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Aeroponic Spring Onion Monitoring System using IoT Platform

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Abstract

In the past decade, there has been a significant upswing in people's curiosity about the origins of their food. A growing number of consumers now seek food that is not only considered "safe" but is also cultivated through sustainable and conscientious growing practices, free from pesticide residues. Aeroponics, a method of growing plants without soil in a misty environment using water vapor and an enriched nutrient solution, has emerged as a solution to achieve accelerated plant growth. However, the current aeroponics methods face a crucial challenge. They lack a monitoring system necessary for optimal plant growth. To overcome this problem, a comprehensive monitoring system was developed to monitor the temperature, humidity, water level, and pH sensor. These sensors were strategically chosen to measure the temperature and humidity of the plant surroundings, the water level of the nutrient solution, and the water pH condition. The parameters' output is then displayed on both an LCD and the Blynk application, allowing users to observe and assess the plant conditions in real time. This versatile system accommodates the cultivation of plants indoors or outdoors, depending on the user's preference. A five-week study was conducted, during which results were systematically collected.

1. Introduction

Agriculture is one of the most major productive industries and food sources, particularly for growing countries; yet the rise in population density means fewer agricultural lands are available. Malaysia's population growth rate is a 1.09% increase from 2022, with approximately 34,308,525 people [1]. In this case, alternatives to conventional agricultural methods are sought after, including aeroponics, hydroponics, aquaponics, etc. Although the land is limited from time to time for people to start farming, they can start with some alternative farming methods that use less or do not need soil such as the aeroponics farming method.

Aeroponics is the process of growing plants in the air or mist environment without soil or an aggregate medium. Living Green Farm states that many people often confuse hydroponics and aeroponics because both methods are similar in that they do not require soil, only different in the way of delivering nutrients [2]. Hydroponics plants may be suspended in water all the time but aeroponics plants have never been placed into the water instead being given nutrients from a mist that sprayed onto their roots. In these cases, aeroponics methods are more efficient for nutrients delivered.

There are a lot of traditional aeroponics towers that are in the market nowadays. The aeroponics farming method can be done in outdoor and indoor gardens [3]. Technology is used in this idea, including automated systems and communication interfaces. With the addition of other tools, like the Internet of Things (IoT), the variable data can be collected and used in subsequent studies to improve crop growth and optimize crucial elements in product development. An automated system in agricultural processes not only allows proper monitoring of the crops [4].

In this context, the purpose of this work is to provide the result of an automated aeroponic farming system for spring onions. This system controls irrigation time, temperature, humidity, and nutrient misting at the root level. Given that lettuce is one of the vegetables most frequently consumed in daily family meals, the method is inexpensive and promoted as an environmentally safe alternative for lettuce cultivation. Based on Arduino, this system employs an IoT tool for remote monitoring via an application.

2. Materials and Methods

An Aeroponic Spring Onion Monitoring System Using IoT Platform is divided into two parts: software, and hardware. Specifications and properties of materials, equipment, and other resources used in the software used are as follows:

- Software: Blynk Application
- Hardware: ESP8266 ESP 01, Durian Uno

Fig. 1 *Durian Uno*

As shown in Fig. 1, Durian Uno was selected due to its incorporation of a relay module within a single microcontroller. Furthermore, this device facilitates an LCD I2C connection, minimizing the need for extensive wiring between the LCD and the microcontroller. This choice contributes to the reduction in size and complexity of the monitoring system's circuit design. Additionally, the device offers numerous input ports suitable for the sensors required in the current project or any potential future enhancements.

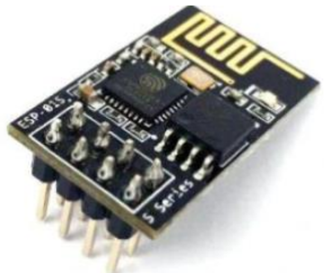


Fig. 2 *ESP8266 ESP 01 Wi-Fi Module*

The ESP8266 ESP-01 Wi-Fi Module in Fig. 2 was selected with precision due to its seamless compatibility with the Durian Uno microcontroller. This choice enables a smooth connection between the microcontroller and the Blynk application, facilitating the real-time display of sensor readings and parameters. The integration of this Wi-Fi module enhances the overall functionality and connectivity of the system.

