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Implementation of Maggot Cage Temperature and Humidity Control Using ESP8266 Based On the Internet of Things

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Abstract

Black Soldier Fly (BSF) is a fly that can produce a maggot or larvae that are useful for human life, like a decomposer waste in the form of composting, animal feed, animal oil production, source of chitin, and for the economic incomes of the society. This study aims to develop a device that can be used to control the maggot cage temperature and humidity using the ESP8266 microcontroller based on the Internet of Things (IoT). The benefit of this study is the utilization of nozzle-based water spraying that can be used to maintain the maggot cage temperature and humidity to improve the quality of maggot cultivation results. In this study, the sensor used to read the temperature and humidity on the maggot cage is DHT11, then used a water spraying method to handle the temperature and humidity controlled by using the ESP8266 and online based on the Blynk IoT platform. This study result shows that the device built in this study can maintain the maggot cage temperature between 28 to 30°C and humidity over 60%.

Keywords: Black Soldier Fly, Maggot, DHT11, ESP8266, Internet of Things

1. Introduction

Maggot is a larva produced from the Black Soldier Fly (BSF), which has many benefits for human life, such as helping in the decomposition of organic waste so that it can be used as fertilizer in the form of compost and for catfish feed [1][2]. However, the quality of maggot breeding depends on the number of nutrients consumed by maggots when they are 0 to 21 days old and the environmental conditions when they grow and develop, namely the state of temperature and humidity. Therefore, the importance of controlling the temperature and humidity conditions of the maggot cage air has become an essential concern for several researchers because it is one of the supports in the successful breeding and maintenance of BSF maggots.

The development of a device to manage the temperature in the BSF cultivation process as an alternative to reducing organic waste has been conducted by Wakidah [3]. The researcher used an LM35 sensor to detect the enclosure's temperature and then used the Arduino Uno microcontroller to control the device. In controlling the temperature of the maggot cage, the researcher used incandescent lamps and heaters to increase the temperature when the temperature in the cage was less than 25°C, then used a fan to decrease the temperature when the temperature was more than 30°C. Furthermore, the implementation of IoT to monitor the temperature and humidity in the maggot cultivation media using Wemos D1 Mini has been carried out by Novianto [4]. The researcher used a DS18B20 temperature sensor and YL-69 humidity sensor to detect the temperature and humidity of the air around the maggot, then using a Wemos D1 mini microcontroller to send sensor data information to a smartphone using the Blynk. Monitoring of environmental quality in IoT-based BSF larval cages has been applied by Tegas [5]. In this study, the researcher used SHT20 and SEN0193 sensors to read the temperature and humidity of the BSF enclosure, then processed it using an ESP32 microcontroller, and after that, sent sensor information to the user using Antares as an IoT application. The

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implementation of mamdani fuzzy logic to monitor the maggot cage temperature has been studied by Harlim [6]. The researcher used a DHT22 sensor to read the air temperature and humidity and used incandescent lamps and fans to regulate the temperature and humidity of the cage. In addition, the researchers also used the ESP32 microcontroller to read sensor inputs and control the on/off lights and fans so that they could control the temperature and humidity conditions of the BSF enclosure. The monitoring of maggot cage temperature with a lamp for BSF maggot cultivation based on the IoT has been implemented by Putra [7]. The researcher used a DHT22 sensor to read the temperature and humidity of the cage, Arduino Uno microcontroller to process the data, lamps to maintain the temperature of the cage, and Bluetooth module HC-05 to send the cage temperature information to the user's smartphone device.

In this study, we built a device that can be used to monitoring the maggot cage temperature and humidity based on IoT using ESP8266 microcontroller and Blynk. The idea applied in this study is to maintain the temperature and humidity conditions of the cage using a nozzle-based water spraying technique. This is a development of the research that we did compare to previous research, where previous researchers had used fans, heaters, and incandescent lamps to control the temperature of the maggot cage. One of the drawbacks of using only fans, heaters, and incandescent lights is when adjusting the humidity of the cage air, where the humidity level is very dependent on the wetness level of the air. The advantage of the technique when using nozzle-based water spraying is that the temperature and humidity of the maggot cage can be managed together without adding another tool to the cage. The sensor used to read the temperature and humidity of the maggot cage is DHT11, then use the Blynk platform application to monitors and controls the temperature remotely based on IoT. This nozzle-based water spraying technique can be controlled automatically using the ESP8266 microcontroller so that it is active when the cage temperature is more than 30^{o}C or the humidity is less than 60% [17]. Pumps can also be controlled manually using the Blynk platform so that users can activate or deactivate the water pump motor remotely based on IoT.

