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Automated Vertical Hydroponic Farming

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Abstract: In the era of globalization, by producing our own food would lessen the food waste also save earth. Hydroponics farming is technique to grow a plants via a medium without the use of soil but nutrient solution or inorganic nutrients is involves. While vertical farming is where the plant is planted in stacked manners. Therefore this project are combination of both methods with the touch of technology. The process of taking care of the plant is reduced by using Blynk app to control and monitor the farming system. Thus, less interaction from human are requires. This project is an Automated Vertical Hydroponic Farming that would save energy and time consume for the consumer. Therefore, the aim of this project is to make an automated system that can monitor and control the required variable such as nutrients, water, light, and ambience to grow a type of Chinese cabbage name Pak Choy by using Float and Drain technique applied. The system is equipped with real-time mode for the consumer to monitored and control the farming system via smartphone. Hence, this project have been tested for the functionality of the sensors used in the prototype. Result of this study shows Automated Vertical Hydroponic Farming able to monitor growth of Pak Choi plants in aspect of humidity, temperature, grow light and nutrition levels.

Keywords: Vertical Farming, Hydroponic Farming, Blynk App.

1. Introduction

Nowadays people revolving toward healthy life's style. Not only they wanted to be healthy but to have freshly picked vegetable at any time will help in time managing [1]. Vertical farming method can help to reduces the used of big spaces also the millennium gardeners have implemented hydroponics on a smaller scale to grow their own fresh vegetables year round and to grow plants in smaller spaces, such as an apartment or balcony. "Hydroponic" is technique to grow a plants via a medium without the use of soil but nutrient solution or inorganic nutrients is involves [2][3]. Traditional agriculture requires large numbers of work and different activities to be carried out in agriculture. Modern agriculture, on the other hand, requires little work since it all cares of the mobile and machinery [4]. This system may have develops the agriculture modernization toward less human involvement but gain more production. The main concern in hydroponic is the frequent of time to spend checking and babysitting the system [5].

Therefore, the aim of this project is to make an automated system to monitor and control the required variable such as nutrients, water, light, and ambient to grow a type of Chinese cabbage name

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Pak Choy using the vertical hydroponic system. This system will be controlled by Arduino Wi-Fi UNO ESP8266 WeMos D1. Implementing a hydroponic system requires research and knowledge about the type of plants to be grown. Different plants require different nutrient levels as well as a balanced water supply in terms of pH thus in order to detect the required variable, DHT11 Humidity Sensor Module is needed for measures the temperature and humidity. While, HC-SR04 Ultrasonic Ranging Module to detect the level of water and nutrient solution also pH sensor module to measure the pH level in the reservoir. Thus, these sensor will be sync with Blynk IoT platform to monitor also control the variables with the help from arduino microcontroller.

2. Methodology

2.1 System design

The Automated Vertical Hydroponic Farming system design consists of a hardware and software implementation part. As for the hardware part, it consists of components such as Arduino Wi-Fi UNO ESP8266 WeMos D1 attached with DHT11 Humidity Sensor Module, HC-SR04 Ultrasonic Ranging Module and pH sensor module. At the four channel relay module that is attached with grow light emitting diode, water pump motor and exhaust fan. Meanwhile, for the software part, it used an IoT platform or also known as a cloud where the selected cloud is Blynk IO. This cloud platform will store all the information about the data and display the information in a real-time mode at Blynk App. The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study.

