IoT Based Monitoring of Environment in a Smart Hydroponic System

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***Abstract*— The amount of usable agricultural land is gradually diminishing as industrialization progresses. To address the challenges of unsuitable soil in certain areas, hydroponic farming has emerged as a viable solution for producing fruits, flowers, and vegetables. This soilless gardening technique is especially useful in large greenhouse operations for growing exotic crops. We cannot grow all the plants and vegetables in extreme weather conditions. Few species cannot tolerate this kind of extreme condition. In this manuscript we have designed a methodology in which we can grow plants and vegetables indoors. We have used a hydroponics system in this manuscript. Hydroponics is a type of system in which we grow plants and vegetables without using soil. We have used microcontrollers and sensors to make this system fully automated. We have implemented things for the analysis of the growth of plants in hydroponics technology.**

Keywords—hydroponics, temperature, humidity, IOT, automation

I. Introduction

Agriculture is one of the primary sources of livelihood throughout the world. The technologies for the same have been changing day by day. IOT is one of the recent technology which has been mainly used for monitoring and control purposes in modern agriculture. There have been tremendous efforts in the development of IOT-related technologies in recent years [1]–[5]. IoT has been used in the agricultural domain for various purposes including monitoring [6], [7]. Sridhar and Rao [8] have suggested a system that uses sensor data to determine the amount of water needed for irrigation. Two sensors communicate daily with the base station, sending information about the soil's temperature, humidity, and length of daylight. The suggested method calculates the amount of water required for irrigation based on these factors. The key advantage of this system is how well it integrates cloud computing with a smart irrigation system, which will maximize the use of water and fertilizer while boosting crop output. It will also aid in field weather analysis. Saraf & Gawali [9] has suggested the connecting of numerous devices is referred to as the Internet of Things (IoT). Each item is connected to every other with a unique identity in order to transfer data without requiring humans. It enables the creation of solutions for improved natural resource management. According to the IoT concept, smart objects with sensors incorporated enable interaction with the logical and physical worlds. In this research, an IoT-based system that employs real-time input data is proposed. Utilizing a wireless sensor network, a smart farm irrigation system employs an Android phone for remote drip monitoring and control. Nawandar & Satpute [10] has proposed a monitoring and autonomous irrigation system for greenhouses, gardens, and farms that can detect crop water requirements, alert the irrigation unit and user, and offer real-time and historical farm data. It also achieves optimal water utilization by employing an autonomous irrigation system for plants while taking into account the demands of the plant and the soil. Suma et al. [11] have offered details on the various environmental components that the data collection has shown. Monitoring environmental factors alone will not suffice to maximize agricultural output. Other variables can also contribute considerably to productivity loss, hence automation is required to handle these challenges. An integrated system is critical for managing all of the components affecting productivity at all levels and giving a solution to these challenges. However, due to a number of difficulties, agriculture cannot be completely automated. Even when automation is used in research, farmers cannot access it as a product to take advantage of its resources. So, the goal of this research is to create an intelligent IoT system for agriculture that farmers can use.

Hydroponics is one of the recent technologies to be used in agriculture for growing various types of vegetables and fruits. Monitoring of the environment is one of the important things important for the health of plants. Various technologies have been proposed in this area [12]–[14]. The work by Rahmatia et al. [15] talks about Zigbee-based communication for monitoring hydroponic systems. The authors in [16] proposed a user-friendly approach where one can monitor the vitals of the environment with the help of a phone app. In a hydroponics system, we place plants in a solution that includes nutrients like nitrogen, phosphorus, potassium, and water without using soil. In a traditional hydroponics system, we have to set parameters like the EC and PH of the water before arranging the hydroponics system [17]. Parameters like air, temperature, and humidity cannot be controlled. But in this manuscript, we can control these parameters by using a microcontroller [18]. The aim of this manuscript is to increase the effectiveness of the hydroponics

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systems and create an automated system for the indoor growing of plants and vegetables. These parameters are very important for the healthy growth and development of plants and vegetables. In this method, first, we have to prepare a nutrient solution according to the needs of the plant that we are growing and mix that solution in the water. After that, take a pre-grown plant and keep that plant in water such that half of the plant root should dip in the water. If we maintain parameters like temperature, humidity, etc to the required level, then we can see faster and healthier growth of plants as compared to ordinary growth.

II. Proposed Methodology

The main aim of this manuscript is to make a system that is affordable and fully automated. After placing the plant in water no human interference is required in this system. The other aspect of this manuscript is that it is simple and easy to use.

