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Optimization of ideal temperature using Mamdani fuzzy logic alogorithm on tunnel flow type chicken cage for brooding period

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Optimization of ideal temperature using Mamdani fuzzy logic alogorithm on tunnel flow type chicken cage for brooding period

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Abstract. Consumption of meat, particularly chicken meat, is increasing in Indonesia year after year, resulting in an increase in chicken meat output. The first step in improving the quality of chicken meat production is to boost success during the brooding stage, with one of the most critical stages being the achievement of the appropriate temperature requirement throughout the brooding period. Good broiler performance will result from uniform cage temperature during brooding. Too-cold temperatures will cause chicks to cuddle close to the heater and be too lethargic to conduct activities such as feeding and drinking. Chickens suffer from stunted growth as a result of this condition. A temperature that is excessively high, on the other hand, will force the chicks to flee the heater and seek a cooler location with better airflow. A fuzzy algorithm is an alternate way for temperature regulation that can maintain the temperature requirement of chicks during brooding. The Mamdani fuzzy approach utilized has the advantage of producing better results than other fuzzy methods. The findings of a temperature management system designed utilizing the Mamdani fuzzy approach with a tunnel flow cage design, a 100-watt bulb heater, two cooling pads, and three fans were able to maintain the appropriate temperature for 14 days in this investigation.

1. Introduction

Indonesians' consumption of meat, particularly chicken meat, is increasing year after year. According to data from the Central Statistics Agency for 2020, chicken meat consumption was 2,116,449 tons in 2017, 2,155,239 tons in 2018, and 2,194,029 tons in 2019. Indonesia's broiler farm production is growing in tandem with the country's rising consumption of chicken meat. According to data from the Central Statistics Agency 2020, broiler meat output in Indonesia was 3,175,853 tons in 2017, 3,409,558 tons in 2018, and 3,495,090 tons in 2019. The production of chicken meat that is always increasing is a benchmark for the development of the chicken farming industry in Indonesia.

The brooding stage is one of the crucial steps in the poultry farming industry for improving the quality of chicken meat production. Because the brooding stage decides whether or not the quality of chickens is good for the next stage, this stage strives to offer a comfortable and healthy environment that is efficient and economical for chicks [1]. The brooding stage's success is controlled by temperature, humidity, and air quality in the cage; chick temperature and humidity requirements are external needs that might affect chicken quality [2]. The key to successful whole house brooding is the uniform distribution of heat throughout the house [3]. In addition, the need for different temperature settings during brooding is very important to achieve the success rate of brooding.

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There are still many chicken farming enterprises today that use automatic methods, both scheduled and fuzzy, which are still ineffective since they have not achieved brooding success. To maximize temperature regulation and increase brooding success rates, a closed enclosure with a tunnel flow architecture is required. A tunnel flow design can be used to alter the air flow in a confined enclosure. Tunnel flow is a ventilation system with a water input at the end that serves as a cooling system with a cooling pad *[4]*. The cooling system with a cooling pad is a system that is used to lower the air temperature with a variety of media, that cooling method based on mechanical and thermal contact between air and water *[5]*. With a more complex system where temperature regulation is needed to adapt quickly, it requires an algorithm that can adapt quickly, namely fuzzy *[6]*. The fuzzy algorithm is able to apply reasoning so that it is suitable for the brooding chicken coop temperature control system *[7]*.

Based on the above description, an application for controlling brooding period chicken coop temperature using Fuzzy Logic Mamdani will be developed in this project. Because of the necessity for varied temperatures every day based on the age of the hens, this algorithm generates many rules, and Fuzzy Logic Mamdani is able to apply reasoning to each rule in order to adjust to temperature needs. This application is expected to offer an alternative solution for a reliable and efficient temperature control system.

2. Method

The object of this research is broiler chicken brooding period. The purpose of this research is to create a temperature control system that can stabilize the ideal temperature for 14 days or during the brooding period using fuzzy control system. in fuzzy systems there are processes that characterize that the system is fuzzy, namely fuzzification, inference and defuzzification mechanisms [8].

2.1 Determination of Set Point

Based on the literature study, the temperature set point was determined to have a temperature range below 34°C and a temperature above 24°C which was adjusted for the age of the chicks from 0 to 14 days based on Ross [9]. The determination of the set points is detailed in Table 1 below.