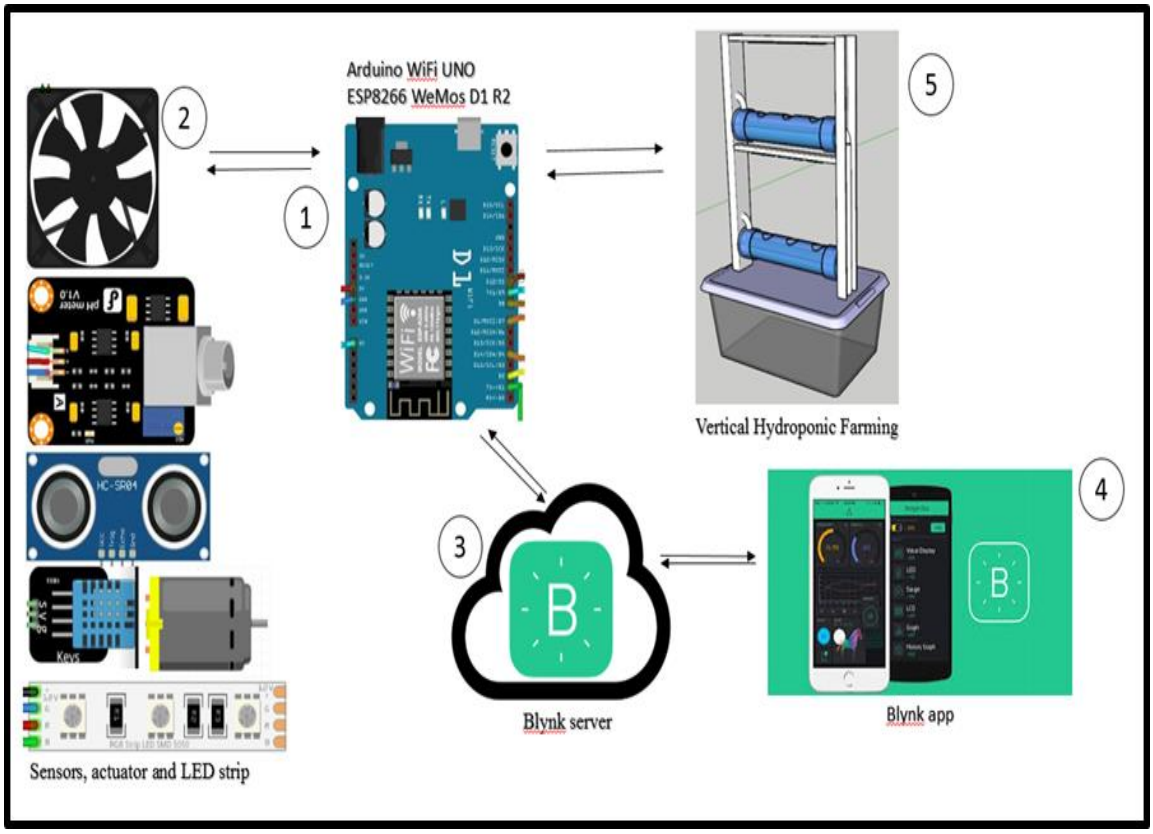

Figure 1: System design diagram

Table 1: Explanation of the system design diagram

Label	Name of label	Explanation
1	Arduino UNO	Will be used as the central processing unit to process and manage the input data and produces the necessary information (output).
2	Sensors, actuator and LED strip	To detect and measure the required variables. Also an output to create constant water flow and inject fertilizer also control the humidity in the system.
3	Blynk server	Responsible for all the communications between the smartphone and hardware. Also store the data to Blynk cloud.
4	Blynk app/ mobile phone	To create interfaces for the projects using various widgets provided. It also can control hardware remotely and it can display sensor data.
5	Vertical Hydroponic structure	To implement the Pak Choi plant in the Automated Vertical Hydroponic Farming.

2.2 Circuit design and connection

The software that used for designing Figure 2 is Fritzing. In this project, the connection between the Arduino Wi-Fi UNO ESP8266 WeMos D1 and sensors used is connected via jumper wire. The sensors that been used are DHT11, HC-SR04 Ultrasonic sensor and pH sensor. The pins that been used are AO, 5V, GND, D1, D2, and D4. While the output such as water pumps and exhaust fan of this circuit are connected to four channel relay module, then the relay module is connected to the arduino via jumper wires at pin D7, D8, D9 and D10. The grow light is connected to first relay, the exhaust fan is connected to second relay while the water pump is connected to third relay.