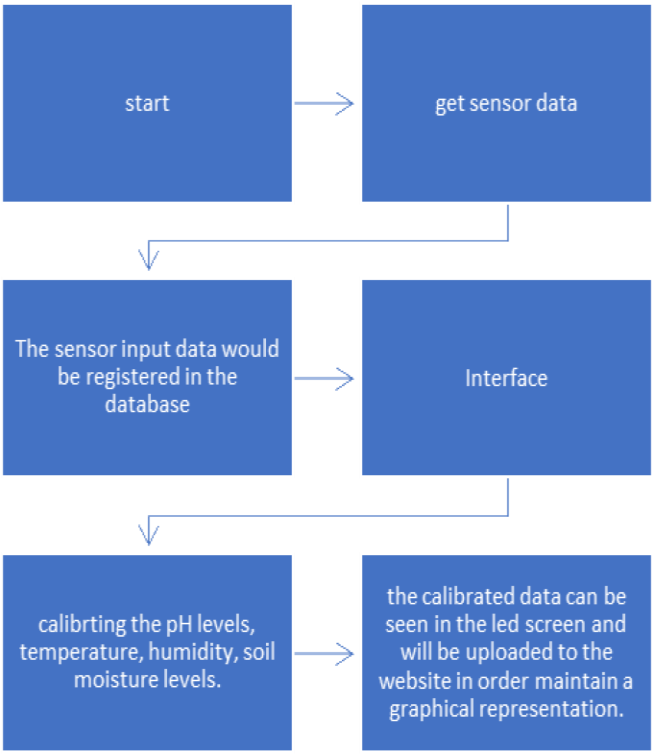


Fig. 1. Schematic block diagram of proposed methodology.

The system depicted in Figure 1 has been fully automated, utilizing several sensors, microcontrollers, and IoT technology for online monitoring and control. The system receives data from the sensors and makes the necessary adjustments to make sure all parameters stay within the desired range. In this manuscript, we have grown spinach plants. The climate conditions considered for this system are as follows:

Humidity levels ranged from 40% to 70%, pH values between 5.5 to 6.6, EC values between 1.8-2.3, and PPM values between 1260 to 1610. Temperature requirements vary as follows:

The highest temperature that is recommended for this system is 75° Fahrenheit, while the optimal day cycle temperatures are 65-70° Fahrenheit and the optimal night cycle temperatures are 60-65° Fahrenheit. The seed storage temperature should be kept between 40 to 70° Fahrenheit.

The proposed system uses one Arduino microcontroller to take data from different sensors onto the IoT network using the Wi-Fi module. We have used a breadboard for circuit building. Temperature and humidity are measured by the DHT11 sensor. DHT11 sensor has four pins. The power supply is connected to the first pin, and the second pin is used for data entry. The fourth pin is connected to the circuit ground, and the third pin has no particular function in this context. One three-pin resistor (potentiometer) is used to control voltage. Temperature and humidity can be seen on the LCD screen that is used in this system as shown in Fig 2.

Fig. 2. Experimental setup for proposed methodology.

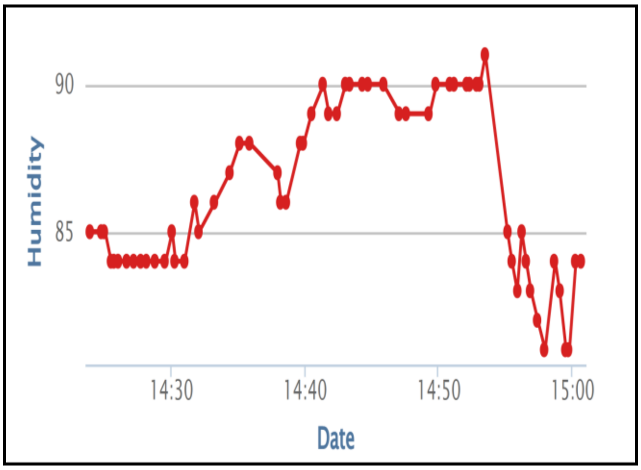
III. Experimental Results

The system is built with NodeMCU, which is coded with the Arduino IDE. In this system, Thingspeak software is used. It is an IoT analytics platform that is used to visualize live data in the cloud. Sensors send data to the cloud with the help of Thingspeak software. The data for temperature, pH and humidity has been in Fig 3. The figure shows the variation of these quantities for particular day. In this way continuous monitoring of hydroponic system environment can be done. The system employs an Arduino board to analyze and control the received data. One DHT11 sensor is used to measure temperature and humidity. The microcontroller will take input with the help of sensors and send this data to a Wi-Fi network using the Wi-Fi module (ESP8266).

