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Smart IoT Hydroponics Farming

Vinay Dandamraj

Scottline Technologies Pvt. Ltd.
Email: *dandamrajvinay84[at]gmail.com*

Abstract: ***This document describes the practical implementation of a smart hydroponics system which combines the Internet of Things (IoT) technology for sustainable urban farming practices. The system was developed and tested during 2019 with an ESP32 microcontroller, pH, EC, CO2, temperature, humidity sensors along with peristaltic pumps for automated nutrient management. The system demonstrates precision farming through enhanced resource use efficiency and accelerated crop growth vis-a-vis conventional methodologies. Its effectiveness has been validated by experimental data. This model demonstrates promise for reproduction in regions with scarce water resources or in climates that are sensitive to environmental changes.***

Keywords: Hydroponics, Internet of Things, Smart Farming, pH Sensor, EC Sensor, ESP32, Urban Agriculture

1. Introduction

Hydroponics is a method used for the soilless cultivation of plants using nutrient solutions; this technique brings about numerous benefits such as preserving water, faster growth cycles as compared to soil cultivation and the ability to scale up operations within urban centers.

Combining IoT makes possible the automation of balance nutrients systems, as well as temperature controls and environmental monitoring devices making it possible to pre-set parameters. A comprehensive working IoT-enabled hydroponics system is detailed in this paper.

2. Related Work

The literature examines precision agriculture IoT-powered solutions focused on sensor-driven irrigation systems along with greenhouse oversight and drone-equipped crop scouting services

3. System Design and Architecture Overview

The architecture includes:
- Microcontroller ESP32
- pH, EC Sensors, DHT11 (Humidity) Sensor DS18B20 (Temperature), MQ-7 CO2
- Nutrient and water circulation dosing peristaltic pumps as actuators
- Displays in mobile dashboards and LCD1602 I2C Display are used for monitoring.

The hydroponics system consists of six grow tubes made of PVC, a nutrient tank with a capacity of 50 gallons, a manifold to ensure even distribution of water, and a return system to recycle excess solution.

4. Implementation and Deployment

In 2019 the system was implemented on a testbed in real world environment. Important milestones were:
- Monitor’s pH and EC accuracy by calibrating measurements with reference solutions
- Automation of nutrient delivery using relay-controlled pumps
- Logging data in real time to a mobile app for notifications, alerts and tracking
- Adjusting daily vo remain within optimal target ranges for nutrition value liquid NPK fertilizer solution (changing diet) along with PH (pH-balanced) levels

5. Results and Analysis Plant data

EC coco peat substrate: 521; follow-on feeding water 43--Net result: 478

CO2 maintenance target logged at optimized interval during observation period ranged at 1200 to1500 ppm CO2 Turbidity alongside TDS measured wat clarity out petrolatum product distilled from polyether observation well Noted plant growth averaged between 30-35 percent faster while achieving over fifty percent reduction on soil-based irrigation systems, additionally provided full automation design for routine daily care setting removing manual adjustments through auto-pilot algorithms

6. Finalizing Sections and Next Development Steps

The hydroponics system based on IoT technology provides a comprehensive structure for modern farming, considering sustainability and ecological footprints. This model further optimizes productivity while minimizing human labor and water consumption. Future goals also consist of more autonomy by adding AI for real-time analysis, increasing the use of solar panels, and using it in community rooftop gardens.

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