International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 08 | Aug 2022 www.irjet.net p-ISSN: 2395-0072

Smart Aeroponics Using IoT

Issac K Joy[1], Christy V Vazhappilly [2]

[1] PG Student, Industrial Automation and Robotics, Jyothi Engineering College Thrissur, Kerala, India.
[2] Assistant Professor, Mechanical Engineering, Jyothi Engineering College Thrissur, Kerala, India.

Abstract - *Urban farming has been increasingly popular recently as society has become more conscious of the quality of the food it consumes. One urban farming method that uses air as a growing medium is called aeroponics. Compared to hydroponic or conventional farming, aeroponics enables a significant reduction in water usage with enhanced yield. This work presents a design and implementation of an Aeroponics system that employs the Internet of Things (IoT) for online and automated monitoring capability. The pH level of the solution in the tank is maintained using a pH sensor. The AM1011A sensor is used to meticulously track the temperature and humidity in this chamber. With the use of a peristaltic pump, the liquid level sensor is employed to liquidate the tank level. All of these operations are precisely timed and published to the ThingSpeak Platform and Blynk App for user engagement using the Atmega 328P Microcontroller and ESP 32 Wi-Fi module.*

Key Words: Aeroponics, Liquid Level Sensor, ESP 32 CAM, AM1011A, Atmega328P.

1. INTRODUCTION

The foundation of organic farming is the soil. However, soil degradation and nutrient contamination are some of the unfavorable effects of soil-based agriculture on the ecosystem. This encouraged scientists to create urban agricultural techniques. Aeroponics, which substitutes the air for soil as a growing medium, is one of the most promising techniques. Without using soil or a bulk media, aeroponics is the practice of growing plants in an atmosphere of air or mist. The Greek words for "air" and "labour," ponos, are where the word "aeroponics" comes from.

Contrary to traditional hydroponics, aquaponics, and plant tissue culture growing, aeroponics culture is unique. Aeroponics doesn't use a growing medium like hydroponics or aquaponics, which use water and fish waste to support plant development and a liquid nutrient solution as the growing medium. Given that nutrients are transferred through water in aeroponics, it is occasionally regarded as a form of hydroponics. The changes in the food industries have been driven by a significant rise in global health consciousness over the past two decades. The general public is now more conscious of food quality issues including nutrition and safety.

Urban gardening has been increasingly popular recently as society has become more conscious of the quality of the food it consumes. One urban farming method that uses air as the growing medium is called aeroponics. Compared to hydroponic or traditional farming, aeroponics enables a significant reduction in water usage with greater yield. The Internet of Things (IoT) is used in this work to build and implement an aeroponics system with online and automated monitoring capabilities.

1.1 Existing System

In the current aeroponics method, plants are often placed inside a sealed container and inserted into the platform top holes on top of a reservoir. You must make a support collar that will hold stems in place because there is no root zone material for plants to anchor in. These collars must be both hard and flexible to provide room for root growth while supporting plants upright and holding the roots in place. The pump and sprinkler system creates vapour from the nutrient-rich solution, a hydro-atomized spray of water, nutrients, and growth hormones, and sprays the mist in the reservoir, engulfing and absorbing the dangling plant roots.

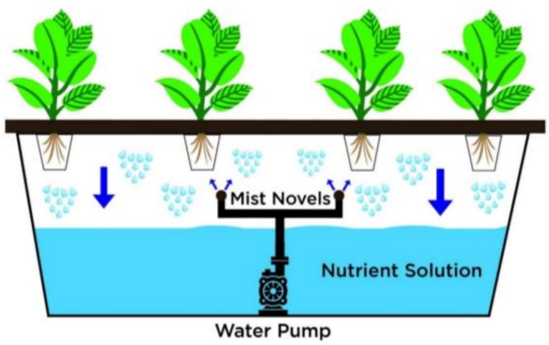

Fig 1: Existing System

1.2 Problem Statement

The current situation we face in systems or in household farming is one where land is needed and where the land soil should be suitable for farming. The second one is that sufficient water supply is required for farming. These two major problems will change through this aeroponics farming. In current aeroponics farming there are also drawbacks, like there is no monitoring system, no user interaction etc. This project provides a solution for that. The project is based on Arduino UNO and a mobile application to control this farming. The main focus of this project is to remove the limitations by creating an IoT-based monitoring system that handles this task autonomously. The user is free to do this physically demanding and time-consuming task.

