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SMART HYDROPHOONIC AUTOMATION SYSTEM

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ABSTRACT

The Smart Hydroponics Automation System is an innovative agricultural solution based on the Internet of Things that makes it possible to cultivate without soil with more precision, efficiency, and sustainability. This system makes use of multiple sensors such as the soil moisture sensor, water level sensor, and DHT11 to continuously monitor important environmental variables like the level of nutrient solution, humidity, and temperature. A microcontroller processes the collected sensor data and displays the real-time readings on an LCD screen for local surveillance To ensure intelligent automated control, the system incorporates a relay module that based on predetermined thresholds, controls the switching of water pumps, motors for nutrient dosing, and cooling or aeration devices. When sensor readings indicate unfavorable conditions, the relay. The connected electrical components are automatically turned ON or OFF to maintain optimal plant growth. Due to its battery-powered operation, the system is suitable for agricultural settings that are off-grid or remote. Additionally, the IoT-enabled cloud application provides remote access to live sensor data, historical analysis, notifications, and manual control of the hydroponics setup through a handheld device This makes real-time decision-making more efficient while reducing manual intervention.

The system ensures precise operation through wireless monitoring, relay-based switching, and automated control. nutrient delivery, reduced water wastage, consistent plant health, and improved yield. Overall, the smart Using a hydroponics system, you can find a long-term, low-cost, and cutting-edge answer to today's agriculture challenges by combining IoT, automation, and relay-based control mechanisms.

KEYWORDS: Hydroponic System, Automation, Sensors

I. INTRODUCTION

Agriculture is one of the oldest and most essential practices for human survival, even though traditional soil-based farming faces significant challenges in the modern world. Problems such as decreasing fertile land, water scarcity, soil degradation, climate change, high labor costs, and erratic weather Productivity in agriculture has been negatively impacted by the conditions. A further reduction in agricultural land as a result of rapid urbanization and industrialization makes it difficult to meet the growing demand for food. demand of the growing population. These challenges led to the search for innovative, efficient, and sustainable methods of farming.

One such cutting-edge agricultural technique is hydroponics, in which water is used to grow plants instead of soil. mixed with vital nutrients derived from minerals. In this method, plant roots directly receive the necessarynutrients, oxygen, and moisture through a controlled solution. This process results in faster plant growth, a higher yield, and crops of higher quality than in conventional farming. It also allows cultivation in urban spaces, greenhouses, and rooftops where soil farming is impossible, and even indoors. However, manual monitoring of the hydroponic system was necessary at first. level of water, pH, temperature, and concentration of nutrients, making it less labor-intensive and less efficient.

To overcome these limitations, automation and smart technology were introduced into hydroponics.

The incorporation of sensors, microcontrollers like Arduino or ESP32, the Internet of Things (IoT), and cloud platforms transformed basic hydroponics into a Smart Hydroponic Automation System. DHT11 (temperature and humidity) sensors, water level sensors, and other sensors are utilized in these systems. pH and EC sensors to monitor plant conditions continuously. The collected data is processed by a microcontroller, which automatically controls devices like water pumps, nutrient dosing systems, grow lights or exhaust fans with relays. This reduces manual supervision and ensures precise nutrient delivery, optimal growing conditions, and efficient plant development.

II. RELATED WORK

[1] C. J. G. Aliac and E. Maravillas, "IOT Hydroponics Management System,"
It focuses on monitoring key environmental parameters such as pH, water level, temperature, and humidity to boost plant growth. The system integrates sensors and actuators to automate irrigation and the delivery of nutrients, which reduces the need for manual labor and boost productivity. Data collected data is kept in a backend system and made available to users online, making it easier for remote control and monitoring. The study demonstrates that IoT integration can significantly enhance resource management and crop yield in hydroponic settings.

[2]SrideviNavulur, A. S. C. S. Sastry, and M. N. Giri Prasad , "Agricultural Management through Wireless Sensors and Internet of Things"
It introduces a Raspberry Pi-based solar-powered platform with wireless sensors to keep an eye on important agricultural parameters like crop health and soil moisture. The system enables remote data collection and control through a mobile application, facilitating real-time decision-making for farmers. By incorporating AI-based analytics and external data sources such as weather services, The platform aims to improve crop productivity and resource utilization. This research contributes to the development of "AGRIPI," a patent-pending innovation focused on automating and integrating IoT to improve agricultural practices.

