Internet of Things based Smart Environmental Monitoring for Mushroom Cultivation

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Article Info	ABSTRACT
	Environmental condition is a significant factor that needs to be controlled in mushroom production. Mushrooms are unable to grow if the temperature is higher than 33°C or lower than 25°C. Thus, this work focuses on developing an automatic environmental control system to provide optimum condition to mushroom production house. Environmental factors considered in the system are temperature, humidity and carbon dioxide. For this, DHT11 temperature humidity sensor and MQ135 CO2 sensor are connected to the ESP8266 Wi-Fi module to become IoT (Internet of Things) sensors that send big amount of data to the internet for monitoring and assessment. This enable users to monitor the environmental condition anywhere whenever accessing the internet. Based on the analysis of the data, the system will automatically on and off the irrigation system to put the temperature at an optimum level.

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1.   INTRODUCTION

Environment Control Agriculture (ECA) is the modification of the natural environment to achieve optimum plant growth. This implementation is significantly needed in Malaysia as the demand for food increases rapidly. By controlling the environment for cultivation, the production and quality of crops can be increased as the crops obtain optimum conditions such as temperature, carbon dioxide, humidity, water, sunlight, nutrient and pH. This modification can also be applied to any kind of plant-cultivation to extend the growing seasons that enables plants to grow during periods of the year not commonly used to plants open field crops. By applying ECA devices, the increasing demands for mushroom can be fulfilled as the production rate increases.

Environment Control Agriculture is a system where plants are cultivated under greenhouse or production house with embedded automatic systems. The environment can be controlled automatically to maintain optimal conditions. Nevertheless, local farmers are still not familiar with this system due to lack of knowledge and exposure. Besides, not many information and research has been done on the effects and benefits of ECA in Malaysia especially for oyster mushroom. In mushroom production such as oyster mushroom, temperature is the main factor that needs to be controlled. This is because green mold [1] will appear if the mushroom bag temperature is less than 25°C.

Various plant was planted using environment control agriculture such as tomatoes, lettuces, strawberries, mushrooms and spinach. For these crops, the production has increased proportionally because the environment factor was controlled automatically to its optimum condition [2]. The rate of productions and quality of the crop increases if optimum environment condition is provided to ensure perfect growth. Using ECA device, the data for each environmental factors can be determined by using sensors [3]. The data

will be processed by the microcontroller to decide the actions needed to be taken in order to maintain the optimum conditions.

There are several methods of plants cultivation such as hydroponics, poly bags, capillary mat, aeroponics and open field. These methods except open field, are usually done under greenhouse or production house. Hydroponics is a system where plants are cultivated using water containing nutrients. Water flows inside the water tube and the plant roots are immersed into the solution. This method uses nutrient solution to replace soil. In the meantime, water is being pumped through the tube and recycled all over again in a closed system.Capillary mat is also used to replace soil because the mat is able to absorb nutrient water. This method is usually used to plant lettuce since lettuce needs larger space for growth. The systems use timer in the pump to trigger the watering automatically.

Greenhouse is also a new system in which crops are cultivated fully under system control. The controlled factors are water, temperature, humidity, CO2 level, light intensity, air flow, pH and nutrient level. All of these factors are being controlled automatically with the use of an automatic system control with suitable sensors [4].

This project is an implementation of smart farming for mushroom cultivation. Smart farming is about real-time data collection, processing and analysis, as well as automation technologies on the farming procedures to achieve improvement on the farming activities. In conjuction with 4.0 industrial revolution, Internet of Things (IoT) sensing and mobile technologies has now becoming a daily assistant to numerous activities, smart farming has also improved to a new level. An IoT technologies has been widely implemented in measuring human acivities [5] smart grid [6], smart home system [7] and agricultural monitoring system [8]. Mobile applications interacting with the IoT based agricultural sensors are now used to facilitate management of cultivation and/or livestock [9]. For examples, Herdwatch [10] is herd management system which allows cattle farmers to manage their beef via a smartphone or tablet. Another example on livestock is MooMonitor+ [11] that monitors cow's health and fertility by means of wearable collars, allowing farmers to monitor their entire herd, from their phone.

In cultivation activities, example is such in [12] where an Arduino-based environmental control system was developed with ESP8266 (WIFI module) as the system IoT device that send environmental sense data to the server for processing. Apart from the ESP8266, work in [13] use zigbee technology to communicate the sensors to the server. Then, decision is made to control the irrigation system of the cultivation house. Similar systems were also presented in [14] and [15].

Comparing WIFI module versus the zigbee module, generally zigbee is promoted as having lower power usage. However, its protocol is more complicated than WIFI. Since ESP8266, if configured properly, also consume tolerable low power, it is a good pick if WIFI module is to be used. Thus, this work will explore how to optimally implement the ESP8266 as the IoT device on the environmental control system.

Although proven to be working properly, works in [12-15] were assumed to work for any greenhouse environmental control system where non, have been implemented at the mushroom cultivation house. Thus, this work will study the environmental behaviour inside the mushroom cultivation house to optimally control the temperature and humidity.