1.3 Aim and Objectives

This project's major goal is to create an inventive aeroponics agricultural automation model employing microcontrollers and web/mobile applications. This technique will improve the aeroponics farming's operating effectiveness. The pH level and water level in the tank will be maintained by this automated model. Additionally, it keeps the aeroponics chamber at ambient temperature to promote a better growing environment. With the use of an IoT platform and smart devices, users can effortlessly monitor farming without the need for manual intervention.

The objectives of this project are:

1. To develop a prototype that maintains the pH level, temperature level and water level.
2. To design the project without any user interaction is required after it's turned ON.
3. To develop an IOT based monitoring system and update daily reports to reduce user maintenance.
4. To make the prototype environmentally friendly, as the only resource needed is electricity which is stored in its battery.

2. LITERATURE SURVEY

Today's agricultural development technologies are not only sophisticated and clever, but they have also increased the use of resources like labour, land, and other natural resources. The most recent innovation for automation in the aeroponics system is not only encouraged but also widely recognized and employed because it is a very fresh concept of cultivation and requires additional expertise and technology assistance. A lot of research has gone into automating the aeroponics system.

Adache Paul et al.,2022 [1] This system's independent automated structure for indoor small farming in urban areas does not require soil or manual watering. This mechanization will stimulate the provision of fresh product in a set quantity to those who aren't even actively engaged in gardening, and it will also allow for the monitoring of system status using a web service that provides parameter data. They came to the conclusion that the system would become more effective and exact by adding a pH sensor, which would also measure the nutrient solution's quality. The system would then become even more automated at that point.

Jositha C et al.,2021 [2] They have suggested an Internet of Things Hydroponics Agriculture Using Web/Mobile Applications for this project. The monitoring, control, and delivery of the plants' nutritional and water needs are all done using Internet of Things (IoT) technology. According to the findings, the plants did well under the nutritional and environmental conditions that they were subjected to for a period of six weeks. These can be seen in the visual inspections and computer vision employed as proof of plant growth.

Jamhari C A et al.,2020 [4] This project successfully built and deployed an IoT System for Aeroponics Chamber Temperature Monitoring. This system carried out online, real-time monitoring of the temperature and light level. The temperature within the root chamber increased to 32.9 °C with no controls. The root chamber temperature was carefully controlled, yielding an average value of 28.8 °C, well within the range for optimal plant growth. Water spinach was used to test the technique, and the findings revealed that the plants flourished inside the aeroponics chamber.

2.1 Conclusion Based on Literature Review

The following information has led me to conclude that adding automation to the current aeroponics model is necessary for improved performance. I've seen a few problems that need to be resolved for a better system. They are:

- No temperature, humidity, or pH level monitoring or feedback mechanism is available to the user.
- In comparison to the current system, the growth pace is quite slow.
- The water supply to the plants is not automated using a timer.
- There is no automatic method for the tank's water level to be refilled.

In order to make it automated, I have included some of my thoughts; this project is detailed through successive chapters.

3. MATERIALS AND COMPONENTS DESCRIPTION

3.1 Materials

3.1.1 70 Liter plastic container Box

This is the main material which is used in this project for the storage tank. The product is made up of plastic material and is clear in color. It consists of dimensions 62x45x38 cm (L*W*H), a which is in the shape of a rectangle.

3.1.2 PVC Pipe

The nutrient solution is transported using PVC tubing, which is also used to link the submersible head and water sprinklers. 3 meters of length and 25mm diameter of PVC pipe are used in this project.

3.1.3 Micro Sprinklers

Minute-sprinklers are used to create micro droplets that are sprayed on the plant roots. This Micro Sprinkler sprays a 360° mist that rises. It has a flow rate of 40-60 liters per hour and a working pressure of 0.8-1.5 bars.

