Web-based Automatic Monitoring & Scheduling Management of Highland Plantation on Low Ground

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***Abstract*—This paper proposes an automatic monitoring and scheduling management system for growing highland plants on the low ground. It is hypothesized that the plantation of highland plants on low ground is possible if the basic necessities such as temperature, humidity, lighting and water are monitored and controlled to suit their needs. Basically, this automatic system uses temperature, humidity and light sensor to detect the temperature readings, percentage of relative humidity and light availability respectively. The obtained values are sent to Raspbery Pi and are used for controlling the environment parameters. The desired conditions for the plantation are that the temperature must be below 20 degrees Celsius, the relative humidity must be higher than 60% and the lighting must be sufficient. In case any of the conditions is not achievable, mist spray, peltier and UV light will take respective action to stabilize the condition back to the desired setting. Interestingly, this system allows users to monitor environmental humidity and temperature as well as current activities at the plantation through the website in real time. The results show the system is functioning well since fragile highland plants such as strawberry could survive in normal indoor low ground condition for a fortnight.**

***Index Terms*—Horticulture; Humidity; Temperature; Raspberry; Web Based.**

I. INTRODUCTION

Every year, there is a high demand of highland crops such as cabbages, tomatoes, teas and strawberries from all over Malaysia. However, as most of the places in Malaysia are experiencing hot climates every year, except for Cameron Highlands and Genting Highlands, it is quite difficult to grow these highland plants on the low ground. This surely results in high transportation cost for transfering crops from the highland to the low ground. Besides, the freshness of the crops is also hard to be maintained after a long travelling route. Motivating by these reasons, an automatic monitoring and scheduling management system is proposed.

This system has a similar concept of greenhouse, which helps farmers to observe and handle plants from extreme climatic conditions [1]. However, this system is more suitable for small scale gardener due to the small size and its suitability to be placed inside the house. The size and design are flexible as it can be moved anywhere and the settings on the software can be done at any time.

As commonly known, the highland plantations require more attention, especially on the temperature and humidity. This is because the hot climate condition experienced in most part of Malaysia can easily damage cold climate plants. Cold climate plantation, also known as highland plantation demands a specific range of temperature around 10°C-20°C with the percentage of humidity about 60%-80% [2]. Higher percentage of humidity will lead to the growth of bacteria, whereas low percentage of humidity can cause disease to the plant such as allergies. Therefore, there are four effective environment elements that will be monitored and handled automatically by the system, which are temperature, humidity, water and light. Therefore, in order to monitor those elements, sensors will be used.

Generally, sensors have important roles in agricultural sector such as, drought evolution test [3], gravity water monitoring [4], estimation of fungal and bacteria production [5], agriculture monitoring [6-9] as well as crops watering robot [10]. In agriculture monitoring and scheduling, Adamides et al. used semi-autonomous spray robot for watering robot with manual plant monitoring. They focus their analysis and discussion on robot performance and engineering. Meanwhile, Dong et al. studied on the interaction of wireless sensor in the soil with the pivot center to organize watering schedule for large plantation [11]. Next, Li et al. focus their study on the precision of sensor for large plantation agricultural.

As compared to our project, we aim to develop a complete monitoring and scheduling system mainly for highland plants. However, for the initial stage, the monitoring and controlling process only focuses on four key elements, which are the temperature, humidity, water and light of single plant, namely the strawberry. It is important to note that, strawberry is a fragile plant that can be affected by climate changes easily; therefore, a good sample for this experiment[3]. This paper is organized into four sections. After the Introduction Secton, Section II discusses the data collection and experiment. The results will be discussed in Section III, followed by the conclusion in Section IV.

II. RESEARCH METHODOLOGY

The process of the system will start by measuring the values of temperature, humidity and light using sensors. The sensor will measure the current values of temperature, humidity and light. The measured values are controlled by the Raspberry Pi. Then, the data collected are sent to MySQL database. The Raspberry Pi is linked with web servers and the output is displayed on the website. The values displayed on the website are taken from the database. Users get to view the current values from the website. At the same time, the collected data is compared with the optimum values that had been set. The desired conditions for the plantation are that the temperature must be below 20 degrees Celsius, the relative humidity must be higher than 60% and the lighting must be sufficient. In case any of the conditions is not achievable, mist spray, peltier and UV light will take respective action to stabilize the condition back to the desired setting. For example, if the humidity is lower than 60%, the mist will be sprayed; if the temperature is more than 20 degrees Celcius, the cooler (peltier) will turn on; and if the light is absent, the UV light will turn on. Note that, the plant will be watered every day at 8.00 a.m. and 5.00 p.m.; the water pump will be activated during the time to water the plant.