2. RESEARCH METHOD

The basis for the proposed automatic system is the IoT Wi-Fi module device called NodeMCU ESP8266 V2.0, which is used to collect enviromental data (sensor node) and send it to the internet for data monitoring and analysis. The IoT device is also used as the controller to maintain the environmental condition at required level. This ESP8266 is powered by battery and can last for few months if configured properly.

The flow process of the system is shown by Figure 1. Referring to Figure 1, the monitoring and assessment process are done through ThingSpeak.com based on data passed by the sensor node. In total, six sets of the ESP8266, each connected to the environmental sensors (DHT11 temperature/humidity sensor and MQ135 CO2 gas sensor) were used as the sensor nodes. Then, another ESP8266 (single unit) will get information from the ThingSpeak.com to control the actuator to achieve optimum environmental condition.

The controller of the system is connected to the irrigation system to automatically watering the production house in controlling its temperature and humidity to be below a required level. This irrigation system consists of irrigation piping with drippers and mist nodes, and a water pump which its operation is controlled by the controller through connection with relay.

As already mentined, two types of environmental sensors are used in the proposed system; the DHT11 and MQ135 to read internal production house temperature/humidity and CO2 concentration respectively. These three environmental factors are chosen because these are widely measured in various precision agriculture system [14]. Furthermore, these three environmental factors are also the common

concern from the local musroom growers directly and indirectly involved in this work. Theoritically, CO2 is produced during the mushroom's growth in compost, which negatively affects mushroom growth during pinning. Pinning is the trickiest part for a mushroom grower, since a combination of CO2 concentration, temperature, light, and humidity triggers mushrooms towards fruiting.

In configuring the ESP8266 as sensor nodes and controller, Arduino IDE was used to flash the programming code to the ESP8266 module. Thus, implementation of the system is quite easy. Other than that, NODEMCU Firmware Programmer is also used in updating the firmware of the module. The firmware used in this work is version 'prebuild nodemcu 20150127.bin'.
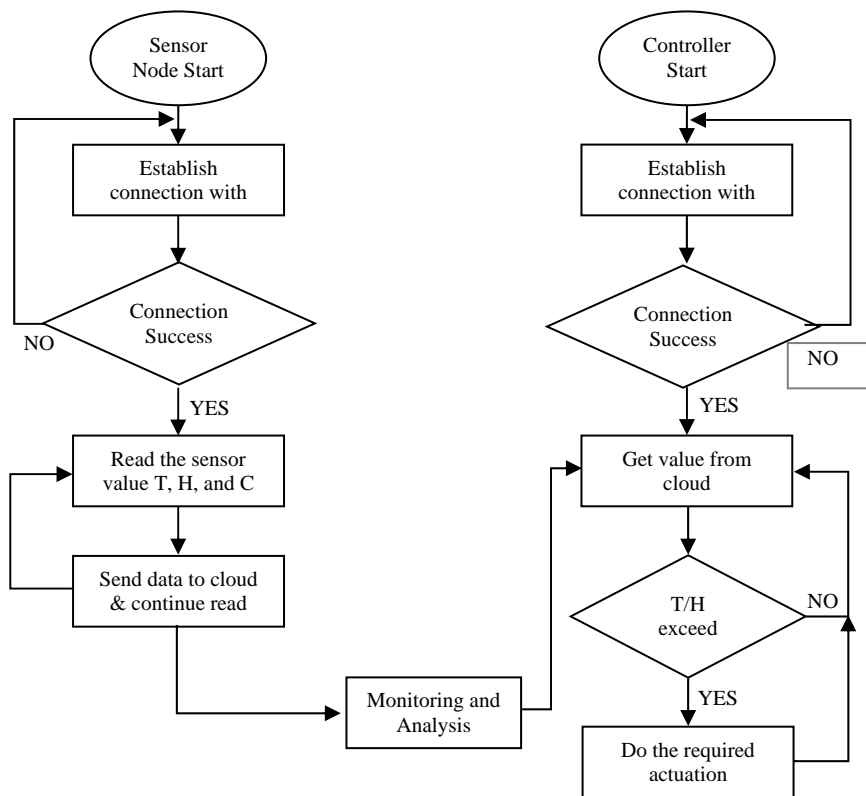
Figure 1. The system flow process

3. RESULTS AND ANALYSIS

The proposed system has been tested using mushroom production house replica and two actual production houses at Kota Tinggi and Benut, Johor. The replica was placed at UTM Agriculture farm to have actual outdoor environmental condition. Figure 2 shows the replica and the ESP8266 installed at the actual production house.

(a) Replica of the production house   (b) Sensor node at actual production house

Figure 2. Mushroom production house replica

In the actual mushroom production house test, the six sensor nodes are installed at random position and run until the battery power dried. Then, an internet connection is established by setting up nearby access point and monitoring to the system is done through ThingSpeak. This is shown in Figure 3. Figure 4 gives an initial set of data that was collected from 10.00 pm to 12.00 am to see the performance of the system. Figure 5 shows an example of one period of data displayed on ThingSpeak. With the IoT implementation, less mobility required in order to collect the data and to monitor the condition of the production house.

