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Design and Construction of Humidity Control System at Kumbung Jamur Cijontang Using Fuzzy Logic and IoT

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Abstract. Mushroom farming in West Java has the largest production compared to other regions, which is recorded at 1,740,456 kilograms according to the Central Statistics Agency. In its growth period, oyster mushroom requires sufficient temperature and humidity. However, manual oyster mushroom treatment is considered less effective because it requires considerable time and (physical) energy. Therefore, this study will model a system that can provide stable humidity for mushroom to grow and develop using fuzzy logic control and IoT (Internet of Things) monitoring. The method used is a quantitative method with data in the form of relative humidity obtained from the sensor. This data will be input (as a feedback value) and will be reprocessed through fuzzy logic until it reaches the required humidity level. It aims to perform watering and drying automatically optimally. The device design is implemented in Cijontang mushroom Kumbung, Sukasari sub-district, Sumedang district and it's expected to produce a stable system modeling and facilitate activities in caring for planting objects. In addition, this research will also get the final result in monitoring the humidity level of mushroom Kumbung based on IoT.

INTRODUCTION

In the cultivation of oyster mushrooms, Kumbung or mushroom house is needed made of wood or bamboo with a board, which is used as a place to treat mushroom Baglog and grow mushrooms. While Baglog is a planting media where to put mushroom seeds. In general, a good temperature for oyster mushrooms is between 24°C to 27°C while the humidity is 80%-90%. Mushroom farmers in Cijontang village, Sukasari sub-district, Sumedang district, carry out care and supervision of mushrooms manually, namely, watering regularly (in the morning, afternoon, and evening) to maintain humidity in mushroom Kumbung, without measuring relative humidity with measuring instruments, but based on the assumptions of the farmers through the texture of the mushrooms. Watering efforts must be carried out evenly in order to increase the humidity in the Kumbung which can affect the quality and selling price of oyster mushrooms.

Based on these problems, we need a system that can perform the watering process automatically and manually using fuzzy logic as well as monitoring and controlling through the IoT platform. Fuzzy logic has a mathematical concept that underlies fuzzy logic reasoning which is very simple and easy to understand. Humidity condition can be monitored and controlled manually and automatically via a smartphone or other android system, and can do watering and drying evenly. Mushroom farmers in Cijontang responded that the tool was considered very necessary, in fact they had never encountered mushroom farming with such a system and assumed that if the system was realized it would certainly be able to assist farmers in caring for and supervising oyster mushrooms in mushroom Kumbung.

SYSTEM PLANNING

Block Diagram

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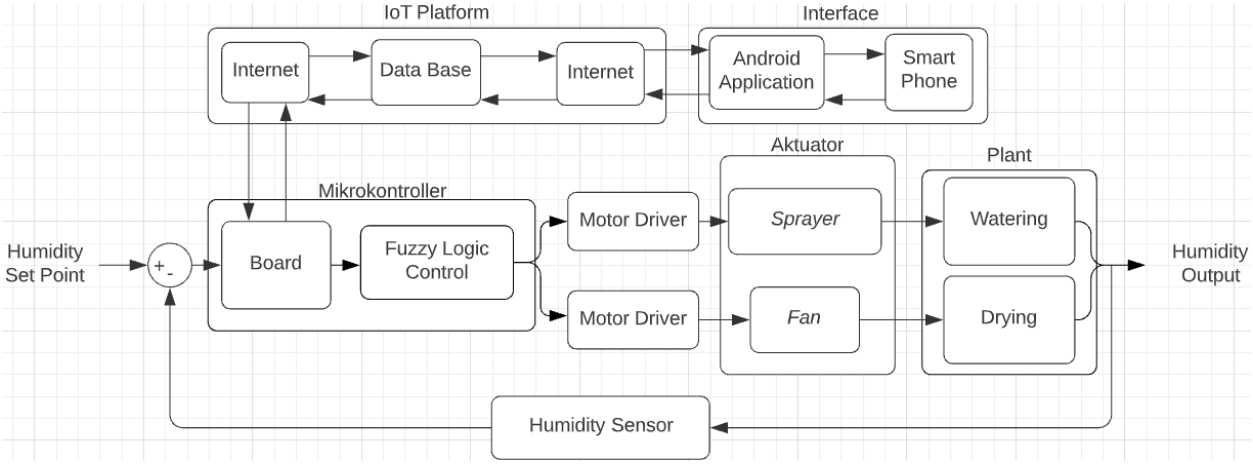

