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Smart Hydroponics System based on NutrientFilm Technique with array of sensors

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Abstract— **Due to hydroponic high yield and low water requirement, soilless farming methods like hydroponics are becoming more and more popular. Hydroponic systems may be made more effective and sustainable by integrating IoT (Internet of Things) technology since it can offer real-time monitoring and control. We offer an Internet of Things (IoT)-based hydroponic system in this work that employs sensors to gather data on water pH, nutrient levels, temperature, and humidity before sending the information to a cloud server. The cloud server subsequently examines the data, which ultimately gives the user feedback via a web application. The device also allows for remote management of the hydroponic system, allowing users to modify nutrient levels and track plant development from any location on Earth. Our results from a pilot study we did to assess the efficacy of the IoT-based hydroponic system demonstrate that the system was able to maintain the plants' ideal growing conditions, leading to enhanced growth rates and yields. Our research suggests that integrating IoT technology into hydroponic systems might boost sustainability, save costs, and increase efficiency, making it an attractive contemporary agricultural alternative.**

Keywords—hydroponic farming, Internet of Things, Microcontroller.

I. Introduction

Our findings from a pilot study we conducted to evaluate the effectiveness of the IoT-based hydroponic system show that the system could maintain the plants' optimal growing conditions, resulting in improved growth rates and yields. According to our research, incorporating IoT technology into hydroponic systems may improve sustainability, reduce costs, and promote efficiency, making it a desirable modern alternative to traditional farming.

Additionally, inadequate irrigation systems, conventional methods of soil analysis, and conventional cultivating equipment greatly hampered agricultural production. As a result, agriculture desperately needs new methods and unconventional approaches. A new method that uses no soil and a little amount of fertilizer solution is hydroponics. The Indian hydroponics market was valued at Rs. 35 crores in 2019; by 2023, it is projected to rise by roughly 26%. It utilizes 90% less water than traditional soil-based farming methods. Hydroponically produced lettuce produces twice as much in 28–30 days as traditionally grown lettuce in the soil does in 60 days. With 1,500 plants, hydroponic farming would use about 20 litres of water each day as opposed to 200 litres with soil-based farming.

In this project, we will use the Nutrient Film Technique (NFT), a hydroponic method that involves recirculating bare plant roots in channels with sufficient air exposure in extremely shallow water containing dissolved nutrients needed for plant growth. The NFT offers certain benefits, including lower nutrient use, quick plant development, increased production, and improved product quality. Therefore, introducing the suggested NFT technology might be advantageous to farmers. Using a sensor array managed by an Arduino microcontroller, we will automate our NFT system.

Here, we will use Tomato to evaluate the effectiveness of an automated NFT system. Important factors including temperature, humidity, adjusting pH value, regular nutrient solution flow, and nutrient solution level in the module will be automatically managed by employing inexpensive sensors.

II. METHODOLOGY

To construct this system to meet the needs of the farmer, relevant theoretical and system design ideas were used. The research employed the following methodologies:

A. Hardware

Figure1(a): Arduino Uno development Board

Figure1(b): Node MCU ESP

In this specific project, the Arduino Uno serves as the microcontroller, as seen in figure 1(a). The combined coding will be able to read and write all of the data, as well as make sure that all of the sensors are operating as intended, thanks to the Arduino standard.

The Node MCU ESP8266 is used as a Wi-Fi module. By Figure 1(b), the ESP 8266 was capable of transmitting sensor data to the. Since it met the minimum requirements, this module was able to transmit all the sensor data through Wi-Fi.

Figure1(c): DHT22 Temperature and humidity sensor

Figure1(d): Ultrasonic sensor

The DHT22 is used as a digital temperature and humidity sensor as shown in figure 1(c) that can be used to measure the ambient air temperature and relative humidity in real-time. The DHT22 sensor consists of a capacitive humidity sensor and a thermistor that measures temperature. The sensor has four pins: VCC, GND, DATA, and NC (not connected). Connect the VCC pin to a 3.3V or 5V power source, the GND pin to ground, the DATA pin to a digital pin on the microcontroller. The DHT22 sensor can measure temperature from -40°C to 80°C with an accuracy of ±0.5°C, and relative humidity from 0% to 100% with an accuracy of ±2%. The sensor has a response time of 2 seconds for temperature and 2-5 seconds for humidity measurements.

The nutrient level in hydroponics is measured using an ultrasonic sensor. Ultrasonic sensors measure the distance between an object and themselves using sound waves. The sensor can be positioned above the nutrient solution in the case of hydroponics, and the distance it measures can be used to calculate the nutrient level. In order to maximize plant development, we may automate the process of nutrient monitoring and change the nutrient levels as necessary.

Figure 1(d): PH Sensor Kit

A pH sensor is a device that measures the acidity or basicity of a solution. pH is a measure of the hydrogen ion concentration in a solution and is expressed on a scale of 0 to 14, where 0 is the most acidic, 7 is neutral, and 14 is the most basic.

