Smartcropplanting: IOT-Based Mobile Application for Hydroponic System

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Abstract

Hydroponic crop production is challenging for farmers and gardeners; they must continuously monitor and control the crop environment to achieve or maintain the best plant growth. Climate changes and disease/pests might occur anytime at anywhere which will consequence in crop-damaging. Studies show that slight rises in temperature from 1°C to 4°C can resulting in a decrease in the production of 10 to 41%. Another study shows that depending on the severity of leaf spot disease it will damage the crop by 10 to 50%. Therefore, this study proposed to improve the current hydroponic system by implementing the Internet of Things and Image Processing technique to optimize and reduce the infeasible tasks with mobile applications. This study has conducted a mixed-mode method with home gardeners, farmers, and related experts. The results show that 80% of respondents agree that SmartCropPlanting will improve the productivity and efficiency of crop planting with IoT and Image Processing techniques.

Keywords: Agriculture, Hydroponic, IoT, Automation, Machine learning, Image Processing.

1. Introduction

Plants are not always easy to grow, farmers/gardeners might lose their crop due to climate changes, plant disease/pest, improper watering, etc. In Malaysia, climate changes have highly impacted negatively on agriculture production. One study shows that the temperature rises from 1°C to 4°C, the production of oil palm can decrease up to 10 to 41% [1]. Thus, this scenario not only effecting oil palm production it also affects many other plant productions. Hence, reduce in-plant production will be affecting the price in the market which can address food security issues in Malaysia [1]. Therefore, improving the agriculture system is an extremely important challenge for food security in Malaysia. Currently, there is a new farming technique where farmers/gardeners can grow their plants indoors and without the presence of soil [2]. This modern farming method growing plants with only nutrient-rich water instead of getting water and nutrients from the soil, Hydroponics planting system has arisen. With the ability to plant crops indoors, they will not be affected by any climate changes outdoor [3]. On the other hand, measuring and controlling hydroponic crops is quite challenging and an infeasible task for farmers/gardeners. Therefore, with the help of modern Internet of Things (IoT) technology, the challenges faced by farmers/gardeners can be solved with low-cost sensors and a few other low-cost electrical components [4][5][6]. With the help of IoT technology, it allows farmers/gardeners to monitor and control their crop environment parameters remotely by providing a mobile application with a user-friendly graphical user interface (GUI) [3] without the need for laboratory instruments [7][8][9].

Besides climate changes, plant disease and pests could affect crop production. Plant disease and pests are

resulting in endanger to agriculture around the world [10]. One study shows that depending on the severity of the leaf spot disease it will damage the sugar yield by 10% to 50% [11]. Thus, this study shows that the effect on plant disease and pests will cause serious damage to the crop. The disease can cause by 2 factors, first are biotic which are fungus, bacteria, virus, and nematodes. The second is abiotic which is caused by environmental parameters like temperature, humidity, nutrient deficiency [12]. Disease on leaf spot initially emerges in small spots, then slowly evolves, and eventually spread to the whole leaf [11] and causes permanent damage to the leaf. Therefore, plant disease/pest should detect instantly to prevent further spread or growth of the disease/pest. To reduce the damage of crops, applying image processing techniques will be extremely helpful for the early detection of diseases and pests. Currently, farmers/gardeners check their crop disease with their naked eyes which might cause human error and time consuming [11]. To solve this issue, it is believed that the image processing technique will reduce infeasibility, reducing human error, and save time to identify the disease [11].

2. Literature Review

Hydroponic planting system became one of the modern planting systems without the presence of soil [2]. Farmers/gardeners need to measure the hydroponic environment parameters by using an additional instrument [3]. Therefore, researchers and developers try to carry out a solution to control and monitor Hydroponic planting systems with IoT technology without the need for additional instruments. There are other similar IoT based Hydroponic systems such as "IoT based hydroponics system using Deep Neural Network (IHDNN)" [2], "IoT Based automated Indoor Vertical Hydroponics Farming Test-Bed (IAIVHF)" [3], and "Automated smart hydroponics system using IoT (ASHSI)" [13]. In this review, it will provide a features comparison table of 3 different IoT-based hydroponic system on Table 1.

