Internet of Thing Based Automatic Temperature and Humidity Regulation Model for Oyster Mushroom Cultivation

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***Abstract*—Digital communication technology between machine-to-machine grew quickly compared to the past years. Due to recent breakthroughs, it is easy to set up small devices which are capable to talk with each other perform automated tasks. Because of this reason, most of Internet of Things (IoT) can be used as a monitoring and automatic regulation model for any sector, namely agriculture. IoT can help the farmers, especially oyster mushroom cultivation to ensure proper mushrooms' growth. Oyster mushrooms require strict conditions to grow properly before harvest season starts. These strict requirements such as temperature and humidity are hard to monitor and regulate hourly, and farmers must check the cultivation one-by-one manually. Hence, IoT-based automatic temperature and humidity regulation model is expected to help farmers to maintain the current temperature and humidity hourly or even live situation of their cultivation. The purpose of this research is to develop an IoT-based automatic temperature and humidity regulation model to adjust oyster mushroom cultivations' temperature and humidity using DHT22 digital sensor with a built-in tool such as pump and fan without human intervention.**

***Index Terms*—DHT22 Sensor; Internet of Things; Monitoring; Mushroom Cultivation.**

I. INTRODUCTION

Communication is known as a method to transfer information between two persons or more. In the modern world, communication is not only between people but also between machines. This kind of technology is known as Internet of Everything (IoE), where every processing-capable device can communicate seamlessly with each other either wired or wireless [1]. These devices are called Internet of Things, which require either internet or small network to communicate with each other [2]. With this technology, it is easier to retrieve or transfer between each device. Hence, this technology can be applied to many sectors such as agriculture. Some of the agricultural cultivations require strict monitoring and regulation, for example, oyster mushroom cultivations, which require certain conditions to ensure oyster mushroom grows properly before the start of harvest season.

Oyster Mushroom or known as *Pleurotus ostreatus* is a kind of edible mushrooms cultivated by farmers that contain high value of nutrition and as an alternative for meat consumptions [3][4]. This mushroom is indicated with white to brownish color and shaped like an oyster. Because of its high nutrition value, this oyster mushroom is being cultivated by the local farmer to boost production during harvest season.

However, one of the biggest problems of oyster mushroom cultivation is the strict requirement for an oyster mushroom to grow properly before harvest season. Oyster mushroom requires a temperature between 16-30˚C and humidity 80~95% to grow properly [5]. Improper cultivation conditions may lead to low-quality harvest and cause loss to the farmers. The farmers are required to maintain those conditions for every oyster mushroom cultivation. Since the farmers handle many oyster cultivation fields, it is hard to monitor and adjust the condition of every cultivation field at the same time. To be able to regulate the cultivation conditions, an automatic regulation model to help the farmers adjust the temperature and humidity conditions of cultivation is required.

The purpose of this research is to design an Internet of Things based on automatic temperature and humidity regulation model to adjust the temperature and humidity of oyster mushroom cultivation. Retrieved information from the sensor will be processed by the main component of IoT, and then uploaded to the internet using a specific API library and server. So, the farmers can check the information easily via smartphone. When the internet is not available or the farmer is near the cultivation, the farmer can check each LCD to see the current temperature and humidity

II. LITERATURE REVIEW

There are several researches that focus on how to automate the regulation of cultivation conditions. Since Internet of Thing technology is used in any sector, one can be used in the agriculture sector to monitor and control the situation inside the cultivation [6]. This can help farmers to either irrigate their cultivation automatically or monitor them from far away. Some of those researches focus on how to monitor the growth of mushrooms with DHT11 temperature and humidity [7]. Besides monitoring, some researches also focus on how to control the condition inside the cultivation by using additional tools like fan or pump on aquaponic cultivation [8].