The number of electronic devices has been determined and listed by referring to the sketch of the monitoring system. The number of electronic devices that have been determined can provide the data needed from the sensor. The Aeroponic Spring Onion Monitoring System using IoT Platform was sketched using Fritzing software shown in Fig. 3. Fritzing is one of the most useful open-source Arduino software. However, in this work, Durian Uno is used but since there is no software that has Durian Uno module, it is replaced with the Arduino Mega for simulation. Wiring connections are performed among electrical components in an electrical breadboard.

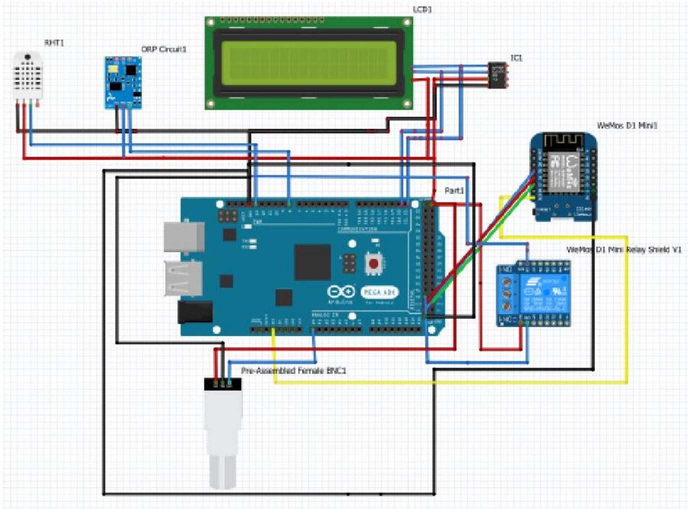


Fig. 3 *Sketch diagram of Aeroponic Spring Onion Monitoring System using IoT Platform in Fritzing simulation*

2.1 Methods

There are many methods and steps are taken to make the work development succeed. In this context, some methods are explained to understand the development of this work. Fig. 4 shows a modified water level sensor. Water level sensor terminal and i/o pins have been sealed using heat shrink and wire insulating tape. This step is taken to prevent the sensor short and causes current leak inside the tank. This sensor will provide water level monitoring in this work.

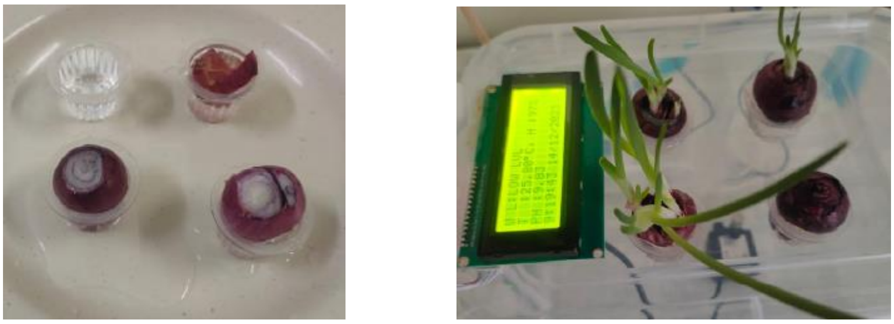
Fig. 4 *Water level sensor sealing process*

Fig. 5 shows a method used to make plant hole using soldering iron. This hole will hold the plant holder on top of the prototype. Whilst, Fig. 6 shows the spring onion as a test plant process. Red onion has been selected for this work test plant. The top of the onion is cut to help the spring onion growth smoothly and then it is placed inside the water nutrient for two weeks.

Fig. 7 shows the installation of hardware into the water tank prototype. All sensors are placed based on the sketching diagram. All wires inside the tank and holes around the water tank have been sealed to prevent water leaks to the microcontroller. Whilst, Fig. 8 shows the complete prototype after all the methods have been done and installation of control system has already been completed.

Fig. 9 shows the Blynk application interface that has been designed for system development. Users can observe the plant condition by using their smart phone that is connected to the monitoring system. This is the free version of the Blynk application. Although this is a free version, it still provided users with the features that are needed to create the control unit and monitoring system.