2. Research Methods

Based on the system architecture information shown in Figure 1, it can be seen that the control device built consists of three core parts, namely input, process, and output. The input to the system built is a DHT11 sensor which functions to read the temperature and air temperature conditions of the BSF maggot cage, then it will be processed on the ESP8266 microcontroller. Furthermore, the output of this system is a relay driver which functions to turn the water pump motor on and off in order to control the conditions of the temperature and humidity of the enclosure air and a 20x4 LCD which functions to display messages on the device being built. The function of Blynk in the system that was built is as an IoT platform that functions to connect temperature and humidity data information to smartphones and control water pump devices remotely using the internet network.

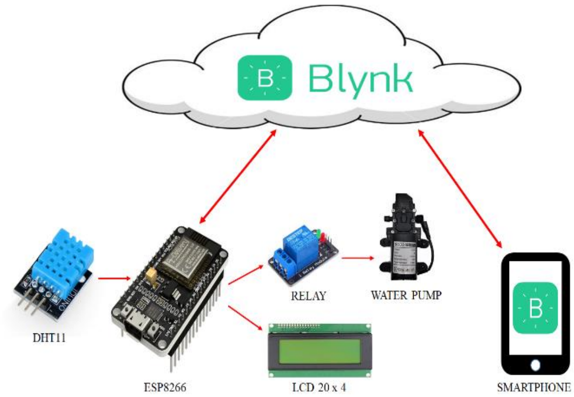

Figure 1. Systems Architecture

The DHT11 sensor is a sensor that can read the temperature and humidity conditions in an environment at the same time [8]. On the DHT11 sensor there are three pins that have a function as a voltage input for the sensor of 5 Volt DC, a ground voltage pin, and a sensor output data pin. NodeMCU ESP8266 is a microcontroller equipped with a Wi-Fi module so that it can be connected to the internet network automatically when controlling a device [9]. On the ESP8266 microcontroller there is a GPIO pin that serves to connect the input sensor device and control the output device. Relay is an electronic switch that can work automatically when getting an electric current voltage [10]. In the relay there are two main parts, namely electromagnetic in the form of a coil which functions to move the mechanical switch when getting an electric current voltage and mechanics which serves to deliver electric current when the relay is active. A water pump is a device that can be used to move liquids from one place to another by increasing the water output pressure [11]. The water pump in this study serves to pump water so that it can come out of the nozzle in the form of fine bursts so that it can lower the temperature and increase the humidity of the air in the maggot cage. Liquid Crystal Display (LCD) is an output device that functions to display messages in text form, where this LCD can be controlled using an I2C data communication system [12]. The LCD in this study serves to display the conditions for reading the temperature and humidity of the air in the BSF maggot cage.

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In this study, we use Blynk as an IoT platform that can be used to send DHT11 sensor information data from the ESP8266 microcontroller to a smartphone using the internet. In addition, it can be used to control the pump device manually remotely using a smartphone. Blynk is an IoT platform that can run on Android and IOS smartphone operating systems and can be used to control devices connected to Arduino, ESP, Wemos, and Raspberry Pi microcontrollers [13]. Blynk is one of the IoT platforms that offers convenience for its users where this platform has three main components in making it, namely blynk apps, servers, and libraries [14]. Internet of Things (IoT) is a technology that allows information on objects around the environment to be sent and controlled via the internet network [15][16]. In this research, IoT technology is used to monitor the temperature and humidity of the maggot cage as well as connectivity so that the water pump as the maggot cage cooler can be turned on or off manually remotely.

Figure 2 shows the flowchart of the software that is built to read input data sent from the Blynk IoT server, read input DHT11 sensor data, send temperature and humidity data to the Blynk server, process sensor data and IoT data streams, control water pumps, and controlling on and off the water pump remotely using an IoT-based smartphone. Based on the information in Figure 2, it can be seen that the initial steps taken in the system are reading the input data sent from the Blynk IoT server and reading the input data from the DHT11 sensor to detect the state of the temperature and humidity of the enclosure. The next step is to send the temperature and humidity data information to the Blynk IoT server using the V1 and V2 datastreams. After that the system will read the V4 datastream input sent from the smartphone via the Blynk IoT server. If the value of datastream V4 = 1, then the system gets a command from the user to turn on the water pump remotely manually. When the ESP8266 receives a command input from the Blynk IoT application to turn on the pump, the system will activate GPIO 3, otherwise the system will return to the initial stage to read input data from the Blynk server and sensor input. When GPIO 3 is active, the water pump will turn on to activate the nozzle water pump, and when GPIO 3 receives an active low command, the water pump will turn off and the nozzle will stop spraying water. Furthermore, when the system does not receive the command to activate the pump manually remotely, the system will read the state of the temperature and humidity of the cage air. If the temperature of the cage is more than 30°C then the water pump will be on to activate the nozzle so that the temperature will drop, if the temperature is below 28°C then the water pump will be off. Furthermore, if the system detects air humidity is less than 60% then the water pump will be on to activate the nozzle spraying, if the air humidity has exceeded 80% then the water pump will be off.