Fig 2: Micro Sprinkler Nozzle

3.2 Hardware Components

3.2.1 ATmega 328P Microcontroller

Fig 3: ATmega 328P Microcontroller

In this project a microcontroller board called Arduino Uno is based on the ATmega328 is used. It contains 6 analogue inputs, 14 digital input/output pins (of which 6 can be used as PWM outputs), a USB port, a power jack, an ICSP header, and a reset button.

3.2.2 ESP32 CAM and Wi-Fi Module

Fig 4: ESP32 CAM and Wi-Fi Module

The ESP32-CAM has a very competitive camera module. ESP32-CAM is a small-sized, low power consumption camera module. The AF2569 camera module consists of 2 MP resolution and provides an onboard TF card slot.

3.2.3 Potential of Hydrogen (pH) Sensor

Fig 5: Gravity Analog pH Sensor

Potential of Hydrogen is what pH stands for. It describes the quantity of hydrogen ions present in a solution. A pH sensor, which ranges from 0 to 14pH, aids in determining the water's acidity or alkalinity. We employ a gravity analogue pH sensor with a response time of under a minute and an accuracy range of 0.1pH in this project. To interface with the microcontroller and receive the input signal from the pH sensor, it has a BNC connector.

3.2.4 Liquid Level Sensor

In this project, the liquid level is checked using a non-contact liquid level sensor. The water induction capacitor can be equipped with an intelligent non-contact liquid level sensor to determine if it is filled with liquid. The sensor is an XKC-Y25 PNP model. Operating voltage ranges from 5 to 12 VDC. It has a 50 cm wire length and a 4 pin connector.

Fig 6: Liquid Level Sensor

3.2.5 4-channel Relay

The 4 Channel Relay Module is a handy piece of equipment that may be used to manage high voltage, high current loads such AC loads, motors, etc. Each channel on this 5V, 4-channel relay interface board requires a 15-20mA driving current.

3.2.6 Temperature/Humidity Sensor Module

An affordable digital temperature and humidity sensor is the AM1011A. It measures the humidity in the air using a thermistor and a capacitive humidity sensor, and it outputs a digital signal on the data pin. It is quite accurate, has strong long-term stability, is simple to use, and performs well.

Fig 7: AM1011A Sensor

3.2.7 Peristaltic Pump

In this project I have used two 12V of NKP-DC-S10D Mini as the Peristaltic Pump. There won't be any direct touch with the liquid when it's being pumped. Contrary to most pumps, peristaltic pumps create the pump action by compressing a silicone tube. This pump can provide a flow rate of up to 80 ml per minute and requires a 12 V DC input.

Fig 8: Mini Peristaltic Pump

3.2.8 Submersible Pump

Fig 9: Sunsun JQP 1000 Submersible Pump

In this project I have used Sunsun JQP 1000 series submersible pump and it's placed directly in the tank. They suck out the nutrient solution from inside the tank itself. The power rating of this pump is 14 W. With a flow rate of 1000 L/hrs and it can lift 1.4-meters.

3.2.9 Cooling Fan

Its main purpose is to maintain the temperature level in the plant. An 8025 5V cooling fan is used in this project. With simple mounting, it is incredibly simple to install and uninstall.

3.2.10 Lithium-Ion Battery

In this project, a rechargeable 18650 batteries with a voltage of 12 V and a charge capacity (C) of 2200 mAh is employed. This battery includes a Low self-discharge feature and may be fully charged in 40 to 90 minutes.

3.3 Software Requirements

I utilized the Arduino IDE for Arduino programming, the ThingSpeak online platform, and the ThingView App to display the previous and present sensor output values in this project.