Many agriculture cultivations exist to support the needs of the customer, for example, *Shiitake* mushroom cultivation. *Shiitake* mushroom has a strict cultivation condition, hence smart monitoring and environment control designed to support the mushroom growth [9]. Not only that the research regarding oyster mushroom cultivation exists, there are research result indicating the capability to monitor the condition inside the cultivation, including gas concentration, temperature, humidity, and light[10]. Due to the lack of condition control, the research continued with control temperature by using IoT and Android device to adjust the temperature inside the cultivation using light and pump [11].

III. RESEARCH METHOD

Before designing any IoT-based model, the first step was to gather data by observing oyster mushroom cultivation and interviewing the farmers. The regulated behavior of the farmer was obtained through data variation, Hence, it is possible to know the temperature and humidity threshold to trigger the regulation components such as fan and water pump.

The design of the automatic temperature and humidity regulation model were based on the obtained data, and it was designed with a specific development cycle for Internet of Things-based system only. This development cycle consists of many steps to specify the purpose, requirements, processes, information model (or data model), service, level, functional view, operational view, device integration and application to be used along with the IoT device.

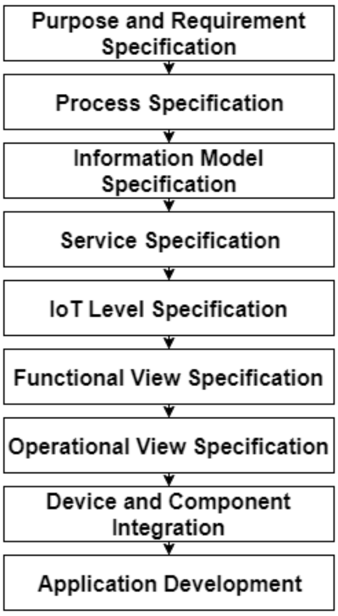

Figure 1: Internet of Things development life cycle

Hence, the purpose of this IoT model is to monitor and regulate the cultivation's temperature and humidity. To build a model with this purpose, the model requires temperature, humidity, and its threshold according to the observation and farmers' interview. Each of the stages must be followed properly to make sure that the IoT device is working properly and fulfill its purpose as an automatic temperature and humidity regulation.

The model works according to the flowchart in Figure 2. The flowchart process explains how the model monitors and controls the temperature and humidity inside oyster mushroom cultivation. The process of the model starts with a sensor checking the temperature and humidity. The model uploads the data to the cloud server, and at the same time checks for the threshold for pump and fan activation. If the temperature is above 30°C, the fan will be activated to suck away the heat. If the relative humidity is below 75%, the pump will be activated to water the cultivation. This process will be repeated until the power interruption occurs to the device.

The information mode exists inside the mushroom cultivation is attributes such as temperature and humidity. In this model, the information model consists of the cultivation itself which has temperature and humidity as an attribute. Inside the cultivation, there are two additional entity which supports the regulation system such as cultivation pump and fan, both have "status" as their attribute.

