Adaptive Temperature And Humidity Control System on Kumbung Mushroom using Fuzzy Neural Network Algorithm

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Abstract. National mushroom production in 2018, 2017, 2016, and 2015 were: 31052, 3702, 40915 and 33485 tons. Mushroom cultivation, especially oyster mushrooms, has the potential to be developed more widely in Indonesia because it has economic value and is environmentally friendly. However, the cultivation of oyster mushrooms has challenges. The challenge that arises in the cultivation of oyster mushrooms is to grow well at a temperature of 16 – 30 °C and a relative humidity of 80 – 95%. Environmental conditioning carried out by farmers on average through spraying water in mushroom kumbung manually. The use of manual methods requires high human resources, besides that it is not effective and efficient. This study aims to develop an Adaptive Temperature and Humidity Control System on Kumbung using Backpropagation Neural Network, where to determine the temperature and humidity the system will evaluate the readings of several sensors at once. The system developed is an adaptive system with an accuracy of 97%, so it is can be used to increase the precision of mushroom cultivation, so that production efficiency and increase in mushroom production can be achieved.

1. Introduction
The Indonesian Institute of Sciences (LIPI) advances the development of food mushrooms with the goal that they can be burned through appropriately and generally by the Indonesian public. Mushrooms developed in Indonesia have high dietary benefits, even mushrooms contain 19-35 percent higher protein than rice (7.38 percent) and wheat (13.2 percent) [1]. National mushroom production in 2018, 2017, 2016 and 2015 amounted to: 31052, 3702, 40915 and 33485 tons [2]. In 2018 the per capita availability is 0.15 [3], this figure should be expanded as an elective food fixing arrangement, this depends on the surface of mushrooms that look like meat and is delightful, making this plant regularly become different sorts of handled food [1]. Development of mushrooms, particularly clam mushrooms, can be grown all the more generally in Indonesia since it has financial worth and is harmless to the ecosystem [1]. In any case, clam mushroom development has difficulties, particularly to deliver the most extreme creation in each kumbung.

The test that emerges in clam mushroom development is that it develops well at temperatures of 16-30°C and relative moistness of 80 - 95%. Natural molding is brought out by the normal rancher through the manual splashing of water in the mushroom kumbung [4]. According to Hariyanto et al, in [5] that oyster mushrooms can be harvested around the age of baglog 40 days after inoculation (planting seeds)
up to a mushroom production period of about 3-4 months with a production yield of 0.6 to 1.3 kg per baglog of mushrooms. This manual strategy resolves a few issues like those found at PT. Nusantara Healthy Mushroom (JASENTRA). The utilization of the manual technique requires high HR, other than that the accuracy of arranging isn't equally appropriated. So it is important to expand the accuracy of temperature and moistness in kumbung with innovation, research identified with the utilization of innovation for mushroom development was completed by [6][7][8], where the examination utilizes the IoT way to deal with consequently screen the stickiness and temperature of the kumbung.

This study aims to develop a Temperature and Humidity Control System in Kumbung using a Fuzzy Logic Controller. This study uses a Fuzzy Proportional-Integral-Derivative (PID) Controller, sensor data (Temperature and Humidity) will be processed as a sensor array [9][10][11], which decides the temperature and humidity of the framework, will assess the readings of a few meetings immediately. This is planned to deliver a precise perusing, the consequences of this perusing will then, at that point, be utilized as a fluffy info variable/deduction motor to decide the treatment/splashing of kumbung to accomplish the objective temperature and moistness. The framework being created is a versatile framework that will adjust to the climate, so it is trusted that the arrangement produced by the device can be utilized to build the accuracy of mushroom development, so creation effectiveness and expanded mushroom creation can be accomplished.

2. Related Work
Research of the utilization of the Internet of Things (IoT) is being grown, particularly compared to its capacity to help people in the entirety of their exercises, one of which is with regards to the climate. Exploration led by [12] fostered the plan and execution of the Wireless Sensor Network (WSN) just as examination led by [13]. Examination identified with the utilization of WSN for mushroom development was done by [6][7][8], where the exploration utilized the IoT/WSN way to deal with naturally screen the dampness and temperature of the kumbung.

