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Automated Hydroponic System for Indoor Plant Growth in Urban Area

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Abstract: The need for an indoor hydroponic farming system as an alternative source for own food consumption spikes interest among urban citizens. Despite their hectic lifestyle, they generally do not have time to build their own farm and need an automated system to minimize operations in farming. In this paper, an automated indoor hydroponic is developed to allow urban citizens to grow the plant indoor. The system is developed with NodeMCU Esp8266 to control relevant parameters by using an actuator and monitor the parameters via a mobile application. The system has been tested to grow Pak Choy in an indoor environment and continuous monitoring through mobile apps demonstrates that a more stable plant growth parameters trend can be achieved as compared to the outdoor environment. The automated hydroponic system provides an efficient way to grow a plant in the indoor environment by resulting in a faster growth rate and bigger leaf size.

Keywords: Automated System, Hydroponic, Indoor, Urban

1. Introduction

Automated hydroponic system for indoor plant growth in urban area, is to leverage the utilization and implementation of hydroponics farming method as well as to develop a system that can work in indoor environment without dependent on environmental parameters and weather. The system is targeted to turn the urban citizen with no farming knowledge to be professional farmer that can help them to produce their daily vegetable supply and minimize the complicated setup for the parameters measurement and control that needed by the hydroponic farming method. In a hydroponic system, as it is a soilless planting method, the plant is mechanical support by growing medium such as rockwool and clay pellets [1]. A reservoir holding nutrient solution with the aid of nutrient pump and tubes to complete a circulate system that provide a constant flow to the plant [2]. Normal hydroponic system that growth at outdoor only focus on the value of the pH of the nutrient solution and set it to the desired value. For the hydroponic plants to grow in indoor environment, there are several essential parameters which are air temperature, humidity, water temperature and lights [3]. The system of Perfect Hydroponic can only use as data logging application for parameters daily record [4]. The system of Flower Care can support only up to three parameters control [5]. All these parameters need to be controlled and maintain to create and optimum environment for the plant growth in indoor environment as the parameters can affect plant

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health and growth rate [6]. The process of the automated hydronic system is work with following mechanism, place the nutrient solution into a reservoir, put the plants above the reservoir and make sure when the plants germinated the exposed root can touch the nutrients solution, by maintaining the parameters in optimum level to boost the growth rate to produce better plants. The conventional hydroponic system needs to carry out parameters measurement and controlling by human for daily routine to ensure the growing environment is good for the plants.

The target of the Automated Hydroponic System for Indoor Plant Growth project is to make an automated system without needed of human interaction after putting the seed in the system. In this paper, the newly invented automated hydroponic system is developed with various microcontrollers, sensors, actuator and integrated with cloud technology for mobile application real-time monitoring and control. The system takes the sensors measurement values as an input and compare with the optimum parameter value and the control the parameters according to the desired value by triggering the actuator as feedback mechanism. This feedback mechanism is the key important parameters that are not yet applicable in the current existing system. This project develops a complete automated system with mobile application for monitoring purpose on the process and parameters needed for the growth of the plant. The organization of the papers are divided as the follows, section 2 discusses the hardware and software integration of the proposed indoor hydroponic system. Section 3 highlights the growth rate of the indoor system compares with the conventional outdoor farm, and finally few conclusions is summarized in the Section 5.

2. Development of automated indoor hydroponic system

The automated system uses two NodeMCU Esp8226 board as controller. One is for the data collection on different parameters values, another one is to control the actuator. The first controller records the important parameters values and send to the Firebase Cloud storage. The second controller retrieves the data from the Firebase Cloud storage to do the feedback according to desired optimum range. The overall system architecture with hardware and software is shown in Figure 1.