4. WORKING

4.1 Block Diagram of the Proposed System

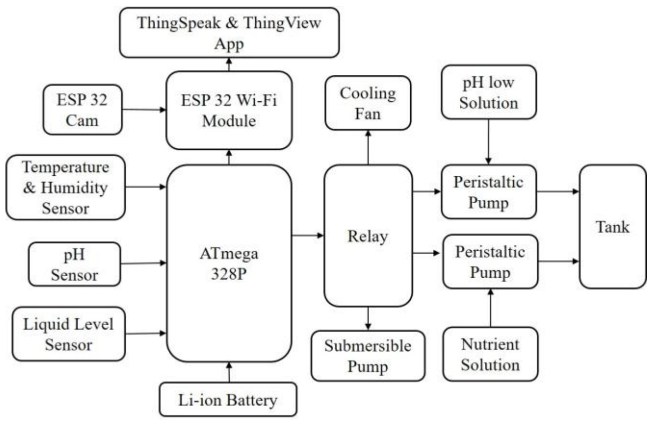

Fig 10: Block Diagram

ATmega 328P is used to control all over the actions in this system. It will give proper timing and duties to the corresponding components on the bases of program which upload in it. Relays are used to give power signal to the output devices like pump, fan, etc. on the basis of microcontroller signal. ESP 32 Wi-Fi module is used as a mediator to send the input sensor data to the ThingSpeak platform and to ThingView app. pH sensor is used to measure the PH value in the water and maintain it as neutral point. If pH value is changed it will be normalized by activating peristaltic pump. Temperature & Humidity sensor is used to measure air temperature in the system If it is not within the normal range, the cooling fan gets activated to bring the temperature to the normal range. Non-contact Liquid Level sensor is used to maintain the water level in the tank without direct contact to the water.

4.2 Nutrients Requirements

1. Master blend
   - Nitrogen (N): 19g
   - Phosphorous (P): 19g
   - Potassium (K): 19g
2. Calcium nitrate: 15 g
3. Epsom Salt: 2.5g

For solution A: Take 100ml of water, add 15ml of NPK, then add Epsom Salt of 7.5ml.

For solution B: Take 100ml of water, add 15ml of Calcium Nitrate.

Nutrient Solution: Add 4ml of solution A and solution B to 1 liter of water for getting the final nutrient solution, for this experiment, I used 20 liters of water.

4.3 Working

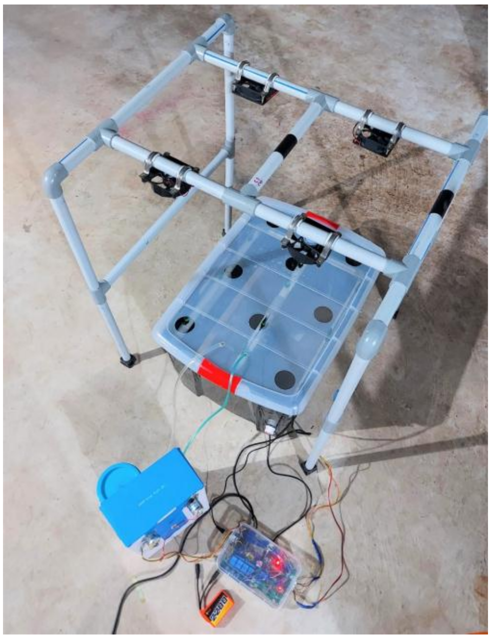

Fig 11: Final Setup Model

The pH value of the nutrition solution is determined in this project using a pH sensor. Using a peristaltic pump and a pH-low fluid, a high Ph value can be reduced. The submersible pump's head level is maintained by the liquid level sensor. Peristaltic pumps are used to maintain the level when it has been decreased. By using a cooling fan, the AM1011A sensor keeps the space at a constant temperature. Cooling fans turn on when the temperature range exceeds 30°C and stay on till it does. Circuits are opened and closed using relay mechanisms. Submersible pump will be triggered by a relay circuit with a time sequence of 20 seconds ON and 2 minutes OFF, and it will run. For user interaction, the ESP 32 CAM is employed. The ThingView app will display the current pH value, temperature, and humidity value. On the ThingSpeak web platform, a day-by-day chart of pH, temperature, and humidity will be displayed.