Table 1. Related work comparison

Features	**IHDNN**	**IAIV HF**	**ASHSI**
Web application	/	/	X
Mobile application	/	X	/
Notification	/	X	X
Monitor Crop Parameter	X	X	X
Control crop Parameter	X	X	/
Automatic Control Parameter Action	X	/	X
Plant disease/pest detection	/	/	/

Table 1 shows 3 different types of IoT-based hydroponic systems. As shown above, all 3 types of IoT-based hydroponic systems did not provide plant disease/pest detection. However, it does provide monitoring and controlling features. Thus, farmers/gardeners still need to physically check their plant's health.

Plant diseases/pests have been a significant concern in farmer's organizations since they will cause the reduced quality and production of the crop. Thus, early detection is important for preventing further crop damage. To detect plant diseases/pests, image processing technology can be applied for plant disease detection and classification [14]. Kusumo, B. S., et al. has tested different type of various image processing features such as [15]

1. Red Green Blue (RGB)
2. Scale-invariant feature transform (SIFT)
3. Speeded up robust features (SURF)
4. Oriented FAST and rotated BRIEF (ORB)
5. Histogram of oriented gradients (HOG)

Different type of machine learning algorithm has been tested such as Support Vector Machine (SVM), Decision Tree (DT), Random Forest (RF), and Naïve Bayes (NB) [12]. To elaborate the comparison result, the statistic of comparison is shown below.

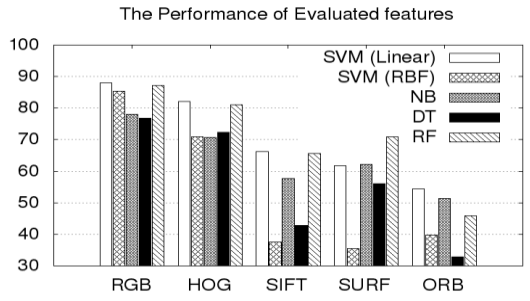

Fig. 1. Statistic of Comparison Result [6]

Fig. 1 shows that the best classifier type is RGB which has the best accuracy compared to other classifiers. Therefore, by using a free online plant disease dataset with the plant name and disease type [16] train it with RGB classifier with SVM machine learning algorithm, believed that the accuracy result will be accurate to detect plant disease/pests.

2.1. *Problem Statement, Question & Objective*

This study aims to develop an IoT- based mobile application with low-cost sensors and hardware that could help farmers/gardeners to control and monitor their crops without additional equipment. Furthermore, it also provides an image processing technique to detect plant disease/pests. This system could give more convenience to farmers/gardeners and maintain a healthy crop.

RO1: To develop a system with low-cost sensors and hardware with IoT-based Mobile application Hydroponic System. This system only requires a low-cost sensor and hardware to monitor and control hydroponic crops.

RO2: To cut the additional equipment for testing the parameter of their crops with IoT-based Mobile application Hydroponic System. With the help of this system, farmers/gardeners can monitor environment parameters without additional equipment.

RO3: To develop a fully automated system that allows the farmer to control environmental parameters and monitor their plant health remotely with an IoT-Based Mobile application Hydroponic System. The system allows farmers/gardeners to control and monitor their crops remotely and send an instant alert message to Farmers/gardeners via a mobile application if the system detected plant disease/pests.

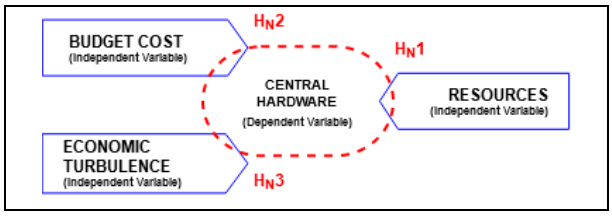

Fig. 2. Hypothesis Research Model

From the objectives derived, these are the summarized hypothesis shown in Fig. 2.
H1: Farmers/gardeners do not require expensive hardware or additional maintenance with IoT-based Mobile application Hydroponic systems.
Constant monitoring of the environment is an extremely important task to maintain a healthy crop. Depends on a different type of plant, crop environment parameter is important to grow a healthy plant. Farmers/gardeners have to physically measure parameters with overpricing and not reusable equipment. Therefore, providing an automation system with IoT-based technology will prevent farmers/gardeners to spend additional costs on equipment.

H2: Farmers/gardeners allow to control and monitor real-time data of their hydroponic crop parameter and their plant health over the internet with IoT-based Mobile application Hydroponic System.
Physically monitoring and controlling crops is a time-consuming and inefficient task. By providing an IoT-based technology, farmers/gardeners allow to control and monitor their crops remotely. Furthermore, this system also provides an image processing technique to detect plant disease/pest and send an alert message to a mobile application which is a very efficient way for detecting plant disease/pest.