In hydroponics, pH measurement is crucial for ensuring optimal plant growth. A pH sensor can be used in hydroponics to measure the pH of the nutrient solution and determine if it falls within the desired range for plant growth. If the pH is too high or too low, certain nutrients may become less available to the plants, which can lead to deficiencies and poor plant growth.

B. Software

ARDUINO

Figure 2(a): Arduino IDE

2 (b) Cayenne

The Arduino Uno board and the ESP8266 Wi-Fi module are programmed using the Arduino IDE, as shown in Figure 5(a). The pH sensor, Ultrasonic sensor, and other sensors will all work with this software package's source code. The serial monitor output includes additional data, such as the attention value.

Cayenne is a powerful and user-friendly platform for building and managing IoT projects, offering a range of tools and features to simplify the process of creating and managing IoT solutions. The platform offers a range of tools and features that allow users to easily connect devices, monitor sensor data, and control devices remotely. Cayenne also includes features such as alerts, triggers, and scheduling, which allow users to automate tasks and respond to changes in sensor data in real-time. The platform offers secure communication through SSL/TLS encryption and provides a RESTful API, allowing users to integrate Cayenne with other applications and services.

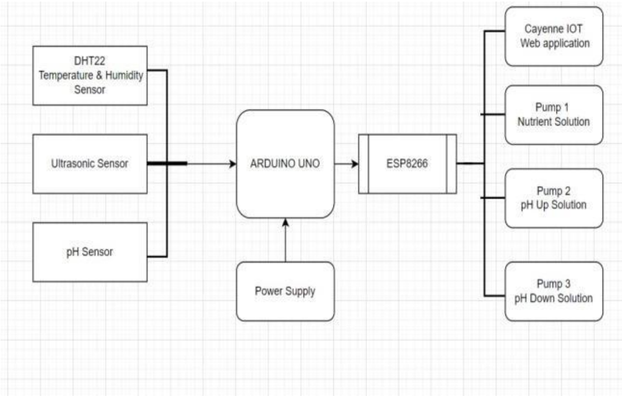

Figure 2(c): Block Diagram

A nutrient pump and the Cayenne IOT cloud will both get the results obtained by the microcontroller, an Arduino Uno and ESP 8266.

The system's block diagram is seen in Figure 2(c). The hydroponics system will be connected to the pH sensor, an ultrasonic sensor, a DHT 22 temperature sensor, and a humidity sensor. Through Cayenne, the data from all sensors will be tracked. A tomato plant will be utilised to test the system's effectiveness.

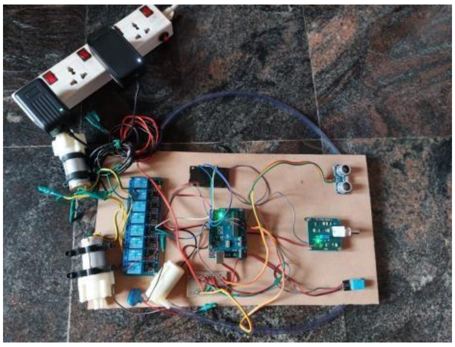

Fig 2(d) Hardware setup

Depending on their size and stage of growth, tomato plants in a Nutrient Film Technique (NFT) hydroponic system typically need between 3 and 6 litres of water per day, and up to 10 litres per day during the fruiting stage. It is important to monitor the water level in the hydroponic system regularly and ensure that the plants are not being over or under-watered. An ultrasonic sensor can be used to help maintain the correct water level in the hydroponic system. Additionally, it is also important to ensure that the pH and nutrient levels in the water are optimal for the growth of the tomato plants.

For tomatoes, a pH of 6.0 to 6.5 is ideal. The system will connect with Cayenne and inject a pH-down solution to the system to bring the pH level down if the pH sensor detects a value greater than 6.5. The pH level is crucial for the development of the plant.

The pH value is optimised using pH-up solution if the pH sensor detects a value less than 6.0.

III. RESULT

In this project, a prototype that uses Cayenne to detect pH, water level, temperature, and humidity in real time will be created. The data will be displayed, tracked, and managed in Cayenne. All data for each parameter will be graphed in order to analyze the variables that could have an influence on plant development and assess if such growth is consistent with tomato features.

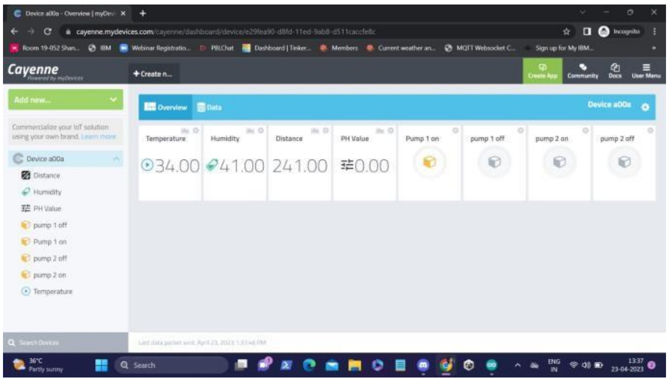

Figure 3(a): Cayenne web Dashboard

The DHT22 sensor's real-time reading of the ambient temperature is displayed in field 1 of the display. And field 2 displays the Dht22 sensor's reading of the ambient humidity. The success of hydroponic plants depends on keeping a constant temperature and humidity level, which is crucial to highlight. Variations in temperature and humidity can stress plants, which can have an adverse effect on their ability to grow and produce.