FIGURE 1. System Block Diagram

Figure 1 describes that the system has input in the form of a humidity set point with a fuzzy logic control method. The output from the microcontroller will be forwarded to two actuators, namely the Sprayer and Fan whose speed has been regulated by the motor driver. Then the process continues with sending and retrieving data between the microcontroller and the IoT platform or interface applications with the IoT platform. In the end, the output signal can be generated from the watering and drying process by measuring the relative humidity by the sensor so that the signal can be fed back by the system. Based on the explanation of the functions above, a tool will be designed that can be a solution to problems in maintaining relative humidity (RH) in oyster mushroom Kumbung with the following features:

1. The process of watering and drying can be done automatically by using fuzzy logic control method.
2. Supervision and control will be carried out anywhere and anytime with IoT.
3. The watering process will have two modes, namely automatic and manual.

System Flow Diagram

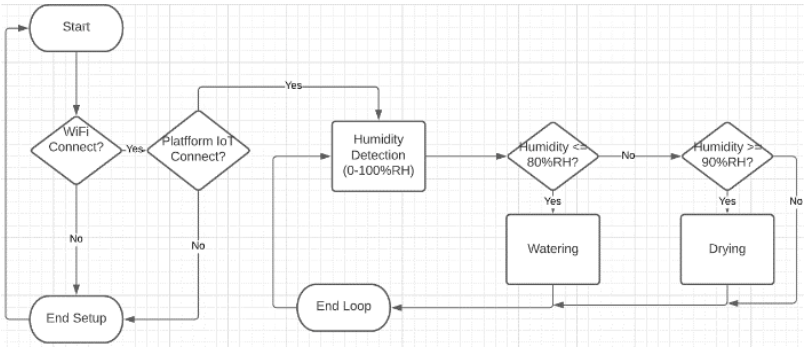

FIGURE 2. System Flow Diagram

The design of the tool was carried out directly on the mushroom Kumbung in Cijontang. The tool that will be designed is expected to be able to stabilize the relative humidity of the Kumbung, which is 80%-90% RH. The system starts by connecting NodeMCU to the internet using WiFi network, then it will be connected to the IoT platform, namely Antares through applications and devices that have been created on the platform. The sensor will measure the humidity and temperature values in the Kumbung, if the relative humidity measured by the sensor is below 80% RH then the watering process will be carried out, while when the relative humidity is above 90% RH then the drying process will be carried out. Both processes (watering and drying) are carried out through fuzzy logic methods so that they affect the speed of the sprayer and fan actuators through predetermined rules.

Wiring System

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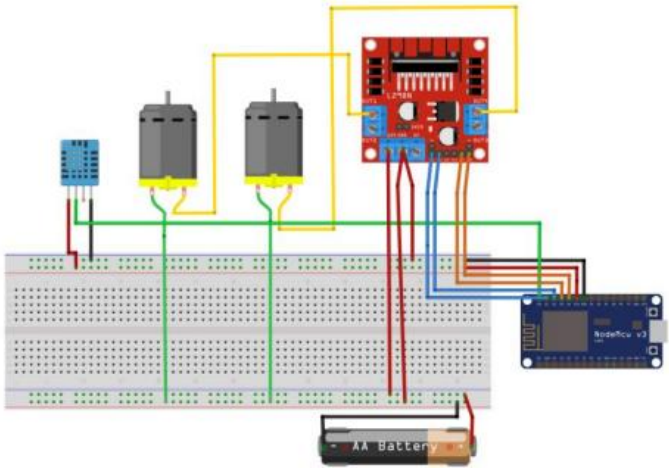

FIGURE 3. Wiring System

Figure 3 shows the relation of each device to be used. The relationship is shown through wiring. Devices will be connected starting from NodeMCU which is connected to sensors, motor drivers, and two actuators with different pins on NodeMCU. Next the diver motor will be connected to the 12V power supply and ground on the NodeMCU.