Table 1. Set point temperature based on chicks' age

No.	Chicks Age	Set Point Temperature (°C)
1	1	32.5 (31-34)
2	2	32 (30.5-33.5)
3	3	31.5 (30-33)
4	4	31 (29.5-32.5)
5	5	30.5 (29-32)
6	6	30 (28.5-31.5)
7	7	29.5 (28-31)
8	8	29 (27.5-30.5)
9	9	28.5 (27-30)
10	10	28 (26.5-29.5)
11	11	27.5 (26-29)
12	12	27 (25.5-28.5)
13	13	26.5 (25-28)
14	14	26 (24.5-27.5)

2.1.1 Fuzzy Control System. In this study, a fuzzy system will be applied to control the temperature and humidity of the fan speed in the chicken coop for brooding period. In the Mamdani method, the implication application uses the MIN method, while the composition of the rules uses the MAX method, therefore the Mamdani method is often known as the Max-Min method.

2.1.2 Fuzzification. The membership function is a curve with a range of 0 to 1 that determines input to membership degree. In a fuzzy closed loop temperature control system functions Error and Derror must

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have a range of -1.5 to 1.5. The Error and Derror ranges are derived from the findings of a literature study in which the temperature range is 33 - 26°C and is divided into 14 days, after which the set-point can be established every day using Table 1. Derror is the Error value minus the preceding Error. Error is the result of the read temperature minus the set point value. While PWM is a membership function of the output. Membership functions error, Derror, and PWM are shown using Matlab Fuzzy Inference System (FIS) based on Sivanandam et al. [10] in Figure 1-3.

Figure 1. Temperature Membership Function Error

Figure 2. Temperature Membership Function Derror

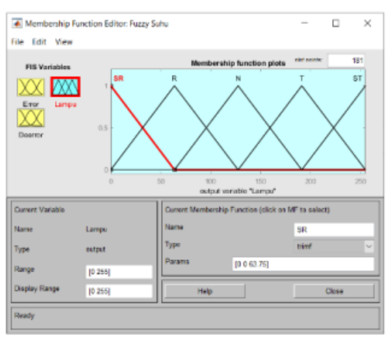

Figure 3. Lamp Membership Function Output PWM

2.1.3 Rule Set (Inference). Rule set is a form of procedural information that relates two or more pieces of information to determine an action. The resulting set of temperature membership is 25 rules which aim to produce an output in the form of a dimmer (heater) light intensity. The rule set obtained can be seen in Table 2 below.

Table 2. Rule set motor output and light intensity of the dimmer (heater)

	NL	**NS**	**Z**	**PS**	**PL**
NL	VB	VB	VB	B	N
NS	VB	VB	B	N	D
Z	VB	B	N	D	VD
PS	B	N	D	VD	VD
PL	N	D	VD	VD	VD

Description:
- NL (Negative Large)
- NS (Negative Small)
- Z (Zero)
- PS (Positive Small)
- PL (Positive Large)
- VD (Very Dim)
- D (Dim)
- N (Normal)
- B (Bright)
- VB (Very Bright)

2.1.4 Defuzzification. In this study, the defuzzification method used was Centeroid. The use of the centeroid method is because the defuzzification value will move smoothly so that changes from a fuzzy set will also run smoothly and the centeroid method is easier in the calculation process. In this method, the crisp solution is obtained by taking the center point (z*) of the fuzzy area. Generally formulated:

$$z^* = \frac{\int_z z\mu(z)dz}{\int_z \mu(z)dz} \quad \text{for continuous variable;} \tag{1}$$

$$z^* = \frac{\sum_{j=1}^{n} z_j\mu(z_j)}{\sum_{j=1}^{n} z_j\mu(z_j)} \quad \text{for discrete variables;} \tag{2}$$

3. Result and Discussion

3.1 Fuzzification

Based on the primary data that has been obtained, a membership function fuzzy input can be made. The membership function fuzzy input graph is shown in Figure 4.