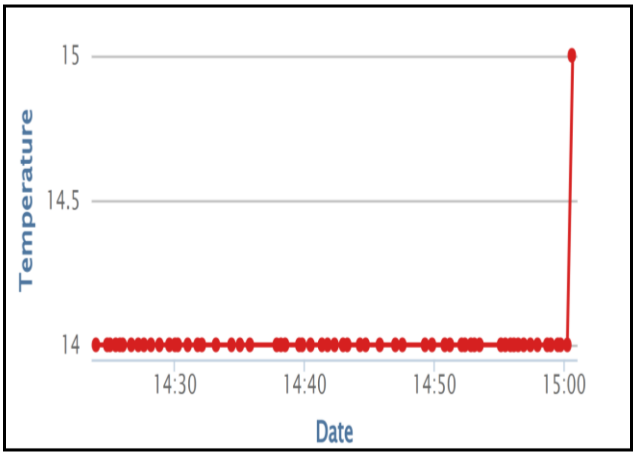
To detect the required amount of nutrients, we have used a PH sensor. We can know the deficiency of nutrients by different values of PH. There are three pins on the pH sensor interface circuit. We have connected these pins to the Arduino board with jumper wires. The first pin is connected to the power source (5V), the second to the ground (GND), and the third pin is linked to the A5 analog pin of the Arduino UNO. The humidity, temperature and pH can be monitored via these sensors mentioned above. We have created different values of the PH level that indicate deficiency in various nutrients: -

If PH <5.5, then we add pH up

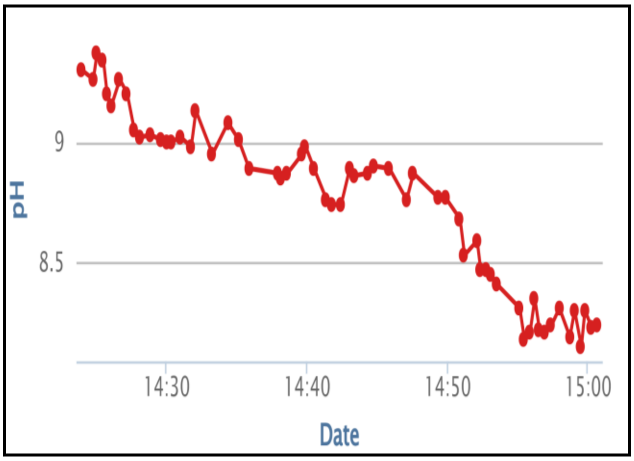
If PH >6.6, then we add pH down



(a)



(b)



(c)

Fig. 3. Variation of (a) humidity, (b) temperature and (c) pH level as displayed on the Thingspeak interface.

The data from the sensors can be accessed on the Thingspeak software. The data is updated at regular interval and is displayed for each day at regular intervals. The data related to temperature of the environment is shown in Fig 3 and is evident that the progression of temperature from 20 to 22 as night turns into day. The maximum temperature for spinach should not exceed 23.88 °C. The optimal daytime cycle temperature should be 18.33°C to 21.11°C, and the optimal night time cycle temperature should be 15.6°C to 18.33°C. During the germination of seed, we must maintain a temperature between 15.56°C and 18.33°C. The optimal pH value required for spinach is (5.5–6.6) . The log of pH is seen in figure 3. As pH increases, it indicates a decrease in nutrients, which can be maintained by adding nitrogen it being acidic in nature. The pH and humidity values are available due to the sensors as visible in Fig 3 (a) and (c). Humidity and pH can be monitored in real time and corrective action can be taken as required for perfect growth of plants.

IV. CONCLUSIONS

The manuscript talks about the IOT based monitoring of hydroponic system. To overcome the multi-manifestations of climate change, the scarcity of freshwater, and the pressing need to meet the growing food demand, we can use the hydroponics system. The solution is cost effective and can be extended for large systems easily. The system can be extended to automated control of parameters incorporating Artificial Intelligence techniques. This proposed solution aimed to develop an automated hydroponics system. The cost of this system is very low and can be operated by an average user. All the parameters required for the test plant will be maintained by this hydroponic system. The results presented at the end confirms the validity of the proposed methodology. .

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