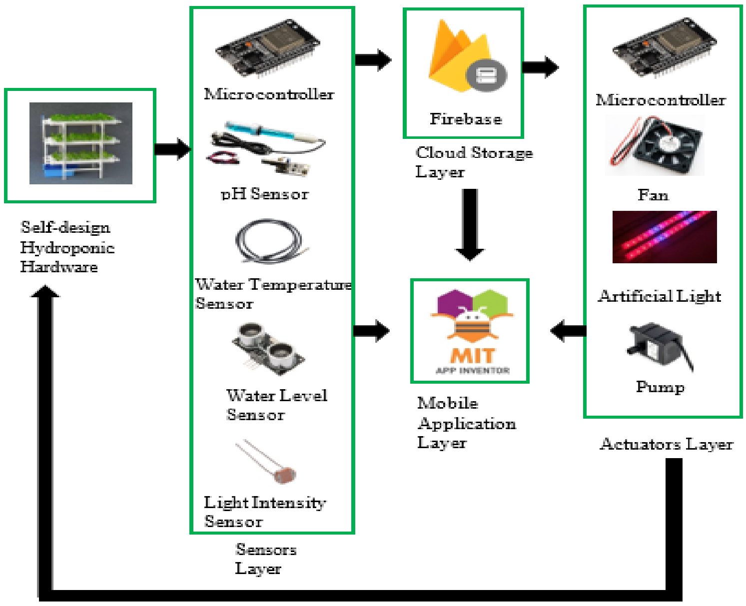

Figure 1: The general architecture of automated hydroponics system

2.1 Hardware architecture

Figure 2 shows the circuit connection on the breadboard before complete installation on the hydroponic system. The fully integrated hardware with the hydroponic system is shown in Figure 3. The microcontroller controls the workflow of the daily care on hydroponic plants. The working mechanism of the system's hardware is explained using the general architecture of the automated system shown in Figure 1. The system operation separates into two parts which data are sending for monitoring purpose, data retrieving for automatic feedback purpose.

The system is developed with data sending for monitor purpose, after the network establish, the reading of the sensors is taken and store it to the cloud database. The first sensor that takes the reading of the system is ultrasonic sensor, as the water level of the whole system is mandatory for the operation, the operation of the system is stopped immediately if the water level is overflow, the system only operate at the water level greater than 5 centimeters from the water tank. The next reading is the surrounding temperature and humidity. Following is the reading of water temperature, pH values and light intensity. The reading from each sensor is sent to cloud database immediately once the reading is ready. The reading is sent immediately without delay as the actuator only able to execute real time feedback depends on the environment condition.

The following part of the system is the data retrieving for automatic feedback of actuators. Once the data is stream and store in cloud database. The reading from the database is retrieved immediately by the microcontroller for the actuators and trigger the feedback control by comparing the reading with the optimum value of parameters of plants. Once the reading is out of the optimum parameters value, the feedback actuators is triggered automatically. The operation status of actuators is sent to cloud storage for mobile application development. The fan is triggered when the reading of the surrounding temperature and water temperature is greater than 30 °C, also when the humidity is less than 70 %, the fan is triggered to cool down the environment. The artificial light is triggered by the reading of light intensity sensor, if the light intensity is lower than 2000 lux, the artificial light is triggered. The mandatory actuators are water pump and nutrients pump. The water pump is operated by timing control of on 3 seconds and off 3 seconds, unless the water level is overflow, the water pump is stopped operate. The nutrients pump is working on the reading of pH meter, once the reading is too low, the nutrient pump pumps the nutrients for 3 seconds and measure the reading again. If the reading is still low, pump again until the reading is optimum.

Figure 2: Hardware testing on breadboard

Figure 3: Hardware integration with hydroponic system

2.2 Software architecture

The system uses NodeMCU microcontrollers which are programmed via Arduino IDE. The language that used is C++ programming language shown in Figure 4. The code is used to operate all the sensors operation and data sending and data retrieving to Firebase Cloud storage. The Firebase Cloud storage can connect the microcontrollers with the library provided which creates a communication between database and the controllers show in Figure 5.

Figure 4: Arduino code interface

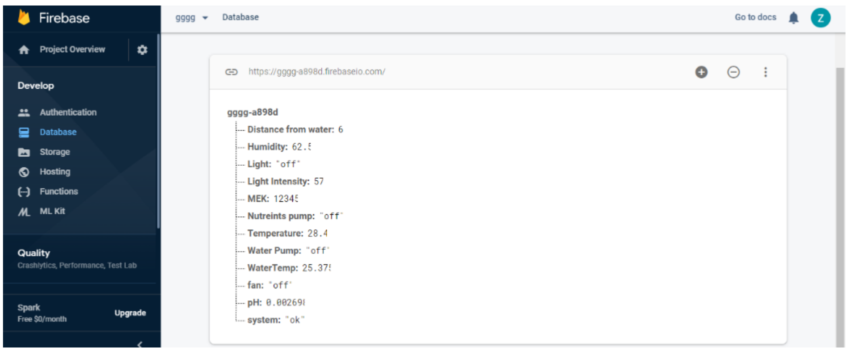

Figure 5: Firebase cloud database library

The main monitoring for the parameters value and controlling process is performed by using a mobile application which is developed via MitApp inventor. The mobile application is deployed with the function of user login, real time parameters and process monitoring, data logging interface and parameters computing as show in figure 6. The mobile application also notifies the user when overflow or the system breakdown happens.