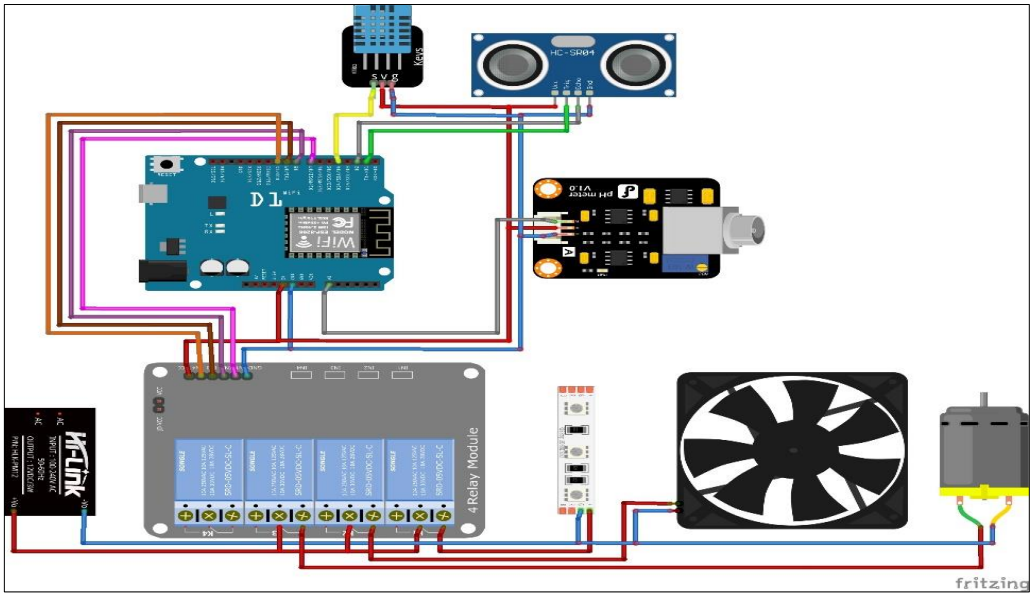

Figure 2: The circuit diagram of vertical hydroponic farming system

3. Result and Discussion

3.1 Prototype design for the system

The prototype of the Automated Hydroponic Vertical Farming is shown in figure 3. This system is designed to be portable and easy to handle. On the inside of the storage box, it is equipped with water pumps for circulation purposes, pH sensor for reading the pH levels of the nutrient solution inside the

tank reservoir, ultrasonic range module for monitoring the water levels in the tank reservoir and separate tanks for AB solution for dosing purposes to the tank reservoir. Furthermore, the electronic components included Arduino WeMos D1 are stored in designated box to prevent the electronic parts to get water on it. Moreover, this product is easy to disassemble and reassemble it. This is because, every connection in the prototype was equipped with socket that will fit easily. Hence, the advantages of this design is user can store away the prototype if no longer use it or wanted to move to new that involve transportation.