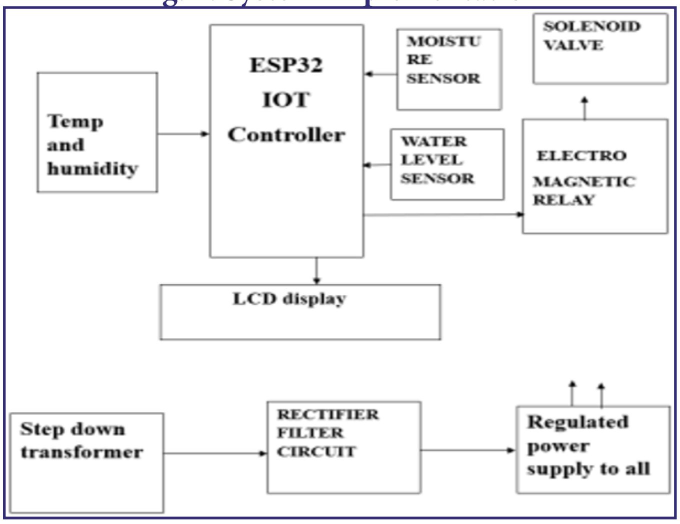
[3] H. J. Dong et al, "Interactive on Smart Classroom System Using Beacon Technology"
Utilizing Bluetooth Low Energy (BLE) beacon technology, it provides a well-thought-out classroom framework that enhances educational environments. The system employs a layered architecture—consisting of the physical, data link, control, and application layers—to make effective data collection easier and interaction. By utilizing BLE 4.0 beacons, the system achieves low power consumption, allowing devices to run long periods of time with little power consumption. This setup enables automatic attendance tracking and personalized notifications based on students' proximity to beacons, fostering a more interactive and intelligent classroom experience. The authors suggest that such beacon-based systems have potential applications beyond education, including in libraries and retail environments.

[4] S. Padmadevi and V. Deepigha, "Smart E-Agriculture Monitoring Using Internet of Things"
It presented at the Sixth International Conference on Emerging Trends in Engineering and At Technology (ICETET'16), a system for real-time agricultural monitoring based on the Internet of Things is proposed. It incorporates a variety of sensors to monitor environmental parameters like temperature, soil moisture, and humidity, facilitating informed decision-making for farmers. The system aims to enhance crop productivity by automating processes for managing nutrients and irrigation. Data collected by the sensors are sent to a centralized platform, which enables remote control and monitoring via mobile devices. This approach seeks to optimize resource utilization and promote sustainable techniques for farming that make use of technology.

III. PRACTICAL IMPLEMENTATION

The block diagram illustrates a smart hydroponic automation system built around an ESP32 IoT controller, which serves as the central processing unit for monitoring and controlling environmental parameters necessary for plant development. A moisture sensor, a temperature and humidity sensor, and a water level sensor are among the sensors that can be connected to the ESP32. These sensors continuously collect data and send it to the controller for analysis. Based on the sensor inputs, the An electromagnetic relay that is controlled by an solenoid valve and activated by the ESP32 regulates the flow of water to maintain optimal moisture levels. An LCD display is used to present real-time data such as temperature, humidity, and the condition of the water, with visual feedback for the user. The system is powered through a step-down transformer that reduces the input voltage, followed by a rectifier filter circuit that converts AC to DC and smooths the output. After that, a controlled power supply delivers a constant voltage to all of the components, ensuring their consistent operation. This integrated setup is as shown in fig 1

Fig. 1: System Implementation



IV. IMPLEMENTATION AND DESIGN

By integrating sensors, controllers, and actuators into a closed-loop setup to grow plants without soil, a smart hydroponic automation system maintains optimal growing conditions. The system uses sensors to continuously monitor parameters such as pH, electrical conductivity (EC), water level, temperature, humidity, and light intensity. These readings are processed by a microcontroller or IoT-enabled device, which then automatically adjusts nutrient dosing pumps, water circulation, grow lights, and ventilation to keep conditions within the desired range. The Automation reduces manual labor by ensuring precise nutrient delivery and stable environmental control. intervention and minimizing resource wastage. Data collected from the sensors is logged and transmitted to a cloud platform or mobile application, allowing real-time monitoring, alerts, and remote adjustments. This design not only improves plant growth and yield but also enhances sustainability by optimizing water and nutrient usage. In implementation, the system is built step by step—definition of crop requirements, hardware assembly, programming of control logic, calibrating sensors, and finally deploying the IoT interface for user-friendly monitoring and management.