Fuzzy Logic Model

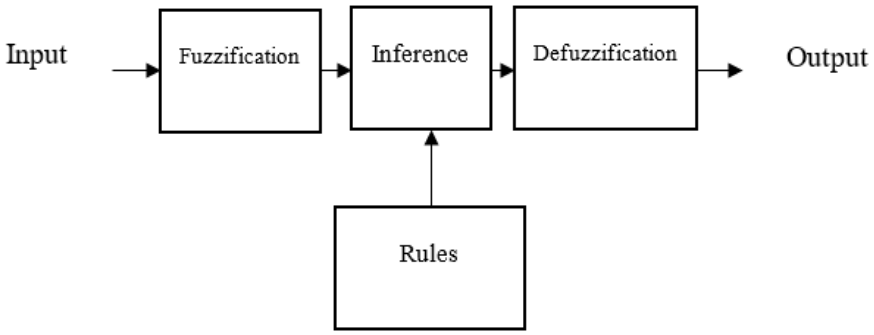

FIGURE 4. Fuzzy Logic Block Diagram

Fuzzy logic is a logic of thought with a value of fuzziness. Fuzzy logic was discovered and developed by Lofti Astor Zadeh in 1964. Fuzzy logic requires shifting variables that assume that something is partially true and partially false through the degree of membership in a set based on a scale of 0 to 1. Fuzzy logic system is often applied because it is relatively easier and flexible as an automatic control system application that has feedback with the desired input reference to maintain the output value. The output value will proceed by mathematically through several stages such as Fuzzyfication, Inference, and Defuzzyfication.

1. Fuzzy set

TABLE 1. Fuzzy Set Domain

Function	Variable	Domain
Input	Humidity	[0-100]
Output	Sprayer	[0-255]
Output	Fan	[0-200]

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a. Humidity variable fuzzy set

TABLE 2. Fuzzy Set Humidity Parameter

No.	Description	Parameter (%RH)
1.	Low	0-60
2.	Normal	40-90
3.	High	70-100

b. Sprayer variable fuzzy set

TABLE 3. Fuzzy Set Sprayer Parameter

No.	Description	Parameter
1.	Stop	0
2.	Slow	80-190
3.	Fast	150-255

c. Fan variable fuzzy set

TABLE 4. Fuzzy Set Fan Parameter

No.	Description	Parameter
1.	Slow	0-65
2.	Medium	40-130
3.	Fast	100-200

2. Rules

TABLE 5. Fuzzy Rules

Rules	Humidity	Spray	Fan
1.	Low	Fast	Slow
2.	Normal	Slow	Medium
3.	High	Stop	Fast

METHODOLOGY

Solution Concept Design

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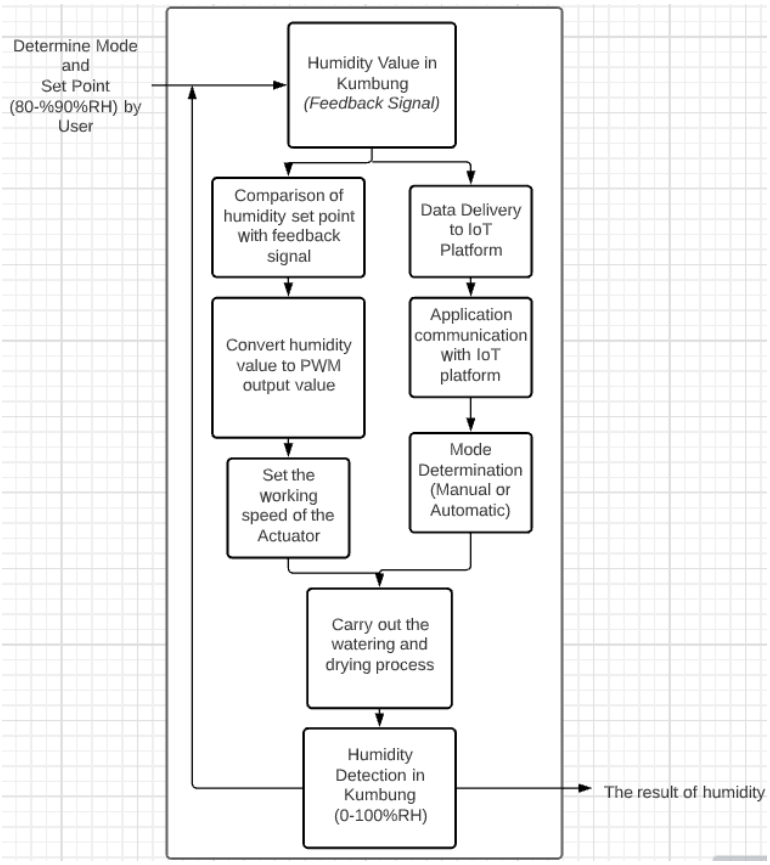

FIGURE 5. Solution Concept Design

The concept used to design a humidity control system in oyster mushroom Kumbung automatically. The control method use fuzzy logic based on IoT. The designed device will be implemented directly on the mushroom Kumbung in Cijontang. It aims to create efficient and maximum oyster mushroom treatment, with automatic watering and monitoring so that the humidity needed by oyster mushrooms in Kumbung is fulfilled. There are several applications that will be used, such as Arduino IDE and Matlab to program the system and demonstrate fuzzy logic methods.

