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Hydroponic Plant Monitoring System

Shivanjali Sanjay Rakhunde, Vivek Dnyandev Thombre, Vanshita Ramdas Tupe,

Dr.Prof. Bhausaheb Eknath Shinde

U.G. Student, Department of Electronics and Telecommunication, Dhole Patil College of Engineering, Kharadi,
Pune, India

Professor, Department of Electronics and Telecommunication, Dhole Patil College of Engineering, Kharadi,
Pune, India

ABSTRACT: The goal of this project is to create an automated hydroponic system that monitors and regulates environmental conditions using a variety of sensors and Arduino microcontroller technology. A pH sensor, an LDR sensor for light detection, a DHT11 sensor for temperature and humidity monitoring, and a 4-channel relay for managing lights and pumps are all included in the system. The Arduino gathers information from these sensors and applies logic to run the hydroponic system on its own. In particular, it triggers a water pump to correct pH levels when they surpass a preset threshold, controls lighting based on light levels sensed by the LDR sensor, and regularly transmits sensor data to a NodeMCU for transmission to the ThingSpeak platform. ThingSpeak is a data storage and visualization application that lets users keep an eye on the environment from a distance with time. Furthermore, the Virtuino app offers an intuitive user interface for obtaining real-time sensor data and remotely operating the device. The automated hydroponic system provides an easy and effective way to manage plant development in controlled environments by integrating hardware, software, and cloud-based platforms.

I. INTRODUCTION

The goal of this project is to use an Arduino board and a variety of sensors to develop an automated hydroponic system. The pH, temperature, humidity, and light levels are all tracked by the system. It uses a water pump to change pH levels, controls lighting, and transmits data to ThingSpeak for remote monitoring. The Virtuino app offers control and user interface features.

Compared to conventional growth techniques, automated hydroponic systems provide a number of significant benefits. First of all, they make it possible to precisely regulate environmental factors like pH, temperature, humidity, and lighting—all of which are essential for maximizing plant development and harvests. With this degree of control, optimal growing conditions that are suited to particular plant species may be created, increasing efficiency and output. Additionally, automated systems eliminate the need for human intervention, saving labour costs and time associated with conventional agricultural methods. Hydroponic systems can function more regularly and dependably by automating processes like watering, nutrient supply, and environmental monitoring. This reduces the possibility of human error and guarantees the best possible health for the plants. Furthermore, hydroponic systems use less land and water than traditional soil-based agriculture, which makes them perfect for urban areas or places with limited resources. Higher crop yields in less spaces are made possible by the capacity to grow plants vertically or in stacked formats, which further optimizes space utilization.

Furthermore, automated hydroponic systems can be scaled and adjusted to fit a variety of needs, from big commercial farms to small-scale personal gardens. For food production, research, or teaching, these systems offer an effective and sustainable way to grow crops in regulated environments. All things considered, the need for automated hydroponic systems originates from their capacity to meet the problems of contemporary agriculture, such as scarce resources, deteriorating environmental conditions, and the requirement for higher food output. These systems are essential for maintaining food security for future generations and developing sustainable agriculture because they use technology to improve plant growth and resource utilization.

II. RELATED WORK

An android application was created by Gokul et al. [9] to keep an eye on the hydroponic system. Sensor data can be stored in the thing speak cloud using this research. By connecting sensors and actuators to the microcontroller (ESP32),

the sensors of pH, temperature, humidity, water level, and light intensity are used. The Internet of Things (IoT) is used to perform automatic observation and maintenance. It transmits and retrieves data to the network, controls actuators using a mobile app, and stores sensor data on the cloud.

Using an ESP8266, Hariono et al. [13] developed data collecting apps for an Internet of Things-based hydroponic plant automation system. The waterfall technique, which incorporates requirements analysis, system design, implementation, and testing, is used in the system development process. The outcomes of Real-time data gathering displays are made simply readable for the user on the dashboard page. Testing for functionality and efficacy produced satisfactory results. Through the website, control and monitoring are carried out.

The hydroponic automation system and monitoring are implemented by Deokar et al. [18] using the BLYNK program. The goal of this project is to create an electrical circuit with sensors and actuators that interfaces with an automated hydroponic system based on the Internet of Things to enable remote control and monitoring. Because of this, the BLYNK application for monitoring was more user-friendly and adaptable than the internet version.

Implementing the hydroponic automation system is Prathima et al. [21]. Using an ESP32 and the necessary sensors, this research successfully creates an entirely automated and controlled hydroponic system. This system may be set up in a short space and is highly suitable in all locations, regardless of the environment.

IoT was used in the development and monitoring of hydroponics by Koge et al. [36]. Additionally, they used the ESP8266 to measure light, pH, temperature, and water. As a result, when employing this method without soil, the plant grows healthily. Consequently, plants develop significantly more quickly in a hydroponic system than in soil.