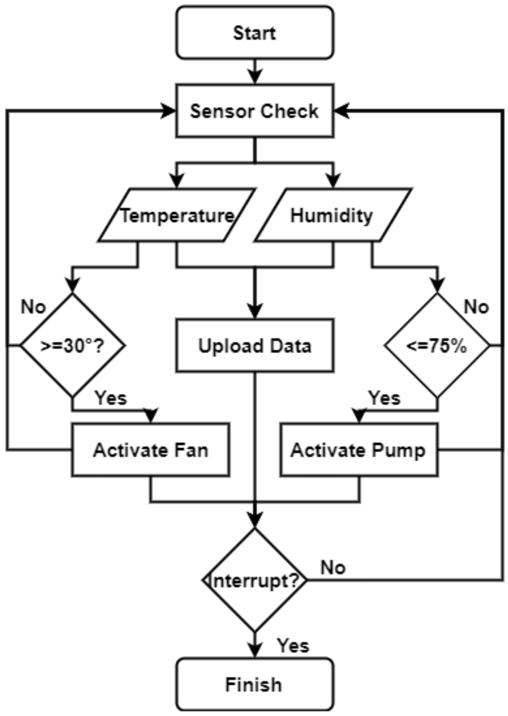

Figure 2: Flowchart process of IoT model

The model must specify the functional view of the automatic regulation inside the functional model, which contains three main parts, such as Device, Service, and Communications. The device part consists of a processing-capable board with wireless connectivity capability, such as NodeMCU, and the temperature and humidity sensor to capture environmental attributes from the cultivation field. The service part consists of the main function inside the board, either programmable or built-in inside the board, such as digital signal capturing. The communication part has a job to publish or send the information from the sensor to the server through wireless connectivity established before the sensor starts capturing the data.

The automatic temperature and humidity regulation model operates by using a processing-capable board such as NodeMCU, temperature and humidity sensor with DHT22 sensor, fan, and pump. Every time the board fetches the temperature and humidity information from the sensor, it will forward the information to the server and retrieve it through an app installed inside the smartphone. The information can be accessed through an LCD.

This automatic regulation model requires a specific application that builds under IoT supported by API's library such as Blynk. This library allows IoT nodes to upload data through wireless connectivity with the help of the API library. This library currently does not support direct data transfer to the central computer, but only to its server and accessible through a smartphone.