The logic and decision making programming are coded into the Raspbery Pi so that even with raw input, data system can work to follow optimum parameters set. Further, explanation regarding the programming of Raspbery Pi and control flow chart will be explained in detail in our next paper.

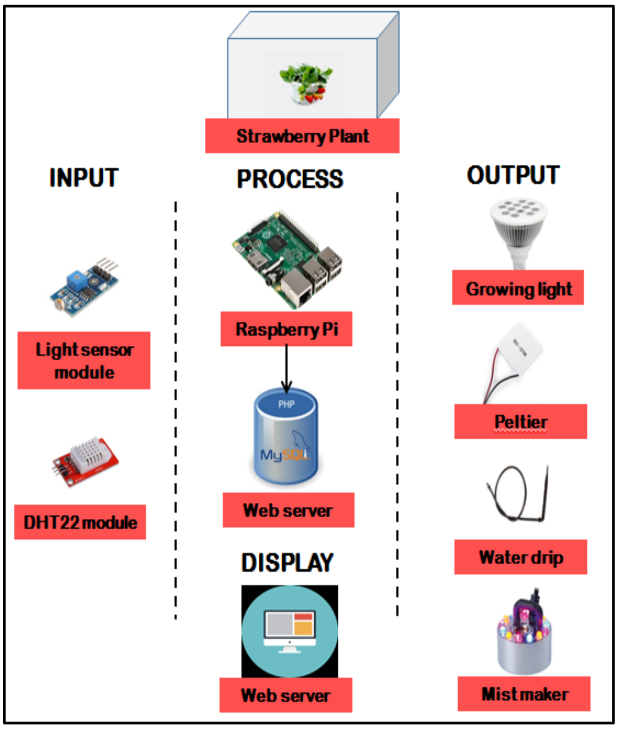

Figure 1: Block diagram of the system

A. *Hardware*

Figure 2 shows the prototype of a closed container complete with all input and output components attached. From the observation, the temperature and humidity sensor was located inside of the container as the sensor measured the temperature and humidity surrounding the closed area. Two DHT22 sensors (temperature and humidity) were used where one was for checking constantly every 3 minutes, whereas the other one was for checking the current temperature, while action (peltier) was activated. All output components were placed inside the container as the actions will be done towards the plant that was positioned in the container.

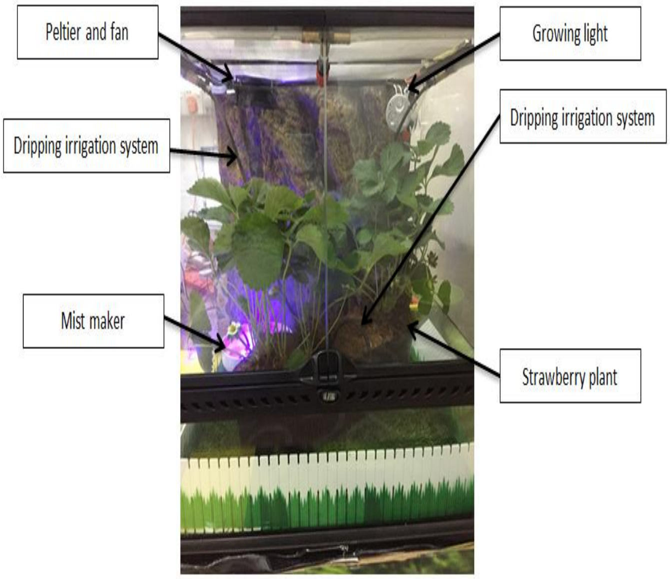

Figure 2: Automatic monitoring and scheduling management system prototype (front view)

The light sensor was placed on the top of the container. This is because it is the best location to detect the presence of sunlight. The peltier which acts as a cooling device requires two fans as the peltier consists of two sides: hot and cold. The cold side of the peltier is facing inward whereas, the hot side is facing upward. The function of the fan for cold side is to allow cold air moves into the container, whereas the fan for hot side is used to remove heat from the hot side of the peltier. Thus, the heat sink was used on the hot side to absorb from moving toward the cold side.