5. RESULT AND DISCUSSION

After series of testing of the automation system, it was seen that the microcontroller device collected data from all the sensors and devices which is attached to it and transmitted to ThingSpeak Web platform and ThingView App.

5.1 Atmospheric Temperature sensor

Fig-12 shows atmospheric Temperature sensor data on ThingSpeak platform.

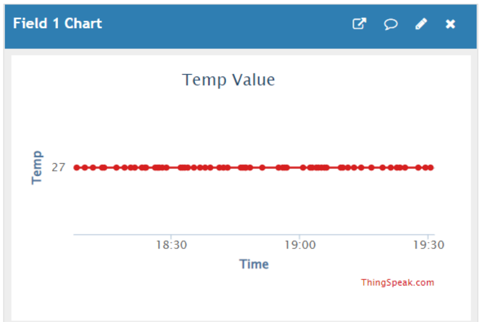

Fig 12: Atmospheric Temperature Sensor Data

5.2 Relative Humidity sensor

Fig- 13, shows relative humidity sensor data on ThingSpeak platform.

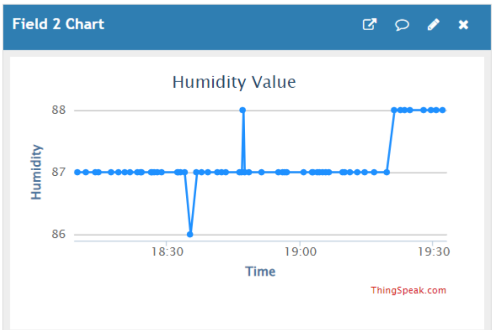

Fig 13: Relative Humidity Sensor Data

5.3 Potential Hydrogen (pH) Sensor

Fig-14, shows pH sensor data on ThingSpeak platform.

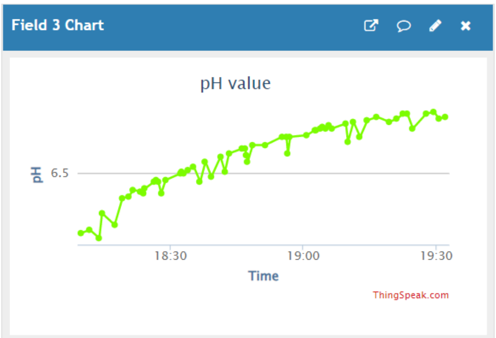

Fig 14: pH Sensor Data

5.4 ESP 32 CAM

Fig 15: Computer Visual using ESP32 Cam

During the series of tests done, ESP 32 CAM successfully gathered and transferred the necessary data about the plant's growth to the mobile application domain. We can stream live video of our farms by connecting to the 192.168.81.39 IP address with our web browser.

5.5 Plants Growth Evaluation

In this Project, I have done the plant evaluation using the plant growth attribute. From the direct visual look, we can see that, the plants height is good. The color of the plants is green. The leaf weight and height are very fantastic, an indication that the formula used to grow the plant is very rich.

Fig 16: Direct Visual Look

I have actually planted four varieties including: Mint, Cowpea, Lady finger and Chili to check if all of them can grow together using the same nutrient solution formulation. And from the result, it is clear that they can be grown together using the same formulation because they all responded well. The planted crops are monitored and controlled them for 15 days The computer vision used in the implementation of the plant growth evaluation was based on the acquisition and application of ESP32 CAM microcontroller. Fig 16 show the results of the evaluation of plant growth.