Figure 3(b): Temperature readings

Figure 3(b) shows the temperature value and 3(c) shows the humidity value from the DHT22 sensor.

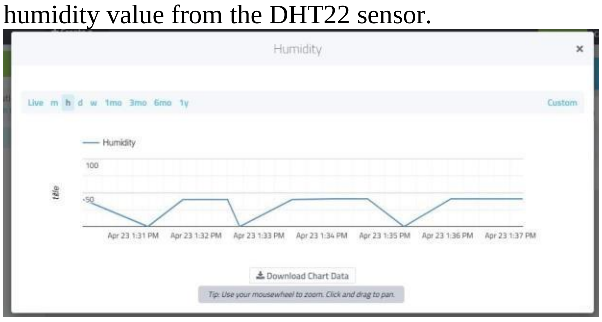

Figure 3(c): Humidity readings

The ultrasonic sensor in field 3 allows us to monitor the water level of the nutrient solution, and if it drops below the preset threshold, the system will immediately start pumping nutritional solution.

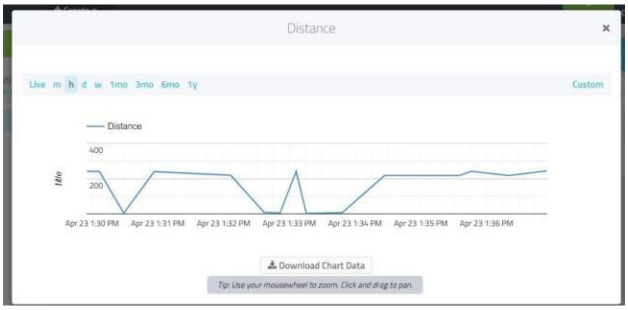

Figure 3(d): Ultrasonic reading

The ultrasonic reading is displayed on the Cayenne web dashboard in Figure 3(d). It is the level of the nutritional solution.

The pH reading of the nutrition solution from the pH sensor is displayed in field 4. If the pH value was over the suggested range, the plant's growth would be impeded. The worst-case scenario is that excessive fertilization will make the plant wilt. Therefore, we may control them by using the pH up and down buttons on the web UI.

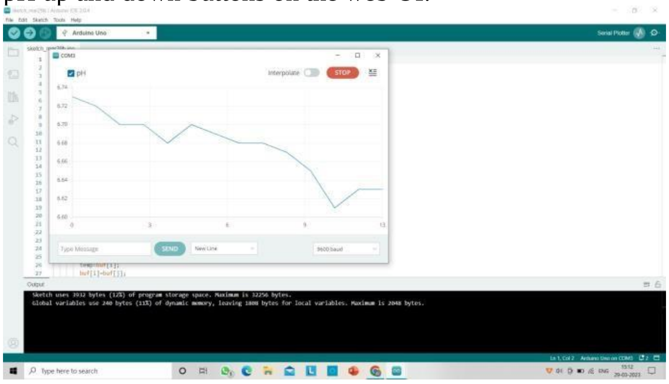

Figure 3 (e): pH range

Figure 3(e) displays a pH sensor reading of 6.73, which is higher than the tomato's ideal range. Therefore, the pH range is decreased when we push the pH-down button because the pH-down solution begins to mix with the nutrient solution.

Fig 3(f): Experimental Setup

IV. DISCUSSION AND CONCLUSION

Because of the Internet of Things and smart hydroponic systems, people now have an excellent platform for tracking and monitoring their plants and garden surrounds. The smart irrigation system, together with the hydroponic system, may be operated by the user via the Cayenne IoT Cloud by continuously updating the state of the garden. This study demonstrates a more effective method of regulating and monitoring hydroponic system activities than the prior approach.

Finally, the hydroponics system was constructed effectively employing Cayenne real-time data via the Internet of Things. The technology regulates the level of nourishment automatically and provides a graphical user interface for easy maintenance and control. This project can be used to create a hydroponics prototype. Data such as pH, water level, and water temperature were analysed and validated in this study to verify they met the criteria for Tomato's attributes. The testing procedure yielded good results, and the implementation is practical, resulting in an increase in productivity.

As part of a future study that will expand the system to include more helpful and flexible linked devices, data mining techniques will be used to assess and forecast data regarding the amount and quality of the plant.

V. ACKNOWLEDGMENT

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VI. REFERENCE

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