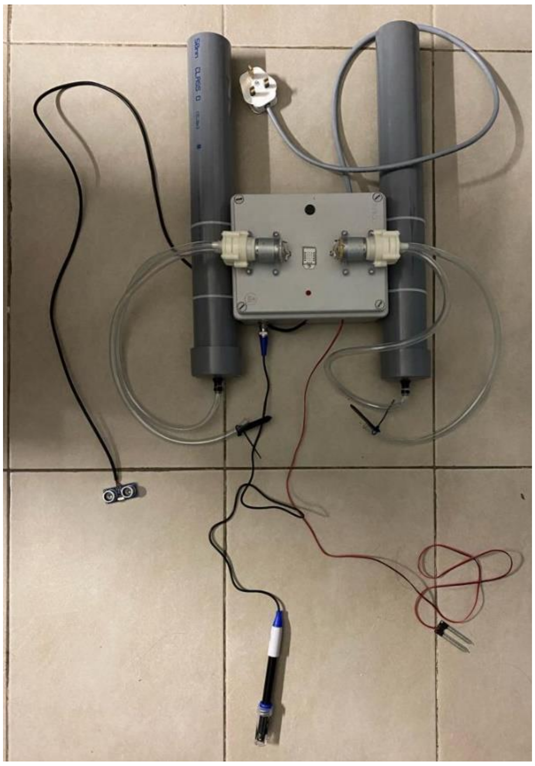
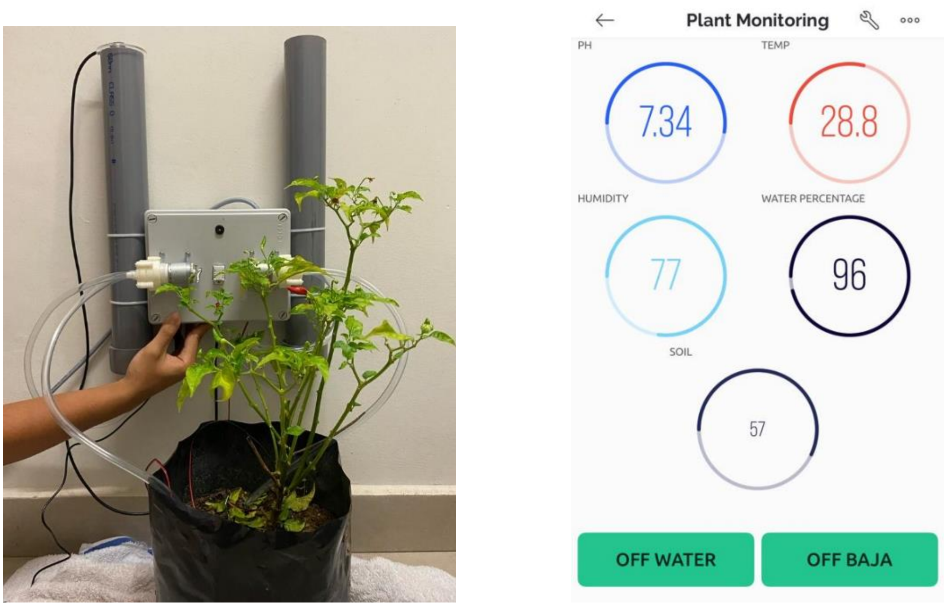


Fig. 4 *Design of actual prototype*

3.2 Plant Health Monitoring

This part evaluates measuring techniques and fertigation system performance, with a focus on precision, dependability, and real-time data capture, which are required for accurate nutrient delivery and irrigation management. To accomplish the third objective of this project which is to test and evaluate the proposed framework or method for fertigation system, a testing on chilies plant has been done to prove that this current project named Fertigation of Plant with IoT Based System for Management and Monitoring works smoothly. Next, based on Figure 4.6, it shows the plant monitoring application, Blynk, indicates that the plant is doing well, with the temperature, humidity, and water percentage at 28.8 degrees Celsius, 77%, and 96%, accordingly. 57% soil moisture is within the acceptable range for this plant variety. Although the pH of the soil is a bit alkaline at 7.34, which is within safe limits for most plants, constant monitoring is advised to avoid any imbalance. The Blynk application not only ensures constant plant care, but also allows users to automate watering and fertilizer by establishing ON/OFF routines. This function offers efficient and effective plant management, ensuring the plant receives the care that it needs to maintain its health and development.



(a) (b)

Fig. 6 *(a) Testing on chilies plant (b) Blynk apps shows reading of each sensor and remote control for water and fertilizer delivery.*

4. Conclusion

This project effectively implemented an Internet of Things (IoT)-based fertigation system, enabling precise plant care via remote monitoring and sensor-driven nutrient supply. The system uses an ultrasonic sensor for potential growth observation, pH, soil moisture, temperature/humidity, and a low-power ESP32 to adjust watering and give out updates depending on real-time data that can be accessed through Blynk. Improved plant development, resource efficiency, and user ease are made possible by this economical and sustainable solution, opening the door to more intelligent and responsive plant care in greenhouses, home gardens, and other settings. Future developments could involve more sensors for even deeper plant observations and machine learning for predictive fertigation, further enhancing this system's potential as a useful tool for effective and responsible plant management. [10]

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Conflict of Interest

To the best of their knowledge, the authors declare that there are no conflicts of interest that might have influenced the conduct or reporting of the study reported in this publication.

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