IoT is a concept that utilizes internet connectivity to something continuously so that an activity can be carried out optimally. IoT has the ability to share data and information over a network with minimal human intervention, thus enabling for communication, control, and collaboration between devices via the internet.

Mushroom Kumbung Design

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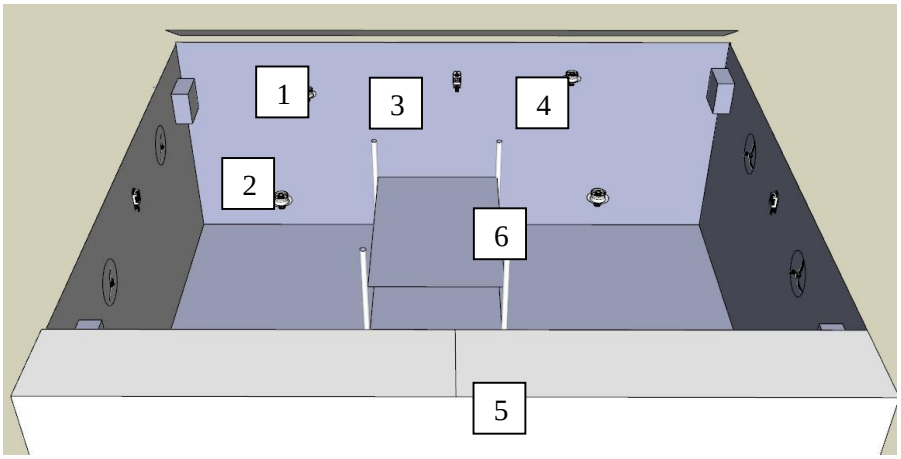

FIGURE 6. Mushroom Kumbung design

Description:
- Dimensions 5m x 4m (Length x Width)
- The name of the component with the number caption:
  1. Controller box
  2. Fan
  3. Sprayer
  4. Humidity Sensor
  5. Wall
  6. Open Cupboard for Baglog

The placement of the sensor aims to focus the detection of sensors around the planting media, so it'll not cause differences of measured relative humidity from certain places of the entire room. Initial detection is carried out through the process of measuring the relative humidity around the planting media to determine the next process to be carried out such as watering or drying. Any changes in the measurement of the relative humidity sensor will affect the process of the actuator based on the control method used. The sensor use a cable transmission (<20 m) to the microcontroller box. The sensor can work optimally which is focused on the planting media because of the limited detection of the DHT22 sensor (100 cm). The watering process will later be carried out by a sprayer actuator equipped with a nozzle mouth and can create water spots that are sprayed evenly (in the oyster mushroom Kumbung) without hitting the planting media. In order to increase the humidity evenly, the sprayers are placed around the planting media. Also, in order to circulate the air evenly, the placement of the fan is on the side of the oyster mushroom Kumbung. The working speed of the sprayer and fan actuators will be regulated by a motor driver which capable to provide a predetermined pulse width modulation based on the control method used. The sprayer actuator placement is four meters above the ground. It can produce water droplets with a diameter of up to 1 m with a 14 mm nozzle diameter. The diameter of fan actuator is 12 cm for circulating air to the outside of the Kumbung with 2000-2800 rpm.