Fig. 5 *Plant holder making process*



(a) **(b)**

Fig. 6 *(a) Spring onion making process; (b) Spring onion growth*

Fig. 7 *Prototype installation*

Fig. 8 *Complete prototype*

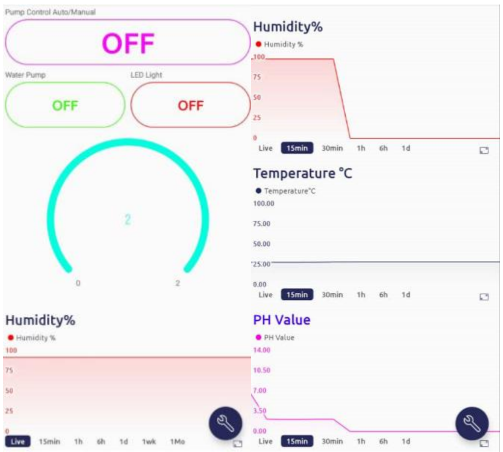


Fig. 9 *Interface of Blynk application*

3. Result and Discussion

This section explains the results and analysis of the work. Four parameters obtained from the monitoring system are shown and discussed in this section.

3.1 Temperature and Humidity

Table 1 shows the result of temperature and humidity for the plant environment surrounding. A weekly average of temperature and humidity has been recorded as in Table 1. It can be observed that when the temperature increases, the humidity in the air decreases. Even at nighttime, the temperatures can increase because of rain in the morning. Fig. 10 shows the result of temperature and humidity from the Blynk application for the plant environment surrounding.

Table 1 *Average of temperature and humidity*

Week	Temperature	Humidity
1	29.4	92%
2	29.8	90%
3	29.0	92%
4	29.3	91%
5	29.6	91%

Fig. 10 *Temperature and humidity result*

3.2 pH Value and Water Level

From the observations, the result for the pH value has slightly changed from 5.6 which is acidic and slowly to the neutral pH value which is 7.0. It means that the plant nutrition decreases week by week. Users need to change the plant nutrition before the value reaches 7.0. The water level in week 3 shows that the water level has dropped 50% from full capacity. It shows that water usage has decreased due to the absorption of mist to the plant. Thus, it can be said that the water needs to be refilled in the water tank every five weeks, to ensure a water mist supply to the plant. Table 2 shows the data obtained from week three.

Table 2 *Result of pH value and water level for week 3*

Week 3	pH Value	Water Level
Monday	59	2
Tuesday	5.9	2
Wednesday	6.0	2
Thursday	6.0	2
Friday	6.1	2
Saturday	6.1	1
Sunday	5.6	2

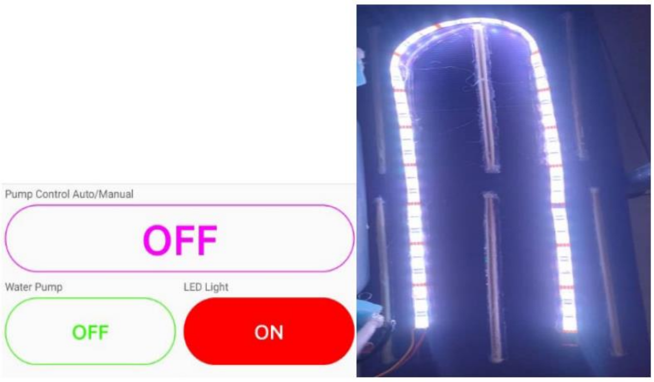
Result of water level is shown inside the Blynk application as in Fig. 11. Users will notice the water level in the tank and can manage when to refill the water inside the tank. Fig. 12 shows that result from Blynk application of pH value water solution inside the tank.

Fig. 11 *Water level result*

Fig. 12 *pH value result*

3.3 LED Control Unit View

Fig. 13 (a) and (b) shows the LED control unit which opened by manual switch in the Blynk application.