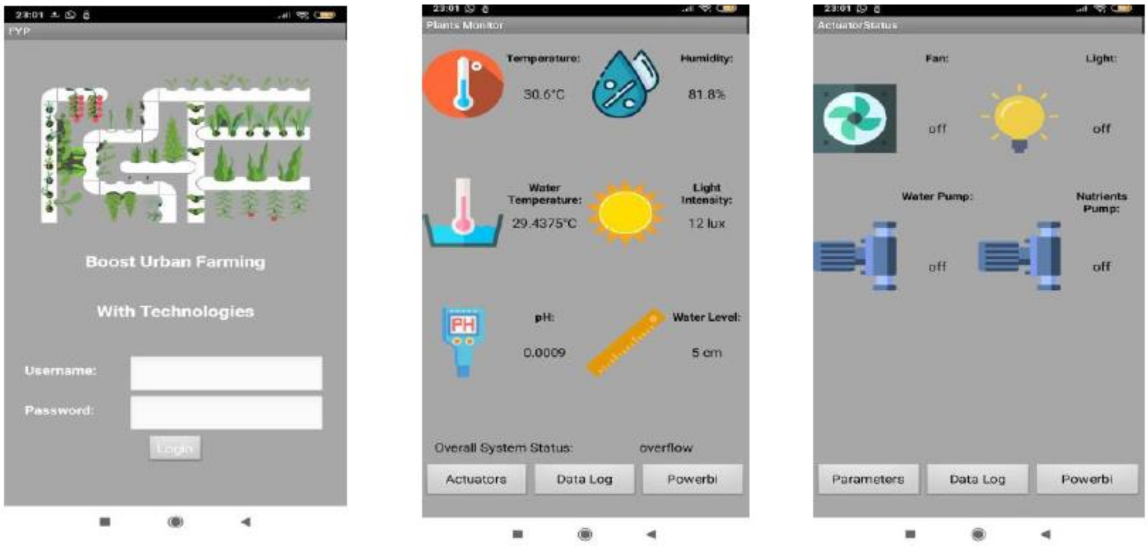

Figure 6: Mobile application interfaces

3. Results and Discussion

The data analysis was done using the data logs that were kept in the developed mobile application. The average value of each day parameters is recorded. The experiment is carried out to identify the workability of the automated system for the plant growth in indoor environment. The bak choy is plant with two different method, one by using the developed automated system at indoor and another one is plant at outdoor using soil method. Both results are compared to investigate the performance of the automated system.

The parameters that affect the plant growing condition are temperature, humidity, and pH. The parameters for the growing cycle by using automated indoor system and outdoor soil method is recorded. Figure 7 show the perfect control of the automated system that used to create an optimum environment for the plant growth and boost the growth cycle of the plant to produce a better plant. The automated system able to retain the optimum environment for the plant growth by showing a constant trend in the plot of the parameters value. The outdoor soil method show a unstable plot this is due to the outdoor temperature, humidity and pH of the soil is affected by the climate change, from the plot, the outdoor temperature went high for few days and cause less humidity for the plant. If the temperature is high for indoor automated system, fan will be trigger. The pH of the soil for outdoor method is affected by the rain. When continuous rain for few days, the soil will turn too acidic and cause the nutrients loss. For indoor automated method , the pH of the solution is not affected by the rain, and if lack of nutrients, the nutrients pump will pump the nutrients to the reservoir that hold the optimum nutrients solution and the reservoir will maintain the pH at 6 to boost the growth rate of the plant.