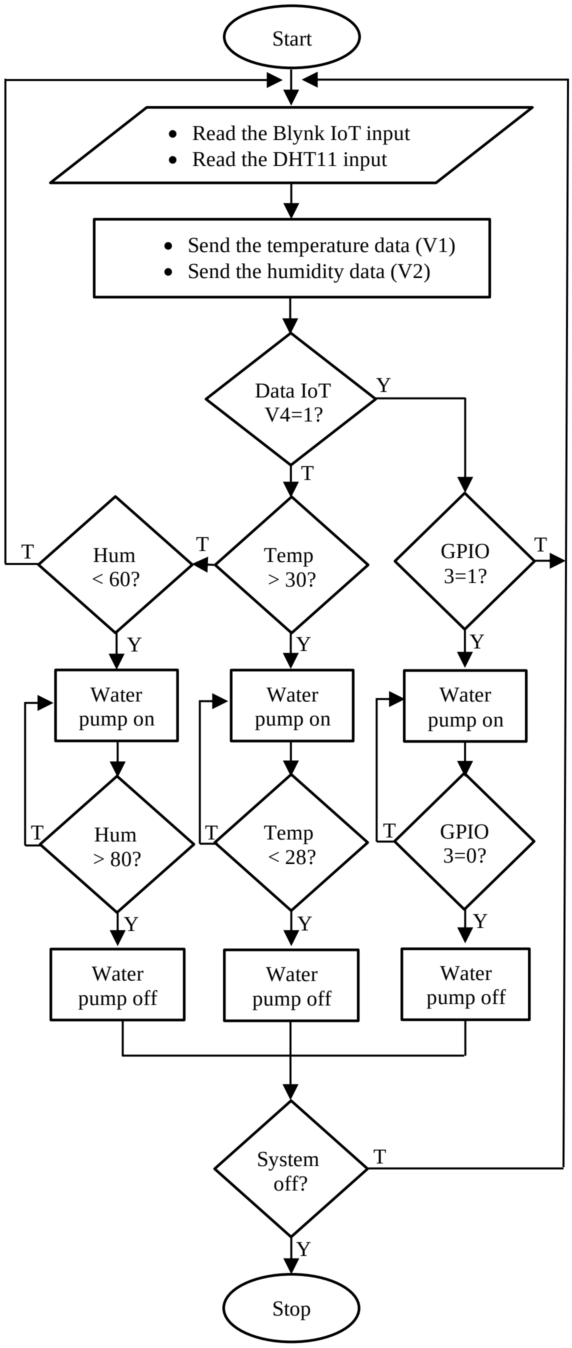

Figure 2. Systems Flowchart

3. Results and Discussions

In this research, a system device that can control the temperature and humidity conditions in the maggot cage has been built so that it is expected to improve the quality of maggot and BSF breeding. Figures 3 and 4 below are the results of the manufacture of the cage and the design of the control device used to control the temperature and humidity of the BSF maggot cage.

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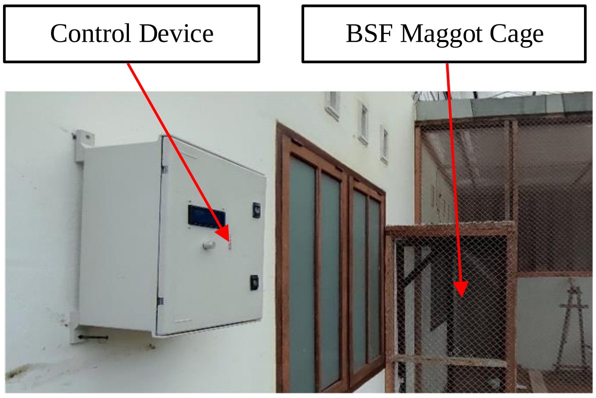

Figure 3. Maggot cage and IoT control device.