This study aims to develop a Temperature and Humidity Control System in Kumbung utilizing a Fuzzy Logic Controller. This review utilizes a Fuzzy Proportional-Integral-Derivative (PID) Controller, the sensor information (Temperature and Humidity) will be handled as a sensor array [9][10][11], were to decide the temperature and moistness the framework will assess the readings of a few sensors immediately. This is expected to deliver an exact perusing, the results of this perusing will then, at that point, be utilized as a fluffy information variable/deduction motor to decide the treatment/splashing of kumbung to accomplish the objective temperature and mugginess. The framework being created is a versatile framework that will adjust to the climate, so it is trusted that the design created by the apparatus can be utilized to build the accuracy of mushroom development, so creation proficiency and expanded mushroom creation can be accomplished.

3. Research Methods
Literature study on dependent on Figure 1 was completed determined to assemble data [16][17] from a few references identified with the issues to be examined [18], to frame the State of The Art. The following stage is create rule. Creating rules is a significant stage in this examination [19][20], in light of the fact that this review utilizes a few sensors (which are utilized as factors) [21]. The outcomes from the sensor perusing will then, at that point, be utilized to decide the proper water splash [22] to get the dampness and temperature as per the ideal development and advancement of Oyster Mushrooms. After the course is created, it proceeds with the execution of the ATHCS.
The rules that have been acquired are then executed into the ATHCS, this is finished utilizing the Fuzzy methodology. The utilization of the Fuzzy strategy plans to create a more precise perusing [22][23]. The following stage is trying, this stage is expected to demonstrate that the sensor readings are proper, at this stage the precision of the instrument will likewise be acquired. The readings will be handled to acquire the exactness of the ATHCS temperature and dampness class readings. The consequences of information handling as device exactness are then contrasted and manual computations, to test the precision by ground truth. The outcomes got at this stage will examine the elements that influence the precision esteem acquired. At this stage is the last phase of the exploration, specifically reaching inferences from the consequences of conversation investigation and giving ideas to additional research.

4. Discussion

4.1. Automatic Temperature dan Humidity Control System (ATHCS) in Kumbung using Fuzzy Logic Controller

The improvement of mushrooms is a biotechnological application that uses practical and direct development that ordinary people in provincial locales can do. Improvement of mushrooms can be a possibility for the usage of typical resources, the extension of food and sustenance, regular protection and business openings for the neighbourhood [24]. The test that arises in shellfish mushroom improvement is that it grows well at temperatures of 16 - 30 °C and relative tenacity of 80 - 95%. A regular trim is assisted by the ordinary farmer through a manual sprinkling of water in the mushroom kumbung [4]. This manual technique settled a couple of issues like those found at PT. JASENTRA. The usage of the manual methodology requires high HR [25][26]. Other than that, the precision of organizing isn't similarly appropriated, so that some BagLog's are hurt. The Manager side can't screen the conditions of the kumbung at whatever point.
Figure 2. Design Tools

These conditions achieved the production of mushrooms at PT. JASENTRA isn't great (the resulting creation is half of the breaking point for sure might measure up to 50 kg for each kumbung). To grow the precision of temperature and tenacity in kumbung with advancement, research related to the use of development for mushroom improvement was finished by [6][7][8], where the investigation used the Internet of Things (IoT) way of managing normally screen clamminess and temperature kumbung.

This review means to support a Temperature and Humidity Control System in Kumbung utilizing a Fuzzy Logic Controller, which is displayed in Figure 2. This investigation utilizes a Fuzzy Proportional-Integral-Derivative (PID) Controller, sensor information (Temperature and Humidity) will be managed as sensors display [9], was to pick the temperature and wetness the framework will assess the readings of several sensors immediately. This method is planned to pass on accurate readings. The result of these readings will then, at that point, be utilized as a fluffy information variable/inferring motor to pick the treatment/showering of Kumbung to accomplish the actual temperature and constancy, tolerating the ideal temperature or clamminess is not developed, the specific image of the instrument is displayed in Figure 2, will begin the spout. The design being made is an adaptable framework that will adjust to the climate, so it is accepted that the approach conveyed by the instrument can be utilized to manufacture the accuracy of mushroom progression, so creation ability and broadened mushroom creation can be refined.