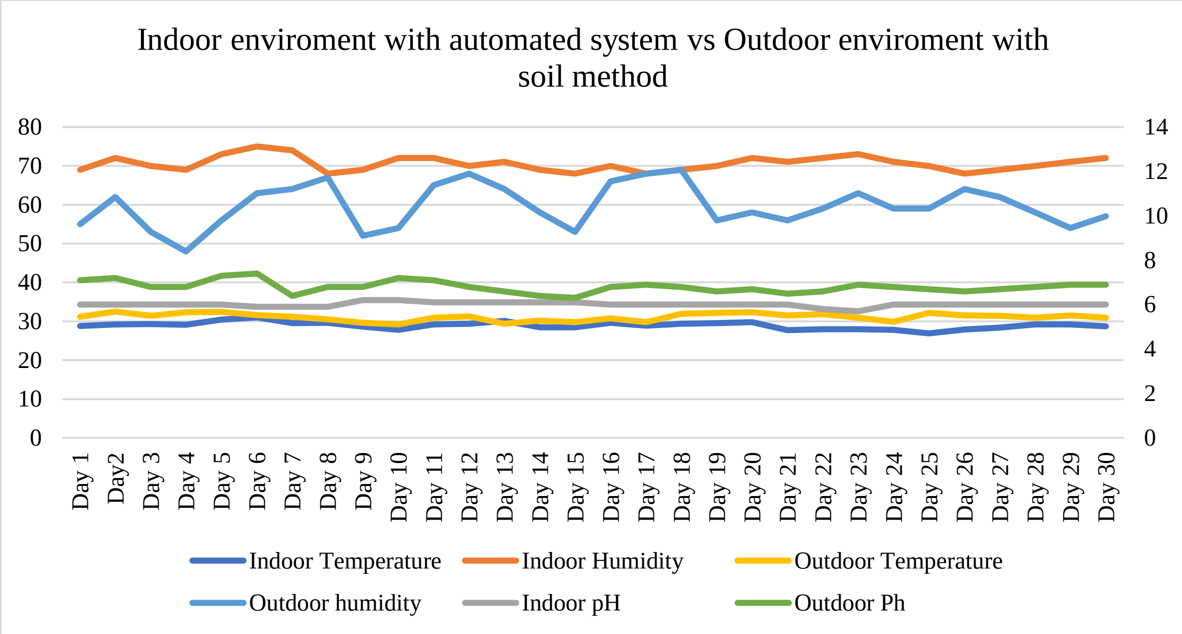

Figure 7: Overall indoor automated system parameters-controlled value

3.1 Leaf size

The effectiveness of the automated system for indoor plant growth can be analyzed by comparing the size of the leaf on different planting method and environment. The comparison on leaf size is show in table 1. From the overall size the plant that growth in indoor with better parameters control produce a better plant. The size of the leaf is almost double compare to outdoor without parameter control.

Table 1: Leaf size comparison

Day	Leaf size with automated system(cm)	Leaf size with soil method(cm)
3	0.3	0.2
8	3.2	1.2
13	4.1	1.8
18	7.8	3.1
23	10.9	5.2
30	15.3	7.5

A comparison of the growing condition of the plant in different environment and method is tabulated in Table 2. The plant is compared on day 17, 23 and 30 to compare determine the different on the plant size. At day 17, the indoor growth plant has grown up to 6 leaves with big leaf size, while the outdoor growth plant has only grown 4 leaves with small size. By comparing day 23, the outdoor growth plant has grown with 6 leaves but the leaf size if still small compare to indoor growth plant. When reach 30 days, the indoor growth plant already reached maturity stage and can ready to harvest while the outdoor growth plant is not yet mature and estimated another 10 more days needed to reach mature stage. The result is significantly showing that the plant growth in indoor with automated in grow better and bigger in size compare to outdoor soil method. The system also boosted the growth rate of the plant in indoor environment with 25% faster growing rate compare to outdoor.

Table 2: Comparison on growing condition of the plant

Day	Indoor with automated system	Outdoor with soil method
17		
23		
30		

4. Conclusion

Throughout the experiment and analysis carried out. The essential parameters that vary the growth rate of the plants are seen and determined. The essential parameters of the plant are temperatures, humidity and pH which can affect the growth rate of the plant directly. From the data analyzed, the results proven that the plants prefer a cooler environment, medium humidity with consistent pH to optimize the growth rate of the plants. The leaf size that growth with the system is double which is 15.3 cm compare to the size of leaf growth outdoor without optimum parameters control. The workability and effectiveness of the automated system for indoor plant growth in urban area shows a positive result and proven that the system can plant the plants more easier by doing all the parameters checking and control daily activity in an effective manner.

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References

[1] Bergeret P., The future of food and agriculture: trends and challenges (Note de lecture). 2017

[2] Food and Agriculture Organization of United Nations (FAO), "PART 2 Hunger dimensions," J. Chem. Inf. Model., vol. 53, no. 9, pp. 1689–1699, 2015

[3] I. Monostori et al., "LED lighting – modification of growth, metabolism, yield and flour composition in wheat by spectral quality and intensity," Front. Plant Sci., vol. 9, no. May, pp. 1–16, 2018

[4] African J. Agric, "Effect of regulated irrigation water temperature on hydroponics production of Spinach (Spinacia oleracea L)", vol. 4, no. 12, pp. 1442–1446, 2009

[5] J. Yin, X. Liu, Y. Miao, Y. Gao, R. Qiu, and M. Zhang, "Measurement and prediction of tomato canopy apparent photosynthetic rate," Int. J. Agric. Biol. Eng., vol. 12, no. 5, pp. 156–161, 2019

[6] H. R. Roosta and I. Rezaei, "Effect of nutrient solution pH on the vegetative and reproductive growth and physiological characteristics of rose cv. 'grand gala' in hydroponic system," J. Plant Nutr., vol. 37, no. 13, pp. 2179–2194, 2014