III. METHODOLOGY

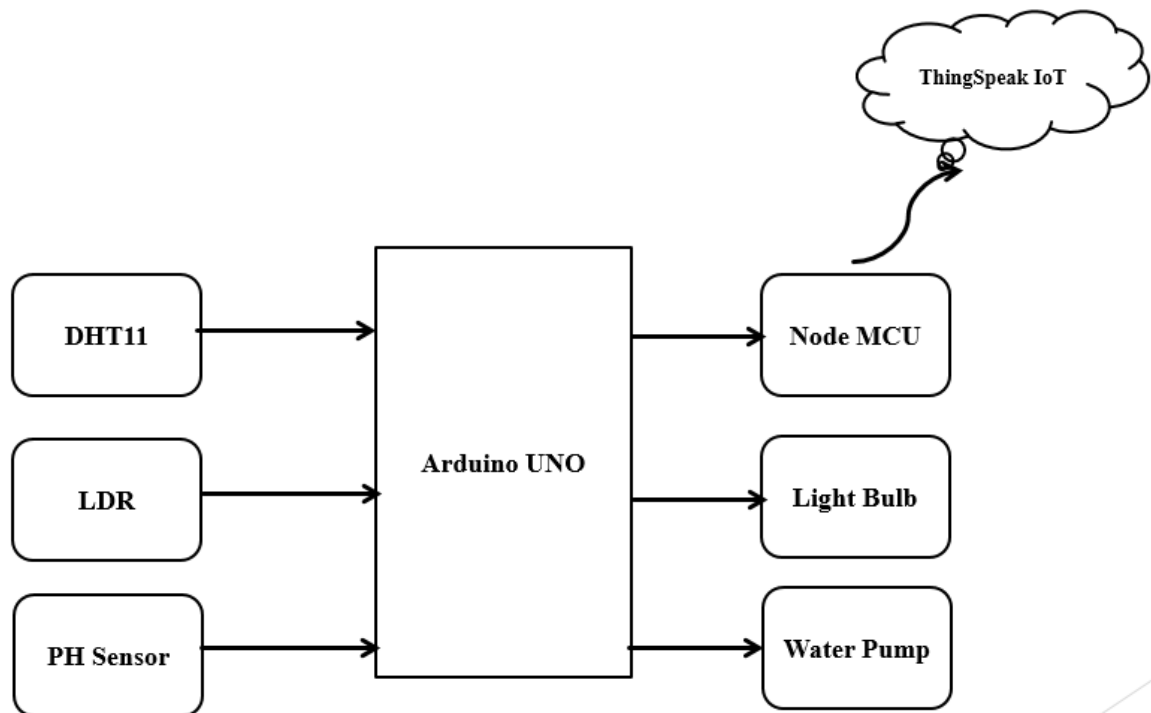


Figure 1 Block Diagram

Block Diagram Description

1. Sensors:

- pH Sensor: Determines if the nutrient solution is more alkaline or acidic.
- DHT11 Sensor: Keeps track of the growth environment's temperature and humidity levels.

- LDR Sensor: This sensor measures ambient light levels to control the lighting schedule.

2. Mechanism of Control:

- Arduino Microcontroller: Serves as the brains of the system, gathering information from sensors and applying control logic.
- 4-Channel Relay: Utilizes sensor readings to regulate appliances like pumps and lighting.

3. Usability:

- Light Control: Based on ambient light levels, lighting intensity is adjusted using data from LDR sensors.
- pH Regulation: Using a pH sensor to track levels, a water pump is triggered when pH rises above a certain point, modifying the pH of the nutritional solution.
- Humidity and Temperature Monitoring: Constantly measures the humidity and temperature using the DHT11 sensor to keep growing conditions at their best.

4. Data Visualization and Transmission:

- NodeMCU: Enables connection between cloud-based systems and Arduino.
- ThingSpeak: Gathers sensor data from the NodeMCU and offers options for remote monitoring in terms of storage and visualization.
- Virtual App: Provides control features for remote management and interfaces with ThingSpeak to display real-time sensor data.

In block diagram, the automated hydroponic system's components and their interactions are depicted in the block diagram. Environmental data is collected by sensors, and the Arduino processes it to manage pH levels and lights. The Virtuino app and ThingSpeak allow for remote monitoring and control thanks to the NodeMCU's ability to communicate with external platforms.

IV. EXPERIMENTAL RESULTS



Figure 2 Mobile App

The Hydroponic Plant Monitoring System's user interface efficiently presents critical environmental metrics required for hydroponic plant production. The interface displays 30.00 degrees Celsius for the temperature, 58.00% for the relative humidity, and 33.990 for the pH level—a figure that seems very high and could be the result of a measurement error. Furthermore, there is a symbol of a lighted light bulb that indicates the light intensity, indicating that the plants have sufficient lighting. To improve readability and speed of recognition, each parameter is color-coded: orange for

temperature, yellow for humidity, red for pH, and blue for light intensity. The colors are displayed against a dark background. By making it simple for users to keep an eye on and adjust the hydroponic system's parameters, its design encourages the best possible growth for plants.

V. CONCLUSION

To sum up, the creation of an automated hydroponic system that makes use of sensors, cloud-based platforms, and NodeMCU technology is a viable way to overcome the difficulties faced by contemporary agriculture. The technology offers multiple advantages by improving plant development parameters, conserving resources, and facilitating remote monitoring and control.

1. Efficiency: Automation reduces human labor and guarantees constant and dependable operation, which boosts plant cultivation efficiency. Examples of automated operations include pH adjustment, nutrition monitoring, and environmental control.
2. Conservation of Resources: Accurate management of water and fertilizer use, together with the capacity to recycle and reuse resources, support agriculture's sustainability and conservation of resources.
3. Scalability: The system's modular and adaptable design makes it possible for it to be scaled for both small-scale residential gardens and substantial business ventures.
4. Remote Monitoring and Control: Growers may enjoy the ease and accessibility of remote monitoring and control of their hydroponic system from any location with an internet connection thanks to integration with cloud-based systems.
5. Data-Driven Decision Making: Growers may optimize growth conditions and maximize crop yields by using real-time data collecting and analysis to make well-informed decisions.

All things considered, the automated hydroponic system is a noteworthy development in agricultural technology, providing a productive and sustainable means of cultivating plants under regulated conditions. Such systems have the capacity to completely transform the way we produce food via ongoing innovation and improvement, enhancing economic success, environmental sustainability, and food security.

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