4.2. Testing Results and Discussion

This study develops ATHCS with a Neural Network [25] setup shown in Figure 3, in the form of 2 input layers (X) (temperature and humidity), one hidden layer (Z) with three neutrons, and finally, an output (Y) consisting of 1 neuron containing the results from the previous calculation. The next step is research to normalize and denormalize.

In the backpropagation algorithm, the conditions that must be met in the activation function used are: continuous, easily differentiated, and a function that does not descend. In this study, the activation function used is a binary sigmoid activation function where the value range is between (0 to 1). So that the data to be used needs to be normalized before being processed using the backpropagation algorithm, shown by Equation 1.

\[ y = \frac{x - \text{min}}{\text{max} - \text{min}} (0.8) + 0.1 \] (1)
The next process carried out by research is to test epochs (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000). This data test aims to obtain the optimal epoch value with a low error rate value. The training data used were 698 training data and the test data used were 300 test data. In this test calculation, the initial learning rate used is 0.2. Each epoch is tested ten times by initializing the initial weight using the Nguyen-Widrow algorithm so that the initial weight value is random and different. Error rate calculation using Mean Average Percentage Error (MAPE).

![Neural Network Setup](image)

**Figure 3. Neural Network Setup**

| Number | Temperature   | Humidity          | Target                       |
|--------|--------------|-------------------|------------------------------|
| 1      | 0.53826086956522 | 0.41419284940412 | 0.57783783783784             |
| 2      | 0.53826086956522 | 0.41462621885157 | 0.5781981981982              |
| 3      | 0.53826086956522 | 0.41419284940412 | 0.57783783783784             |
| 4      | 0.1           | 0.58147345612134 | 0.17207207207207             |
| 5      | 0.53826086956522 | 0.41419284940412 | 0.57783783783784             |

The test results show that the best setup for this research data is Epoch 600 epoch with an average error (MAPE) of 0.599% and a Learning rate value of 0.2 with an average error (MAPE) of 0.645%. So the research using these two setups is testing the test data which is part of the data that has not been used in the study.

| Class | Temperature + Humidity | Range         |
|-------|------------------------|---------------|
| 1     | Bad                    | ≤ 0.5559      |
| 2     | Optimal                | 0.5630 – 0.5836|
| 3     | Bad                    | ≥ 0.5854      |

This study aims to develop a Temperature and Humidity Control System in Kumbung using a Fuzzy Logic Controller, shown in Figure 5. This study uses a Fuzzy Proportional-Integral-Derivative (PID) Controller. The sensor data (Temperature and Humidity) will be processed as a sensor array to determine the temperature and humidity. The system will evaluate the readings of several sensors at once. This method is intended to produce an accurate reading. The results of this reading will then be used as a fuzzy input variable/inference engine to determine the treatment/spraying of kumbung to achieve the target temperature and humidity.

The value of the multi-sensor readings is determined. This worth is then utilized as a contribution to fluflly to get the enrollment level as displayed in Figure 4. The condition utilized in the exploration that
addresses Figures 4 is shown by Equations 2. Separately, the condition has a similar person, where each has two classes as per Table 2. Each class is addressed by $\mu$ so that in every situation, there are two $\mu$.

$$\mu[Bad] = \begin{cases} 
0; & x \geq 0.5559 \text{ atau } x \leq 0.5854 \\
\frac{b-x}{b-a}; & 0.5559 < x < 0.5630 \\
\frac{d-x}{d-c}; & 0.5836 < x < 0.5854 \\
1; & x \leq 0.5559 \text{ atau } x \geq 0.5854 
\end{cases}$$

$$\mu[Optimal] = \begin{cases} 
0; & x \geq 0.5836 \text{ atau } x \leq 0.5854 \\
\frac{x-a}{b-a}; & 0.5559 < x < 0.5630 \\
\frac{x-c}{d-c}; & 0.5836 < x < 0.5854 \\
1; & x \geq 0.5630 \text{ atau } x \leq 0.5836 
\end{cases}$$

Figure 4. Temperature Membership

The results from the previous process are then entered into the rules. The rules used in this study are shown in Table 2. In Table 2, it can be seen that there are 2 classes used by the study for the final evaluation, namely optimal and bad. These three classes will be used to maintain the lemur so that the temperature and humidity conditions remain optimal or in accordance with the conditions R [6] and R [9].