5.6 ThingView App

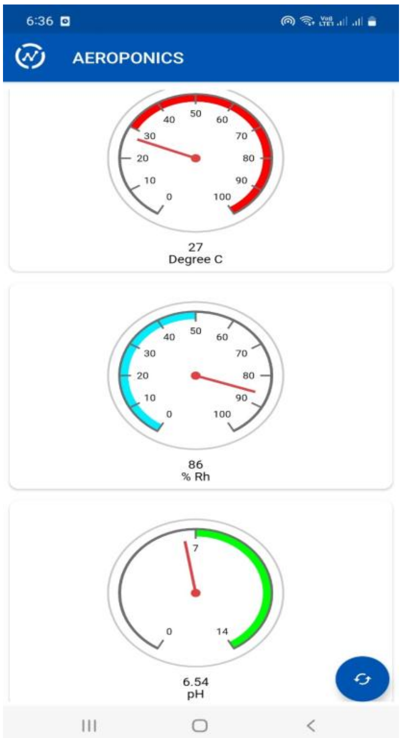

Fig 17: ThingView Domain Data

The current temperature, humidity, and pH value are displayed on this platform. Throughout the series of tests done, these sensors effectively collected and delivered the needed data to the microcontroller.

5.7 ADVANTAGES AND DISADVANTAGES

Advantages

1. The pH level is preserved.
2. The temperature is managed.
3. The water level is retained.
4. User engagement is high.
5. Requires less attention.

Disadvantages

1. When the electricity goes off, the entire system shuts down.
2. High initial cost.
3. Manual work should be used to begin the preparation.

6. CONCLUSION

A smart aeroponics agriculture using IoT has been suggested for this project job. The monitoring, control, and delivery of the plants' nutritional and water needs are all done using Internet of Things (IoT) technology. According to the findings, the plants did well under the 15-day nutritional and environmental conditions that were applied. Healthy roots grow as a result of the microcontroller and submersible pump timing sequence used to deliver nutrients to the plants. These are demonstrated by both computer vision and optical inspection of the figures 15 and 16, which are utilized as proof of plant growth.

With the help of the peristaltic pump's pH-low solution, the pH sensor was able to keep the tank's pH level constant. The non-contact liquid level sensor operates admirably as well. Using a peristaltic pump, it replenishes the water level based on the lack of water. The AM1011A sensor performs better at detecting temperature and humidity, and when the temperature rises too high, it activates the cooling fan. The platforms ThingSpeak and ThingView are used to record and effectively visualize all sensor data. The ESP 32 Cam performs quite well while testing. While using camera and the IP address 192.168.81.39 to view it in my web browser, I can easily keep an eye on farmland and its surrounds. The plant growth that is placed in an aeroponics chamber under 15 days thanks to the performance of all the sensors achieves my goal successfully.

REFERENCES

[1] Adache Paul, Dr. Aminat Ajibola, Dr. Emmanuel, “Internet of Things Hydropnics Agriculture Using Web/Mobile Application”, International Research Journal of Engineering and Technology (IRJET), 2022, Volume 09, issue 02.

[2] Jositha C, Kovur Sarath Kumar, P Kanakaraja, “An Eye On Hydroponics: The Iot Initiative”, International Conference On Electrical Energy System (ICEES), 2021.

[3] Nivesh Patil, Shubham Patil, Animesh Uttekar, “Monitoring of Hydroponics System Using Iot Technology”, International Research Journal of Engineering and Technology (IRJET), 2021, Volume 07, issue 06.

[4] Jamhari CA, Wibowo WK, Annisa AR, Roffi TM. “Design and implementation of aeroponic chamber temperature monitoring”. Third International Conference on Vocational Education and Electrical Engineering(ICVEE) 2020, Oct 3 (pp. 1-4). IEEE.

[5] Herman, & Surantha, N, “Intelligent Monitoring and Controlling System for Hydroponics Precision Agriculture”, International Conference on Information and Communication Technology (ICoICT), 2019.

[6] Ajibade L. T. & Oyeniyi S. T., “Soilless Farming-A Key Player in the Realization of “Zero Hunger” of the Sustainable Development Goals in Nigeria”, International Journal of ecological Science and Environmental Engineering (IJESEE), 2018.

[7] Lakhiar, Imran Ali, et al. "Modern plant cultivation technologies in agriculture under controlled environment: A review on aeroponics." Journal of plant interactions 13.1 (2018): 338-352.

[8] Kumar, Nirdosh, and S. L. Shimi. "Smart farming system for Indian farmers using Arduino based technology." International Journal of Advance Research, Ideas and Innovations in Technology 3.1 (2018): 105-110.