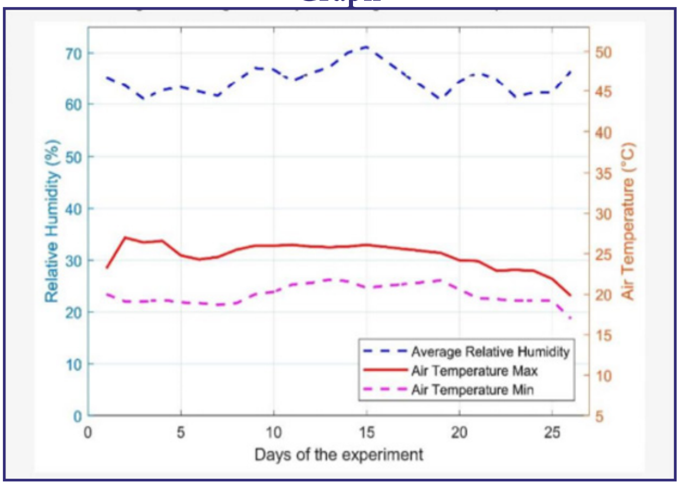
V. RESULTS AND DISCUSSION

Data Table is as shown in below table:

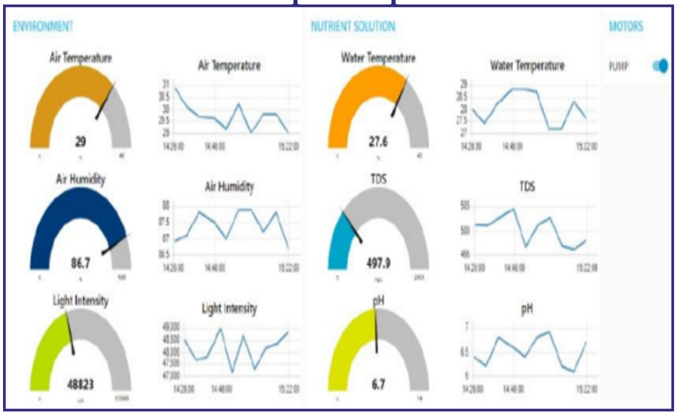
Table 1: Data table

No	Temperature	Humidity	Water level	Soil moisture (pot1)
1	30.7	50	38	No Need Watering
2	30.4	90.4	35.5	No Need Watering
3	30.1	90	35.3	No Need Watering
4	30	97.4	39.17	Need Watering

Graph



Sample Graphs:



MONITORING DASHBOARD

- Air Temperature: Remains around 29 °C, showing stable greenhouse conditions.
- Air Humidity: About 86–88%, suitable for healthy plant growth.
- Light Intensity: High and fluctuating, indicating effective light availability for photosynthesis.
- Water Temperature: Maintained near 27–28 °C, ideal for nutrient absorption.
- TDS: Around 490–500 ppm, showing proper nutrient concentration in solution.
- pH Level: Close to 6.5–6.8, which is optimal for hydroponic crops.
- Pump Status: Pump is ON, ensuring continuous water and nutrient circulation.
- Overall Observation: All parameters stay within acceptable ranges, indicating efficient IoT-based hydroponics control.

VI. CONCLUSION AND FUTURE SCOPE

The Smart Hydroponic Automation System represents a modern and sustainable shift in the field of agriculture by combining cutting-edge IoT and hydroponic farming methods innovations in automation In today's era, where traditional farming faces challenges such as lack of fertile soil, unpredictability of the weather, overuse of water, and rising demand for food that does not contain pesticides, this system is an extremely effective and dependable option. By getting rid of the dependence on soil and the provision of controlled quantities of nutrients, water, light, and climate, the system ensures healthier and faster plant growth with significantly higher yields.

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