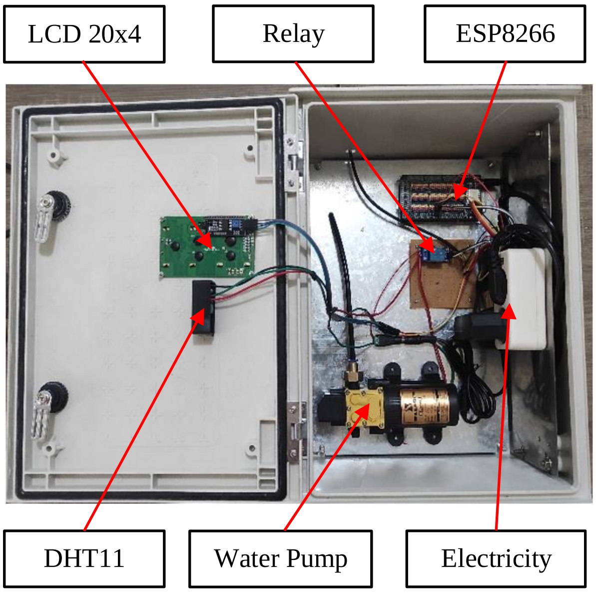

Figure 4. IoT control devices

Based on the information in Figure 4, it can be seen that there are several components that are connected to each other so that it becomes an IoT control center that can be used to control the temperature and humidity of the BSF maggot enclosure, namely the DHT11 sensor, ESP8266 microcontroller, relay, water pump, and 20x4 LCD. The function of the DHT11 sensor is a sensor that is used to read the state of the temperature and humidity of the BSF maggot enclosure. The ESP8266 microcontroller functions to process sensor data, send temperature and humidity data to smartphones using the internet, and control on/off the water pump.

The function of the relay in the device built is as an electronic switch to control on and off the water pump, if the relay receives a command 1 or 5 Volt DC voltage from the ESP8266 microcontroller, the relay will be active to turn on the pump, if the relay receives a command 0 then the relay will deactivate the pump. The function of the 20x4 LCD is to display the temperature and humidity data of the cage in the form of text offline. The electrical voltage used to activate the ESP8266 microcontroller, DHT11 sensor, relay, and 20x4 LCD is 5 Volt DC, while to activate the water pump is a 12 Volt DC power supply voltage. The following table 1 shows the connection of sensor devices and system outputs with the GPIO of the ESP8266 microcontroller.

Tabel 1. ESP8266 GPIO connection configuration with a device

Devices	Pin GPIO	Functions
DHT11 sensor	GPIO 1	Read the temperature and air humidity.
Relay for pump	GPIO 3	Manage the turn on and off the water pump.
LCD 20x4	GPIO 4 & 5	Control the output of LCD 20x4.

In this study, we have used the Blynk IoT platform to monitor the temperature and humidity of the enclosure air and control on and off the water pump remotely using an Android smartphone. Figure 5 below shows the conditions for monitoring the temperature and humidity of the cage when the water pump is on or active. Based on the information in Figure 5, it can be seen that when the temperature of the cage is more than 30ºC, the nozzle water pump will turn on automatically. Furthermore, the water pump will turn off if the DHT11 sensor detects the state of the cage temperature below 28ºC. Figure 6 shows the results of monitoring and controlling the temperature and humidity when the DHT11 sensor detects the cage temperature under 28ºC. In addition, in Figures 5 and 6, information on the temperature graph of the maggot cage can be seen, so that the information displayed is more interactive to the user.

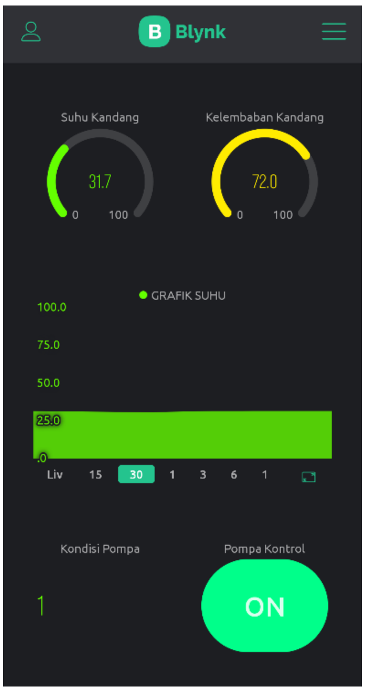

Figure 5. The display of monitoring and controlling the temperature and humidity of the cage when the DHT11 sensor detects a temperature over 30ºC.