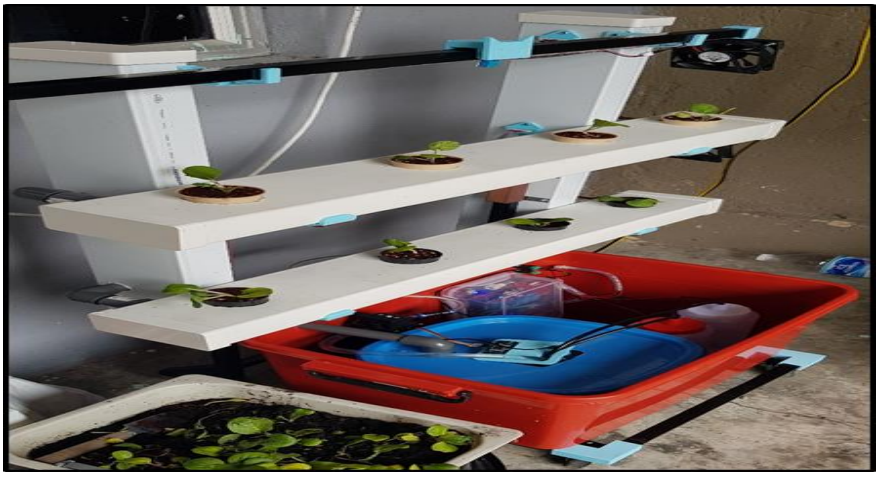

Figure 3: Finished prototype

3.2 Water dosing and circulation

In this project, the tank reservoir and dosing of the nutrient solution are managed by Blynk app with the help of water pump. There are 3 in total water pumps used in this prototype. As shown in Figure 4. The reservoir used 1 water pump for distributing the nutrients mixed with water throughout the whole hydroponic system, the other two water pump placed in each nutrient solution tanks. This is because the provided nutrient solution is divided into two which are solution A and solution B. Thus, each solution is placed in separate tanks. The pH level of the water in the tank reservoir is checked regularly using an analogue pH sensor. Furthermore, the dosing for nutrient solution are control through the Blynk app also timer is used for water pump in the tank reservoir for circulate the water in the system to provide enough oxygen and regulate the system pH levels. Moreover the water will drained to the tank reservoir. An ultrasonic sensor is used to indicate the water level in the reservoir.

Figure 4: Tank reservoir and AB solution located

The pH levels are read by the help of analog pH sensor and manages through the Blynk app. Thus, the level of acidity for the prototype can be alter from the Blynk app according to needs of the plants. As shown in Figure 5, the pH level is displayed in numeric values. There is two widgets is used for adjusting the level of pH in the Blynk app. Hence, the first widget is for lower limit pH from 1 until 7 that is indicate acidity level while the other widget is for upper limit pH value from 7 until 14 that indicate the alkaline level. This feature is useful when the water in the tank reservoir need to manually change or manually add on with fresh water. The water levels is monitored by ultrasonic sensor that is placed on top of the tank reservoir lid. Thus, this function is useful whenever the tank reservoir refilled or change with water. Moreover, the water circulation for this system is using a timer that will start at 8AM for 5 minutes also this routine is applicable on daily. In this project, the overflow system is installed at the left side of the prototype, the PVC pipes used is connected to the tank reservoir from both hydroponic PVC.

Figure 5: Blynk app widgets used

3.3 Temperature, humidity and grow light control

The temperature and humidity surrounding the plant is crucial part in this project. This may affect the growth of the Pak Choy when the temperature rises. Furthermore, Pak choy cultivates well in temperature between 21°C but can tolerate until 35°C [6]. The prototype system have been designed to hold temperatures at about 28°C consistently, while temperatures have periodically risen to more than 30 ° C in the afternoon. When the temperature rises more 28°C the exhaust fan will ON. Hence, vice versa if the surrounding humidity is decreases at that point the exhaust fan will come handy on these situation. The temperature and humidity of the surrounding are detected by using DHT11 sensors. Moreover, to get precise reading since the concept of this project is vertical hydroponic. Thus, each platform of the hydroponic is equipped with DHT11 sensors and exhaust fans.

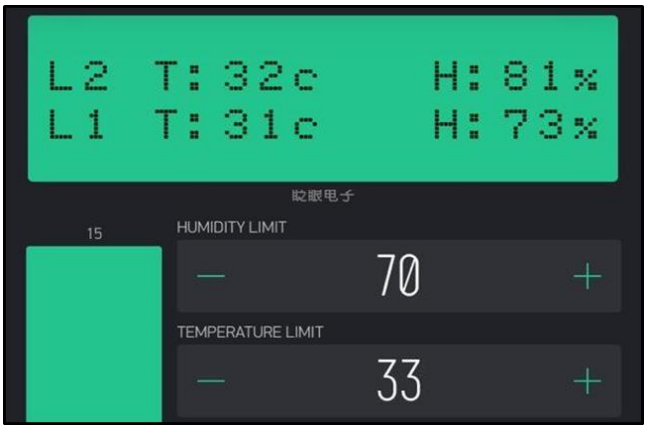

Figure 6: Blynk widgets used for display reading

These parameter are monitored and controlled through designed interface in the Blynk app. As shown in Figure 6, the reading from DHT11 level 1 and level 2 are displayed in the LCD widgets. The reading from level 1 and 2 slightly differ due to the placement of each DHT11 sensor on the prototype. The first sensor placement for level 1 is placed under the second hydroponic PVC. As shown in the Figure 7, the humidity reading lower than the humidity rate on the second levels. This is because the placement for DHT11 sensor for level two were placed above the level 2 hydroponic PVC on a piece of specialized rod to hold the sensor in place is more exposed to air than the sensor for level 1.