Based from the data obtained, the system managed to collect the environment data and the data was compared using HT-2000 Data Logger device to check for its accuracy and reliability. For example, the data from the proposed system during 2.00 p.m. were 33°C, 62% RH and 451 ppm. The reading when using HT-2000 were 32°C, 64% RH and 470 ppm. The differences between the readings from ECA device with HT-200 device, the data from the proposed system is expected because the sensors used have offset reading as stated in the datasheet. However, the difference is considered too small.
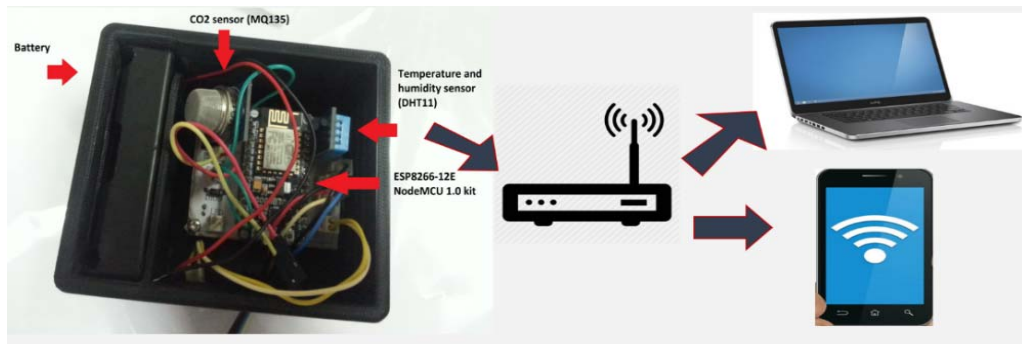

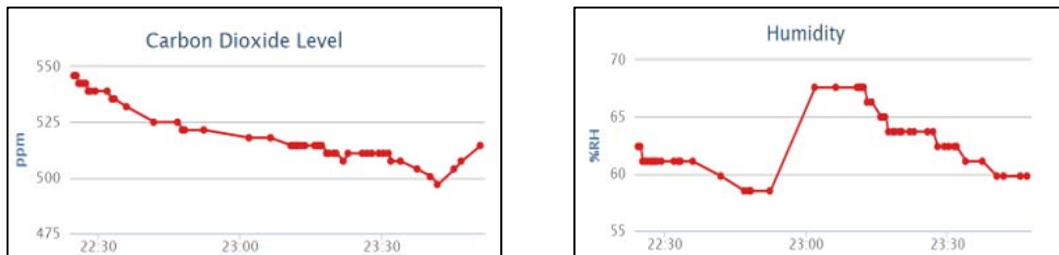Figure 3. The connection of each devices

Figure 4. Data collected for short period of time

From 3 months of reading the environment data, it shows that watering the mushroom production house did lower down the temperature and increase the humidity. Battery usage for the system is moderate where it can stand up to 10 days before the battery is fully dried. Generally, the battery usage can be improved by properly configuring the deep sleep mode. Another option is to connect a Real-Time Clock (RTC) chip to shut down the ESP8266 and power it on when needed
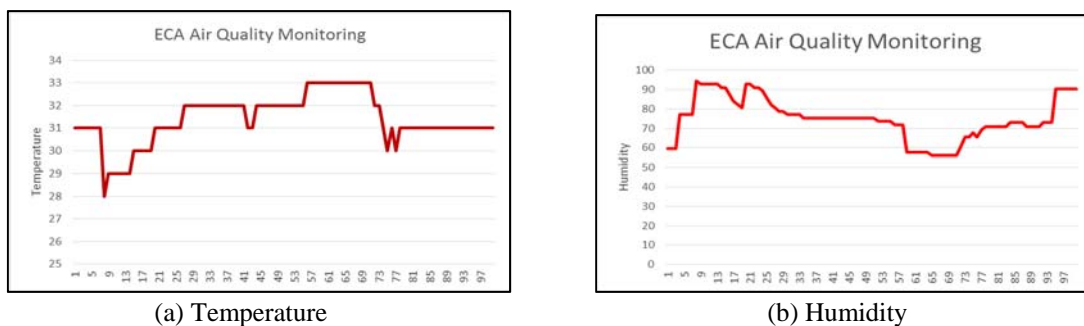
(a) Temperature   (b) Humidity

Figure 5. Monitoring through ThingSpeak for one period

4.   CONCLUSION

Environmental condition is a significant factor that needs to be controlled in mushroom production. The device is able to develop an environmental control agriculture system that will increase the production of crops. It is done by taking the environmental data and store it using the internet. The data collected are temperature, humidity and CO2 level. The system managed to collect the environment data and the data was compared using HT-2000 Data Logger device to check for its accuracy and reliability. The small difference as low as 3% were shown. The control system inside the device is automatically triggered if the environmental conditions are not in optimum condition. This system however requires a stable internet connection to ensure that the data is sent to the internet. The combination of this sytem with water dripper and mist device, will give better effect to the environmental condition inside the cultivation farm. Other than that, this system has successfully implemented the concept IoT and automated control in the precision algriculture.

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