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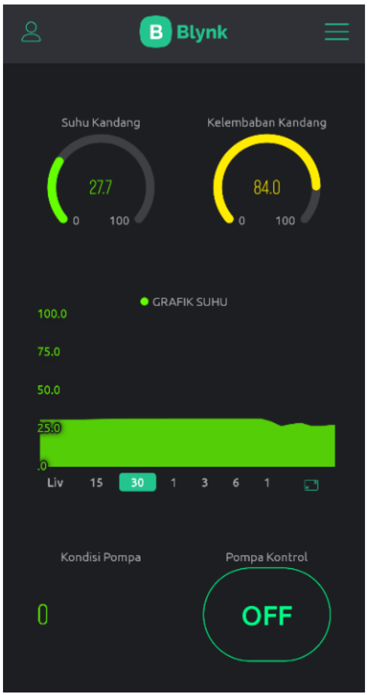

Figure 6. The display of monitoring and controlling the temperature and humidity of the cage when the DHT11 sensor detects a temperature less than 28°C.

Based on the information in Figure 6, it can be seen that when the DHT11 sensor reads a temperature condition under 28°C, the water pump will turn off, then the smartphone will display a message that the pump is off and the GPIO ESP3288 pin is 0 or low. In building an IoT monitoring and control application using Blynk, there are several DATASTREAM configurations that are used to connect data between the ESP8266 microcontroller and a smartphone. The following table 2 shows the DATASTREAM configuration used to connect the data connection between the ESP8266 microcontroller and a smartphone on the Blynk IoT service.

Table 2. The DATASTREAM configurations in Blynk IoT

Interface	DATASTREAM	Tipe Data
Temperature	V1	Double, 0.0/100.0
Humidity	V2	Double, 0.0/100.0
Temperature graph	V1	Double, 0.0/100.0
Water pump condition	V3	INT, 0/1
Pump controller	V4	INT, 0/1

In this study, we have tested the device in monitoring the temperature and humidity of the BSF maggot enclosure and controlling the on/off of the water pump automatically and remotely using IoT technology. The following table 3 shows the results of the monitoring and control testing of the device in controlling the temperature and humidity of the BSF maggot cage. This trial was carried out for 1 month according to the average temperature and humidity conditions detected by the device at the time of testing.

Table 3. Test results of IoT-based devices

Trials	Temperature	Humidity	Water pump
1	30.2°C	72%	On
2	28.7°C	79%	Off
3	31.3°C	69%	On
4	29.8°C	58%	On
5	27.7°C	84%	Off
6	28.2°C	75%	Off
7	29.3°C	82%	Off
8	31.8°C	58%	On
9	29.5°C	78%	Off
10	29.1°C	83%	Off

Based on the information on the test results of the device shown in table 3, it can be seen that when the DHT11 sensor detects the cage temperature is more than 30°C and the humidity is more than 60%, the water pump will be active. When the cage temperature is less than 30°C and the humidity is less than 60%, the water pump will be active. When the temperature of the cage is more than 30°C and the humidity is less than 60%, the water pump will be active. Furthermore, if the DHT11 sensor detects the cage temperature is less than 30°C and the humidity is above 60%, the water pump is in an inactive condition.

The next step, we conducted a test when the smartphone sent commands remotely using an internet connection to turn the water pump on and off. Table 4 below is the test result of remote control of the IoT-based water pump device.

Table 4. IoT-based remote pump control test results

Trials	Command	Water pump	Delay
1	On	Active	0.908 s
2	Off	Inactive	1.2 s
3	On	Active	1.04 s
4	Off	Inactive	1.5 s
5	On	Active	0.992 s
6	Off	Inactive	1.32 s
7	On	Active	1.43 s
8	Off	Inactive	0.988 s
9	On	Active	1.73 s
10	Off	Inactive	1.42 s

Based on the test results of remote control devices shown in table 4, it can be seen that there is a delay when the user presses the on and off buttons to instruct the water pump to activate and deactivate. The length of time the device control delay can affect the quality of the internet connection network received by the smartphone and the ESP8266 microcontroller. The better the quality of the internet network, the smaller the delay time needed to transmit data commands from the smartphone to the ESP8266 microcontroller, but if the internet connection is not good, it will affect the delay in sending control data commands.

4. Conclusion

Control and monitoring of temperature and humidity in maggot cages using an Internet of Things (IoT) based ESP8266 microcontroller has been implemented in this

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study and can be applied to the community to assist in improving the quality of BSF maggot cultivation. The method used to control the temperature and humidity of the cage air is by spraying water with a fine nozzle-based spray in the maggot cage. If the temperature of the cage is more than 30^{o}C and/or if the humidity is less than 60%, the water pump will be active to spray water in the maggot cage. The Blynk IoT platform has been applied in this research to monitor and control the temperature and humidity conditions of the maggot cage remotely using an internet network connection. This study has shown that the technique of watering the cage with nozzle-based water spraying can be used to control the temperature and humidity conditions of the BSF maggot cage. It is hoped that this control of air temperature and humidity can help improve the quality of IoT-based BSF maggot breeding in the community.

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