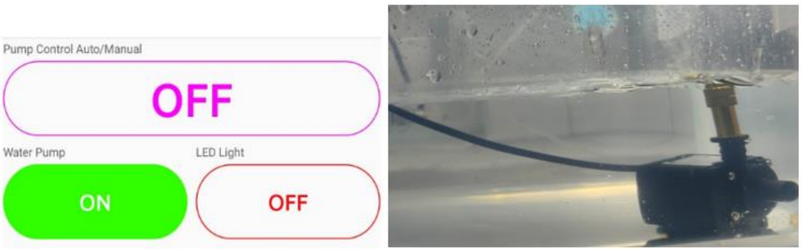


(a) **(b)**

Fig. 13 *LED control unit view (a) Blynk view; (b) Real view*

3.4 Water Pump Control Unit View

Fig. 14 shows the control unit for water pump which is opened by manual switch. It will automatically open for 30 minutes with 2 hours interval time when the automatic switch is opened.



(a) **(b)**

Fig. 14 *Water pump control unit view (a) Blynk view; (b) Real view*

3.5 LCD

Fig. 15 shows the result that shown in the LCD. Parameters such as time, date, water level, temperature, humidity, and pH value.

3.6 Blynk Application Interface

Blynk interface has been successfully done as shown in Fig. 16. All the parameters reading are shown in the Blynk application. Users can observe the plant condition by using their device that is connected to the monitoring system. This is the free version of the Blynk application. Although this is a free version, it still provided users with the features that are needed to create the control unit and monitoring system. For the control unit in the Blynk application, users need to act by switching the switch either on or off by hand.

Fig. 15 *LCD view*

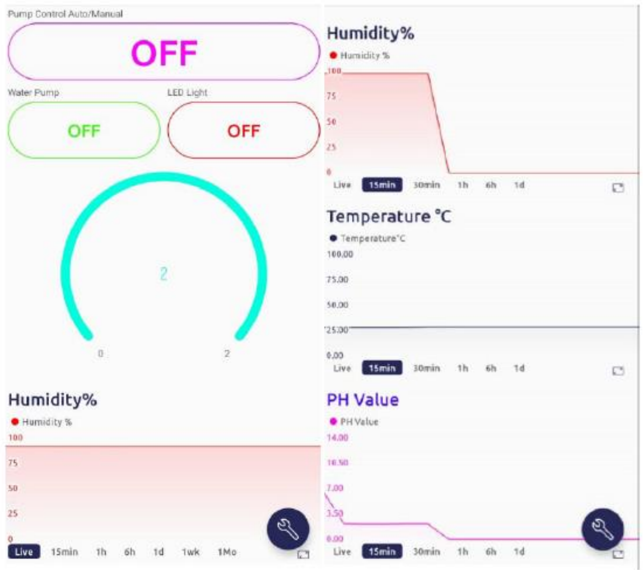


Fig. 16 *Blynk Application Interface*

4. Discussion

Overall, all parts of the system development have successful functions. All the parameters reading can be sent and read through the Blynk application, where all the readings are based on the real time situation. Although the plant was kept in the room at room temperature, it is still can be affected by the temperature and humidity surrounding. It makes the reading become consistent and needs careful observation. Blynk application can shows the parameters output daily but the data are not able to be saved for free version. Users need to subscribe to the premium account of Blynk application to use the advanced features. From here, user can monitor the Aeroponic Spring Onion Monitoring System Using IoT Platform.

5. Conclusion

To develop an aeroponics monitoring system, much research has been conducted just to find out the best way to make an upgrade monitoring system from previous study. To achieve it, microcontrollers have been done research and come out with the best possibility. Others sensor also have been deeply studied to make sure that monitoring system can be perfectly working with the designed monitoring system.

Blynk application work as the Wi-Fi module has been made as a medium between users and devices. Blynk application can provide simple interfaces and easy steps for users to design their own interfaces and control unit to connect with the microcontroller.

After the Aeroponic Spring Onion Monitoring System Using IoT Platform was successfully developed, various analysis was performed. After successfully running the prototype and the parameters reading, analysis has been made to make sure the obtained data was correct or not based on the plant situation and condition.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Gabriel;* ***data collection:*** *Gabriel;* ***analysis and interpretation of results:*** *Gabriel, Tasiransurini;* ***draft manuscript preparation:*** *Gabriel. All authors reviewed the results and approved the final version of the manuscript.*

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