RESULTS AND DISCUSSIONS

Fuzzy set Forming

- Humidity Variable

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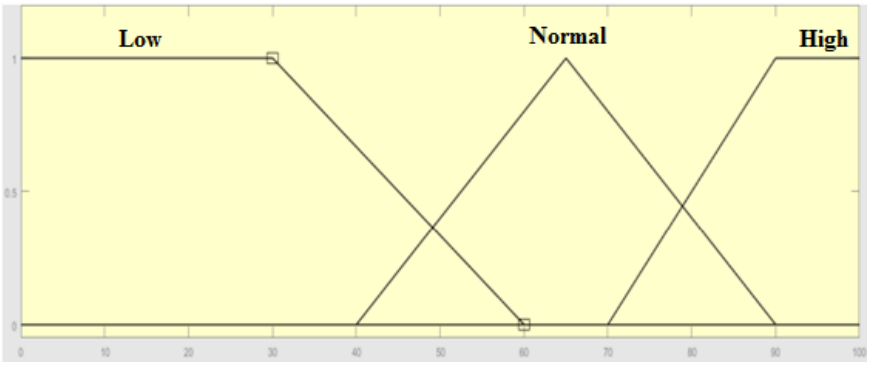

FiIGURE 7. Humidity Variable Fuzzy Set Graph

- Sprayer Variable

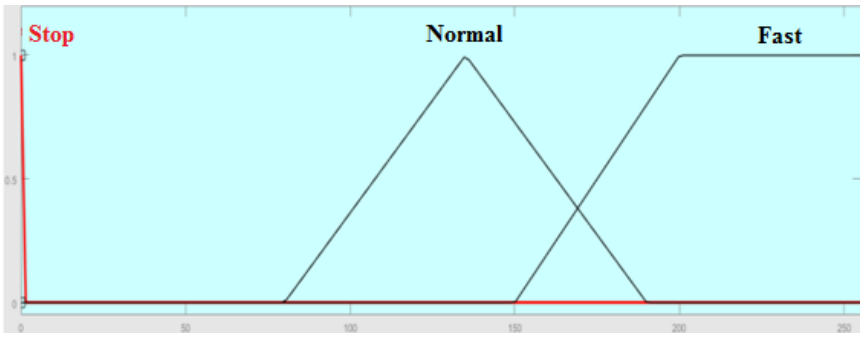

FIGURE 8. Sprayer Variable Fuzzy Set Graph

- Fan Variable

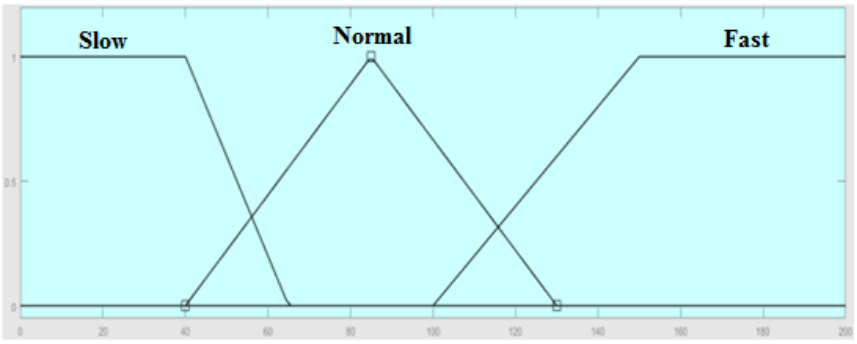

FIGURE 9. Fan Variable Fuzzy Set Graph

Fuzzy Logic Surface

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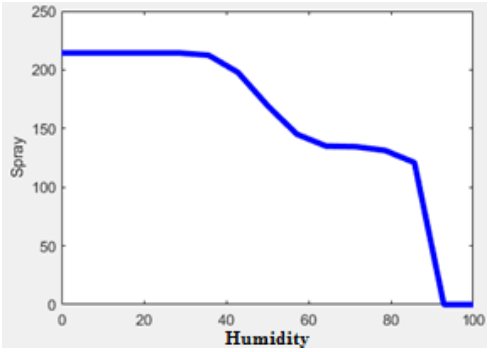

FIGURE 10. Spray and Humidity Surface Relation Graph

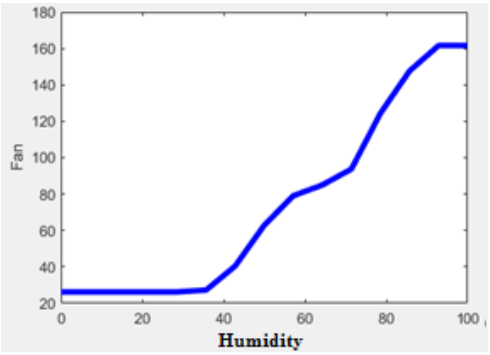

FIGURE 11. Fan and Humidity Surface Relation Graph

Figure 10 states the relation between the humidity input variable and the sprayer output variable, while figure 11 states the relation between the humidity input variable and the fan output variable. It can be concluded that the higher the humidity, the lower the parameter of the sprayer output variable and the higher the parameter of the fan output variable, and vice versa.