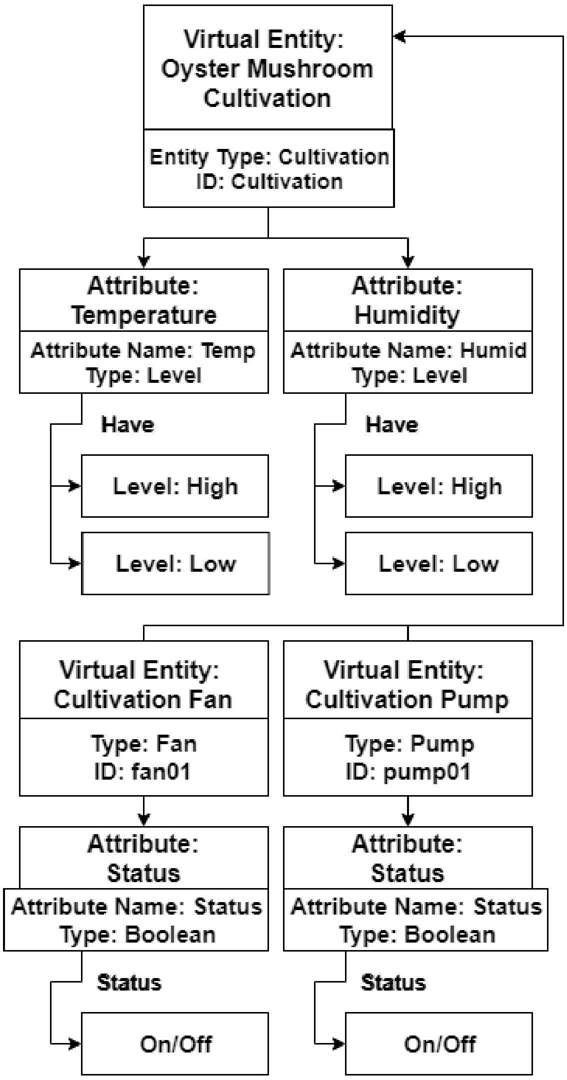

Figure 3: Information model for the regulation model

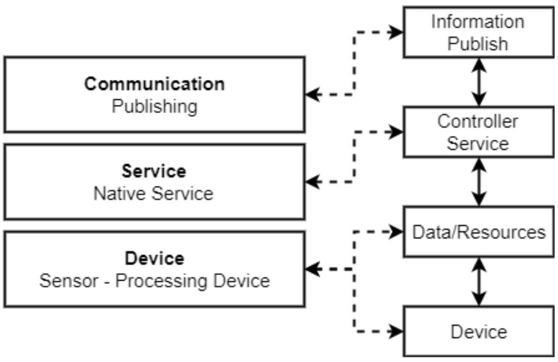

Figure 4: Functional view for the regulation model

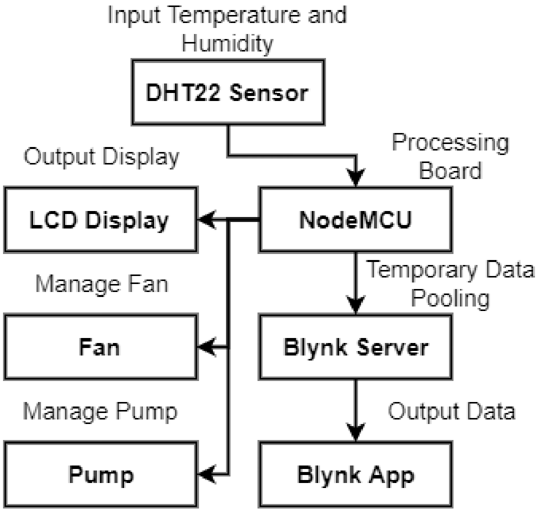

Figure 5: Operational view for the regulation model

IV. Result And Analysis

The result of this research is an IoT model, in which the output data from the sensor is received and exported via smartphone. After the first day of monitoring and regulating the mushroom cultivation field, the processed data from the server are shown below:

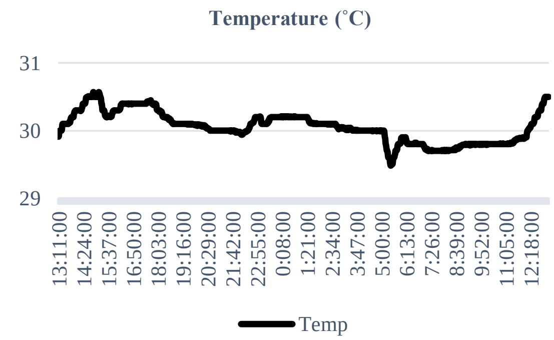

Figure 6: 1 Day of temperature monitoring

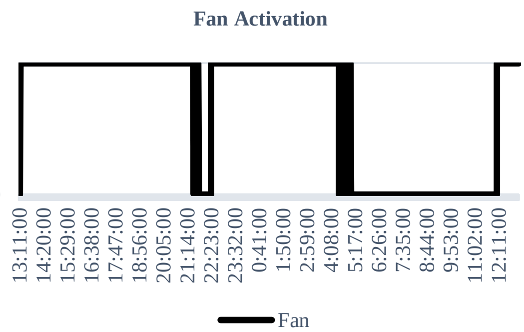

Figure 7: 1 Day of temperature monitoring

According to the figure above, the maximum temperature reached by the cultivation is 30.57˚C (which occurs 4 times or 0.28% from overall temperature data) and the minimum temperature is 29.48˚C (which occurs once or 0.07% from overall temperature data) with an average temperature 30.05˚C from the total 1-day temperature monitoring. During the 1-day of model activation in mushroom cultivation, the fan activated for 971 times and deactivated for 470 times. The threshold for the fan to be active by the board is 30˚C. Hence, the fan will be turned on when the temperature of the cultivation field rises beyond 30˚C.

Table 1
Descriptive Statistic of Temperature Regulation Model

	Result
Average Temperature	30.05˚C
Maximum Temperature	30.57˚C
Minimum Temperature	29.48˚C
Standard Deviation	0.23