B. *Software*

Figure 3 shows the website of the project. The website displays the real-time of temperature, humidity, peltier and mist. Moreover, there were two graphs plotted in the website: temperature and time. The graphs framed-up the changes of temperature and humidity over time. On the other hand, there are manual system on the website, where user is able to switch "On" and "Off" the output components such as the pump, peltier and mist manually from the website. Most importantly, user manages to view a database of temperature and humidity through the website.

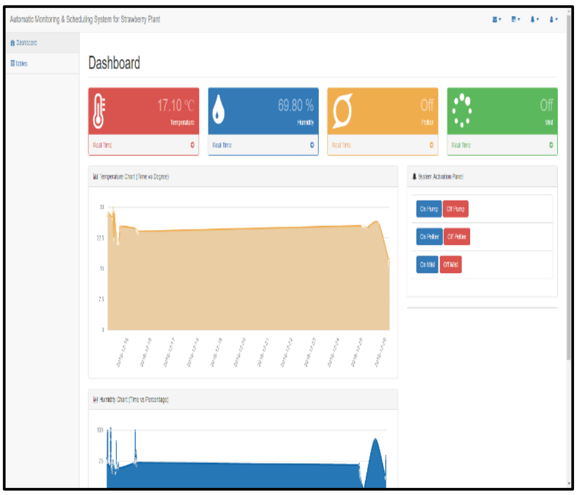

Figure 3: Interface of website

III. Results and Discussion

The temperature and humidity values are measured using DHT22 sensor, the values obtained are compared. For example, when the temperature value exceeds 20°C, peltier and fan activated automatically. The outputs action for temperature continues running until the real-time temperature displayed on website, not exceeding 20°C. Meanwhile, whenever the peltier activates, "On" is displayed as real-time on website. On the other hand, the mist maker activates when Relative Humidity (RH) displayed on website is less than 60% and "On" is displayed on real-time.

When the current time is at 8.00 in the morning and 5.00 in the evening, the water pump activates automatically. The water pump is connected to the drip irrigation system in the soil. As strawberry plant is suitable to be watered through soil instead on the leaves, the drip irrigation system is the best solution. The growing light is the most suitable light that can be used to replace sunlight as it is especially for plant. For instance, when the container is placed in a dark area, the growing light will be switched on automatically.

Table 1
Input and Output Operation System

Sensor Detection	Value	Condition	Website Display
Temperature	<20°C	Nil	Display real-time value Display Off peltier
	>20°C	Peltier and fan activated	Display real-time value Display On peltier
Humidity	<60%RH	Mist maker activated	Display real-time value Display On mist
	>60%RH	Nil	Display real-time value Display Off mist
Light	Light=1	Light switched on	Nil
	Light=0	Light switched off	Nil

The initial temperature varies based on the place, where the system is placed. This means that when the system is placed in a room with air-conditioner, the initial temperature is low and vice versa if the system is located in a room without an air-conditioner. However, the temperature decreases over time.

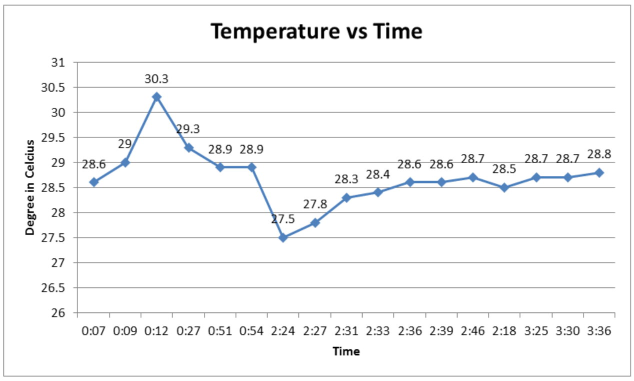

Figure 4: Graph temperature vs time (room without an air-conditioner)

Based on graph shown in Figure 4, the temperature drops from 30.3°C to 29.3°C which takes around 15 minutes. Moreover, another drastic temperature drops from 28.9°C to 27.5°C takes time about 30 minutes. This shows that the fastest time of decreasing 1°C in room without an air-conditioner room takes at least 15 minutes.