Application Design

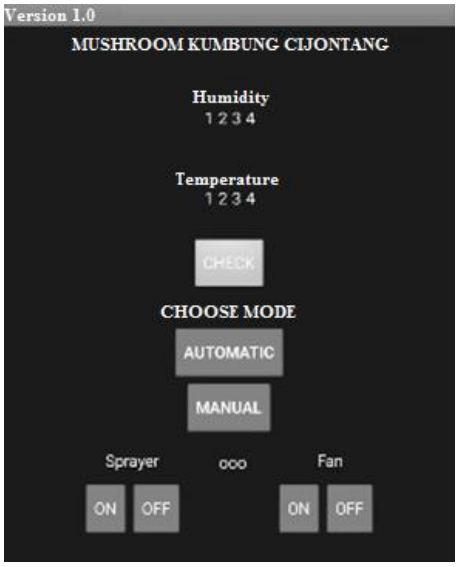

FIGURE 12. Application Design

The application design was designed using MIT App Inventor. MIT App Inventor is a platform that aims to simplify the process of creating simple applications without having to learn or use too many program languages. Applications can be made as desired through a variety of layouts and components available. The mushroom Kumbung design application will be connected to the IoT platform so they can communicate to each other. In addition to checking humidity and temperature, the application will also be equipped with two modes, namely

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automatic mode and manual mode, so the system can work automatically and manually.

Research Table

TABLE 6. Research

Time (min)	Sensor 1		Sensor 2		Sensor 3		Sensor 4	
	H	T	H	T	H	T	H	T
0	70	28	65	29	70	27	76	27
4	74	28	68	28	73	27	79	26
8	77	28	73	27	77	26	80	26
12	79	27	76	27	79	26	79	26
16	81	26	79	26	81	26	82	26

TABLE 7. Average Research

Time (min)	Average	
	Humidity	Temperature
0	70.25	27.75
4	73.5	27.25
8	76.75	26.75
12	78.25	26.5
16	80.75	26

In the table above it is stated that data collection from the humidity sensor is taken based on every multiple of four minutes from the initial condition (minute 0). The table shows the rise and fall of relative humidity and temperature in oyster mushroom Kumbung in Cijontang, Sukasari sub-district, Sumedang district, West Java.

According to the data obtained, the relative humidity increases and decreases in temperature with time. This indicates that there is a change in conditions in the Kumbung due to the process of watering and drying by the system. If you look further at the 4th sensor at 8-12 minutes, there is a small decrease in relative humidity due to the influence of changes in working speed on the sprayer actuator which causes changes in the watering process so that it affects the moisture content in the air in the Kumbung.

In the initial condition, there is a large difference between temperature and relative humidity measeured by the sensor which indicates that the measurements of the sensor (DHT22) on the mushroom Kumbung is different on each side. It concludes that the placement of the sensor can affect the measurement differences because there is a measurement limit at a certain distance. Differences in measurements of oyster mushroom Kumbung can also be caused by the position of the Kumbung from sunlight so it can cause different measured temperature and relative humidity on each side. However, at the last minute (16th minute) the system has very little difference in measurement compared to the beginning of the measurement because each sensor and actuator has a different controller so the way that the actuator works on each side also has different adjustments. At the end, the system can produce a similar sensor output value.

CONCLUSION AND SUGGESTION

Conclusion

Humidity control system in mushroom Kumbung using fuzzy logic and IoT can work according to what the system needs. The relationship between sensors and actuators trough the designed method can influence each other. The measurement of temperature and relative humidity by the sensor can produce different ways of actuator work based on parameters, rules, and membership functions of the set of predetermined input-output variables. The application of an IoT system can assist oyster mushroom farmers in Cijontang in their efforts to cultivate oyster mushroom. The placement of each actuator and sensor can affect the measurement of temperature and relative humidity, so it can affect the quality of oyster mushrooms. The larger the dimensions of the Kumbung and the planting media for oyster mushrooms, the more actuators and sensors are needed.

Suggestion

The wiring process in mushroom Kumbung requires quite a lot of material (cable), which is directly

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proportional to the dimensions of the oyster mushroom Kumbung. The wiring on the sensor would be better if you use a Wireless Sensor Network (WSN) system to avoid long wiring and reduce the noise level on the sensor.

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