Table 2
Frequency Statistic of Fan Activation

	Result
Pump Active	971 Times
Pump Deactivate	470 Times

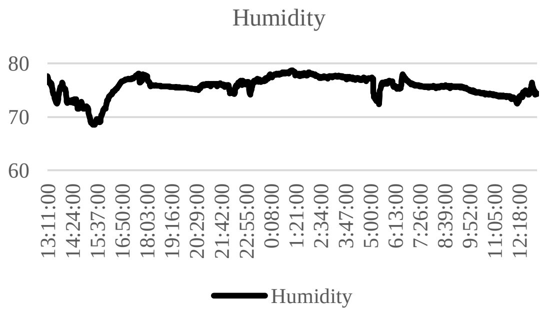

Figure 8: 1 Day of humidity monitoring

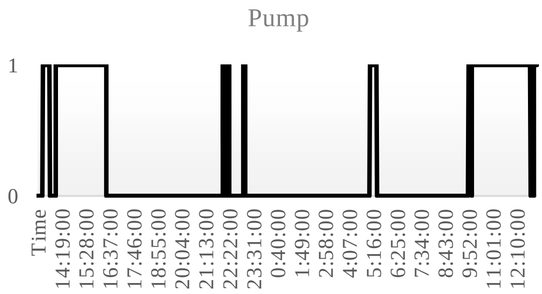

Figure 9: Pump activation frequency during monitoring

Besides temperature monitoring, the obtained data from 1-day humidity monitoring showed 75.64% as average, 78.71% as maximum (which occurs once or 0.07% from the overall humidity data) and 68.53% as the minimum (which occurs once or 0.07% from the overall humidity data). The pump is activated 1046 times and deactivated 395 times during 1-day monitoring with 75% pump activation threshold.

Since the pump activated more frequent than the fan, it indicated that the current temperature and humidity condition in the cultivation is warm, but the humidity is less than expected.

Table 3
Descriptive Statistic of Humidity Regulation Model

	Result
Average Humidity	75.64%
Maximum Humidity	78.71%
Minimum Humidity	68.53%
Standard Deviation	1.88

Table 4
Frequency Statistic of Pump Activation

	Result
Pump Active	1046 Times
Pump Deactivate	395 Times

The gathered data were then processed with *Support Vector Machine* to get the data validation of the sensor and the system when monitoring and controlling the modules. The confusion matrix for each data are shown below:

		Predicted		
		0	1	∑
Actual	0	100.0 %	3.8 %	1410
	1	0.0 %	96.2 %	2920
	∑	1295	3035	4330

Figure 10. Fan activation matrix

		Predicted		
		0	1	∑
Actual	0	99.9 %	0.3 %	3140
	1	0.1 %	99.7 %	1190
	∑	3141	1189	4330

Figure 11. Pump activation matrix

The fan control matrix shows that 100% predicted the fan turned off, and 96.2% predicted turned on with 3.8% misprediction. For the pump control matrix shows that 99.9% predicted the pump was turned off with 0.1% misprediction. 99.7% predicted that the pump turned on with 0.3% misprediction It can be concluded that the control mechanism is working well in regulating the temperature and humidity inside the cultivation.

V. CONCLUSION

The development of Internet of Things helps many sectors, especially agriculture. The main problem which may occur in every agriculture sector is monitoring and regulating the condition inside cultivation. The farmers required to monitor and control their cultivation every day to make sure their cultivation grows properly. Oyster mushroom cultivation is one of the many agriculture cultivations, which has strict requirements to make sure the mushroom grow properly. Hence, Internet of Things technology can help to monitor and control oyster mushroom cultivation until harvest season.

According to the research result, the automatic temperature and humidity regulation model successfully adjust the temperature and the humidity in the mushroom cultivation. The fan will be turned on whenever the temperature in the cultivation rises above 30˚C, and the pump will be turned on whenever the humidity falls below 75%. This process will be repeated automatically until oyster mushroom's harvest season come or the farmers decide to turn off the device. According to data, the temperature recorded by the IoT sensor reached a maximum of 30.57˚C and humidity by 78.71%.

The limitation of this research is the designed model is only capable to cover a smaller area of cultivation due to the sensor limitation. When the design is forced to regulate wider cultivation, the regulation mechanism is ineffective. For future research, the model should have a wider and better temperature and humidity monitoring and regulation built with Internet of Things technology.

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