H3: Farmer's organization will contribute to an increase in food demand harvest and reduce the cause of plant disease with IoT-based Mobile application Hydroponic System.

By providing this system to farmers' organizations, the food harvest demand will increase which resulting in an improvement in food security. It also provides instant alert notification to the farmer if there is any plant disease/pest detection. Thus, it will improve the early action for the farmer to stop further spreading of plant disease/pests and protect their crop.

3. Methodology

The research methodology for this research is using mixed mode.

The quantitative research method is research that asks narrow questions and collects quantifiable data from existing or potential customers by sending out an online survey or questionnaires to ask for their opinion. After collecting this information, it will be used by the researcher to deploy the mathematical frameworks and theories. We are conducting this method by using an online questionnaire. We share the survey with the related field people such as IT-field, gardener, farmers, and researchers related in this field so that we can maintain the accuracy of the result.

The quantitative research method is the most widely used when conducting market research. The qualitative research method is more focused on collecting data through conversational communication. This method not

only asks about what they think but also asking why they think so. It is more like psychology, sociology, and anthropology. Therefore, it is a method that allows getting a further explanation from respondents. By understanding how respondents make the decision, it will gain advantages while concluding the research. We are conducting one-to-one interviews through social media.

4. Results and Findings

According to the research have been found, the awareness of hydroponic crop farming system will reduce the cost of labor for hiring workers. The Fig. 3 below summarize the responses.

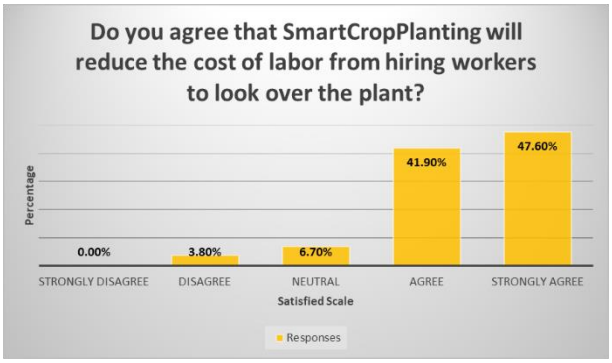

Fig. 3. Survey Question (Cost)

From Fig. 3, we found out that 89.5% of respondents agreed that SmartCropPlanting will get to reduce the cost of labor to take care of the plants and 3.8% of respondents disagree with that. In this case, our expectation for this survey is accurate and the hypothesis for this research is appropriate. In the plantation industry, it requires a lot of manpower to fulfill the tasks of operations. This sector not only far from the city but it also dirty, dangerous, and difficult. So, with the combination of technology, the industry will be able to reduce the cost of labor at the same time it solves the problem for farmers who lack manpower. With around 90% of respondents agree on automation will reduce the cost of labor, it means the research objectives for cost-related is valid. It helps in solving the major issue of the plantation industry which is the budget. By reducing cost
farmers get to increase their profit margin and able to expand their business larger than before.

In the interview we asked about "If there is a way for farmer's organization to detect and monitor their plant's health instantly, should it be implemented? Why?" and most of the answer is yes. It means the image processing which is one of our system features is worth implementing and matches the research objective. With this feature, it will help farmers to detect the disease and check the condition of the plant anytime. Many responses were answered to prevent further spread and increase the efficiency of the overall tasks. The research objective seems to be valid due to the interview responses. With the answer of increased efficiency, stopping disease for further spread and quickly rehabilitate of plant these show that by monitoring the plant's health instantly is required by the farmer or the organization to have the daily routine easier and take lesser time to complete all of it.

5. Conclusion

In conclusion, this application provides the user full control and monitors their hydroponic crop remotely. Users can monitor crop parameters such as pH of the water, the temperature of the water, crop condition, artificial light condition, and water cooler condition. With this feature on the system, it not only safe money on lab equipment it also safe time and reduce infeasible task for the user. Therefore, users can achieve the best plant crop health and harvest plants more effectively. Although this application is used for hydroponic system, but it might be harder to implement for a larger crop. Especially, the image processing and live streaming of hydroponic crops, and the larger the crop the higher the budget. Therefore, this project is only built for home hydroponic systems. For future work, this project can include controlling water pH function, water ppm, and having a backup battery which will bring a huge benefit for hydroponic crop system.

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