The outcomes from the past cycle are then gone into the guidelines. The guidelines utilized in this review are displayed in Table 2. Table 2, tends to be seen that for the last assessment, specifically ideal and terrible. These three classes will be utilized to keep up with the lemur, so the temperature and mugginess conditions stay ideal or as per the conditions R [6][9].

The rule is a rule that contains facts that are connected using the AND operator for cases that use more than one fact. In this study, the input variable used is one variable, namely the value of the calculation of the Backpropagation algorithm. Here are some predefined rules. [R1] If the Backpropagation result is less than 0.5559, then the quality is "Bad", [R2] If the Backpropagation result is more than 0.5854, then the quality is "Bad", [R3] If the Backpropagation result is less than 0.5836
and the Backpropagation result is more than 0.5630 then the quality is "Optimal". The inference stage is the stage to change the fuzzy input variable into a fuzzy output value. The following is an example of a fuzzy algorithm calculation with the input value from the calculation of the Backpropagation algorithm (Input = 0.58496436056773). The defuzzification stage is the stage to change the inference results into firm values. The final result is calculated by finding the average value if the variables used are more than one. Based on the fuzzy value from the calculation above, the fuzzy value taken is the largest value, which is 0.75797809318587, with the fuzzy output included in the Optimal category. So it can be concluded that the temperature and the pond are included in the Optimal category.

![Diagram System](image1.png)

**Figure 5. Diagram System**

![Android Controller](image2.png)

**Figure 6. Android Controller**

![Kumbung](image3.png)

**Figure 7. Kumbung**

This study uses Black Box Testing to ensure that all the features are functioning properly, so the research is testing the software and hardware of the application at once, are shown in Figure 5, 6, and 7. The results of the tests carried out by the research are shown in Table 3. Not only did the test feature, this study also tested the output of the tool, where the 300 data generated by the tool were validated by
experts. The method used in this research is Ground Truth, while the results obtained are an accuracy of 97%, shown in Table 4.

### Table 3. Black Box Testing

| Number | Item              | Function         | Result |
|--------|------------------|------------------|--------|
| 1      | Android App.     | Data W/R Arduino| Success|
| 2      | Temperature Sensor | Temperature Value | Success |
| 3      | Turbidity Sensor | Turbidity Value  | Success |
| 4      | Nozzle Spray     | Water Spray      | Success |

### Table 4. Fuzzy Testing Result

| Number | Temperature + Humidity | Target          | Class | Expert |
|--------|------------------------|-----------------|-------|--------|
| 1      | 0,715955866            | 107,8251782     | 1     | True   |
| 2      | 0,715955866            | 107,8251782     | 1     | True   |
| 3      | 0,708576426            | 107,7880965     | 1     | True   |
| 4      | 0,708576426            | 107,7880965     | 1     | True   |
| ...    | ...                    | ...             | ...   | ...    |
| 298    | 0,110262384            | 104,7815685     | 1     | True   |
| 299    | 0,100513464            | 104,7325802     | 1     | True   |
| 300    | 0,092142654            | 104,6905168     | 1     | True   |

5. Conclusion

This study creates a Temperature and Humidity Control System in Kumbung utilizing Backpropagation and Fuzzy. Sensor information in this review (Temperature and Humidity) will be handled as sensor clusters to decide the temperature and dampness. The framework will assess the readings of a few sensors without a moment's delay. This strategy is expected to deliver a precise perusing. The aftereffects of this perusing will then, at that point, be utilized as a fluffy info variable/deduction motor to decide the treatment/splashing of Kumbung to accomplish the objective temperature and dampness. The test outcomes show an exactness worth of 97%. So it is expected that the design created by the device can be utilized to expand the accuracy of mushroom development, so creation productivity and expanded mushroom creation can be accomplished.

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