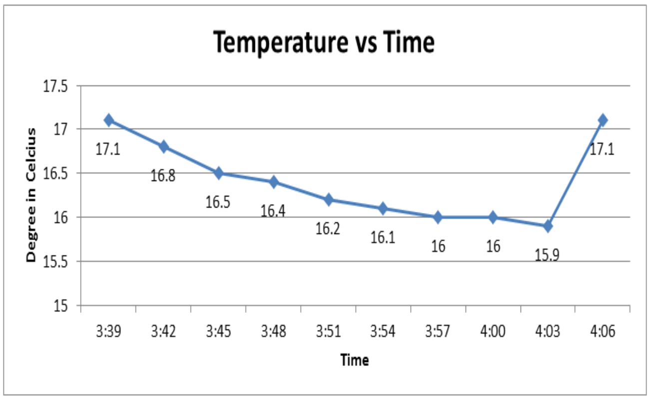

Figure 5: Graph temperature vs time (room with an air-conditioner)

Based from the observation, it can be seen that the 1°C drop in the temperature in a room with air-conditioner took about 15 minutes. Besides, the fastest time to reduce 0.3°C takes only 3 minutes. This shows that the fastest time of a 1°C decrease in a room with an air-conditioner room takes at least 15 minutes. Therefore, when comparing temperature over time for both rooms with and without air-conditioner, it shows that the quickest time for decreasing 1°C temperature is 15 minutes. From this observation, temperature decreases in both conditions of the room, but it can be seen that temperature drops quickly to the optimum temperature, below 20°C when in an air-conditioning room.

In this project, the Relative Humidity (RH) of the surrounding is measured using humidity sensor. Based on observation, it is best when Relative Humidity maintain above 60% RH.

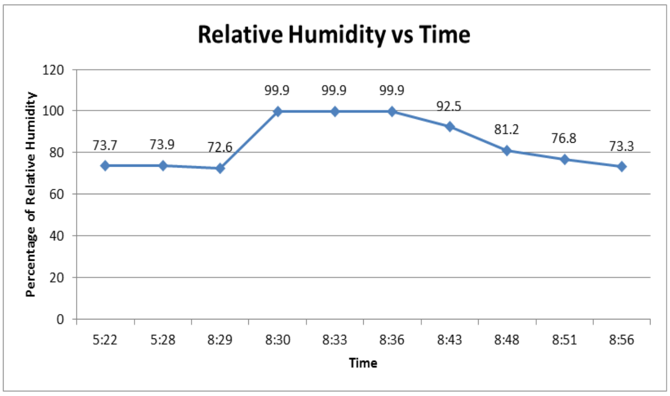

Figure 6: Graph humidity versus time (room without an air-conditioner)

Based on the observation of Figure 6, the highest humidity measured in room without an air-conditioner was 99.9% RH and the lowest was 72.6% RH.

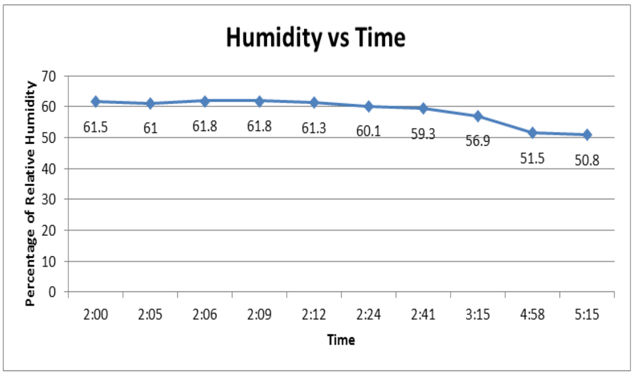

Figure 7: Graph humidity vs time (room with an air-conditioner)

From Figure 7, the highest humidity measured in room with an air-conditioner was 61.8% RH and the lowest was 50.8% RH. Therefore, when Relative Humidity reached below 60% RH, the mist maker activated automatically to increase percentage of humidity back to normal.

Light sensor plays an important role in this project to detect presence of light. When the light sensor detects an absence of light, growing light will be switched on as it replaces sunlight. Based from observation, when the system is located in a dark room, growing light switched on and vice versa.

IV. Conclusion

Overall, this paper described the characteristics and effective elements needed for highland plantation to be planted on low ground, related works, methodology, design including the development of a web based automatic monitoring and scheduling management system of highland plantation on low ground by using Raspberry Pi.

The functionality of the system was analyzed based on observing four important elements, temperature, humidity, light and water. The system was designed in small size and flexible to allow the system to be located at any places effectively. The system proves that highland plantation can be planted on low ground at any places by using this system as all the important elements for plant can be maintained very well.

For future work, it is planned details work on other factor that affect plan growth, such as soil nutrition is studied and used for system improvement. This system could be extended for large plantation, however certain modifications should be done on the hardware to fit large plantation requirement. It is also expected detailed framework, explanations and extended data would be discussed in the next paper.

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