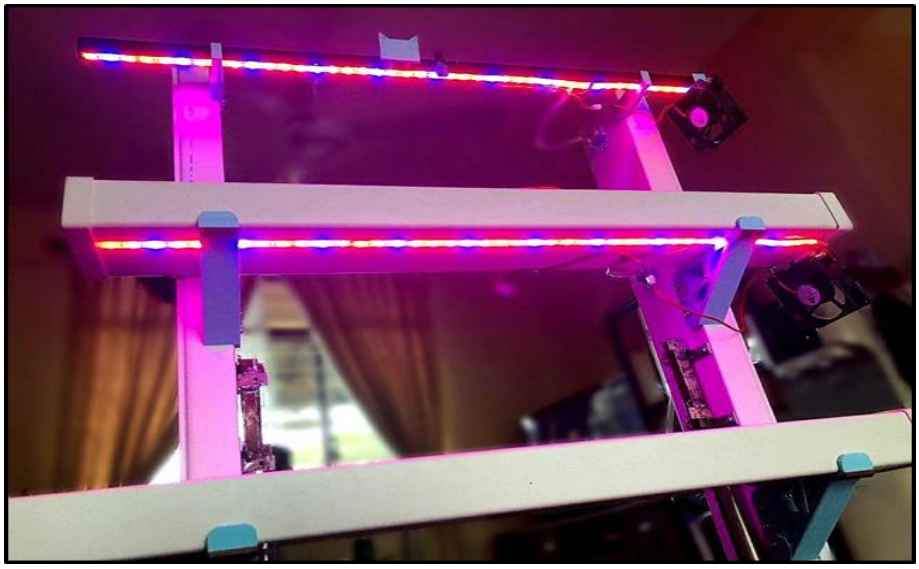

Figure 7: The grow light and ultrasonic sensor placement in prototype

The grow lights is implemented to this project to supply the Pak choy plant the right amount light needed for growing factors. This is because the product is indeed an indoor vertical hydroponic system thus installing the grow light is necessities. Pak choy required at least 7 hours of sunlight a day, but Pak choy don't like the long day or the bright light of summer also too much light is under stress on this vine. By following the requirement needed, on the Blynk app a timer is used to set to switch ON the grow lights at 10pm until 5am on daily.

4. Conclusions and future works

As stated in the title, this project is based on Vertical Hydroponic system with IoT capability. Thus, with implementation of IoT, this prototype can monitor and control the system remotely via smartphone using Bynk App. The Automated Vertical Hydroponic Farming is a system to help out the urban farmer to grow their plant with the touch of technology. Moreover, this system is handy when the urban farmer had an outstation situation. Thus, user can monitor and control their plan via smartphone without worrying the crops for time being. Other than that, this prototype could deliver benefits toward any user who wanted to start farming their own vegetable and being sustainable at the same time. If the space is limited for the user, hence this prototype come in handy.

Upon finishing the Automated Vertical Hydroponic Farming successfully, there are some areas of this project can be upgraded. Firstly, the system itself can be upgraded to a larger scale. In which make the system into commercialize product. Next, this prototype used an Arduino as the microprocessor. Thus upgrading the system to be more capable should be consider. For an example, by using Raspberry Pi an image processing feature could be added to the prototype for monitoring purposes also data analysis. In additional, by adding EC sensors into the system could help to get more additional data for crops condition also water conductivity are one of crucial parameters should be taken care of in hydroponic method. Lastly, adding an actuator to the prototype could make a self-harvesting features into the prototype. This could lead the prototype to be more time efficient and cut cost for hiring worker.

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