In the system made, the sensor reading value is converted into a temperature error value and a temperature derror value where the value is used to find the value of the fuzzy input membership degree. The process of determining the degree of membership with an example of a temperature error of 0.1 and a temperature derror of 0.1 is explained as follows.

$$\mu E[Z] = 0.87; \ \mu E[PS] = 0.13$$
$$\mu \Delta E[Z] = 0.87; \ \mu \Delta E[PS] = 0.13$$

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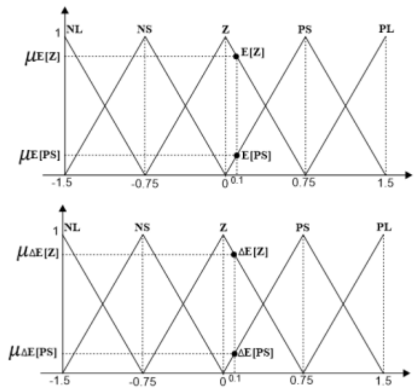

Figure 4. Evaluation of Membership function Error and Derror

3.2 Inference System (Implications and Composition)

After the value of the degree of fuzzy membership is obtained, the process will proceed to the inference system where the value of the degree of membership of the fuzzy input will be evaluated according to the rule set that has been made. The process uses the implication method (Min) and the composition/aggregation method (Max) which are described below.

- Determining the Output Membership Degree Value Based on the Rule Set with the Implication Method (Min) as in Table 3

Table 3. Process Implications (Min)

	Z	PS
Z	N (13)	D (14)
PS	D (18)	VD (19)

	Z	PS
Z	0.87	0.13
PS	0.13	0.13

$$\alpha N = min\ (\mu E[x], \mu\Delta E[x]) \quad (3)$$
$$\alpha 13 = 0.87;\ \alpha 14 = 0.13$$
$$\alpha 18 = 0.13;\ \alpha 19 = 0.13$$

- Determining the Degree of Output Membership Using the Aggregation Method (Max) as illustrated in Figure 5

$$\mu O[N] = max\ (\alpha 13) = 0.87$$
$$\mu O[D] = max\ (\alpha 14, \alpha 18) = 0.13$$
$$\mu O[VD] = max\ (\alpha 19) = 0.13$$

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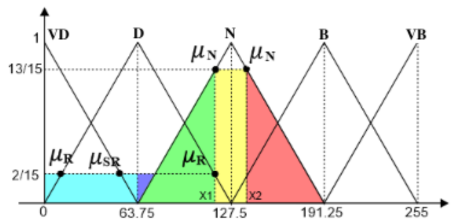

Figure 5. Composition or Aggregation Process (Max)

3.3 Defuzzification

In the defuzzification process, the combined membership degree values are divided into spatial forms, namely squares and triangles, which will be processed using the centeroid method, which looks for the central point value of the spatial shape. The process is looking for the accumulated value of the moment then divided by the accumulated area which is explained as follows.

- Finding the Output Value Using the Centeroid Method

$$z = \frac{\int \mu_x(z)\, z\, dz}{\int \mu_x(z)\, dz} = \frac{\sum Momentum\,(M)}{\sum Area\,(L)} \quad (4)$$

$$z = \frac{271 + 40 + 2408 + 1879 + 3697}{9 + 0.6 + 24 + 15 + 24} = \frac{8295}{72.6} = 114.25$$

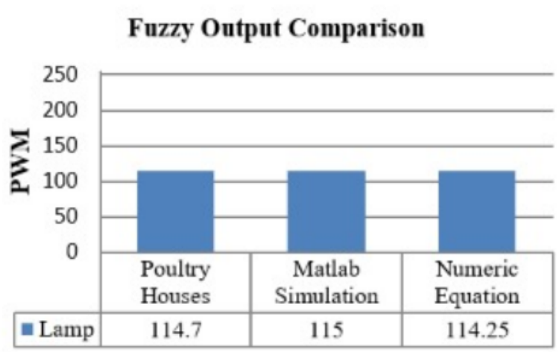

Figure 6. Comparison Graph of Mamdani's Fuzzy Output

The fuzzy output for temperature and humidity produced by the poultry houses and simulation has almost the same results, as given in Figure 6. The difference in the resulting values is due to the rounding pattern of the calculation results in the control and simulation systems. The implementation of the temperature fuzzy system has a very good response which is shown in Figure 7.

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3.4 Fuzzy Response to Temperature Changes

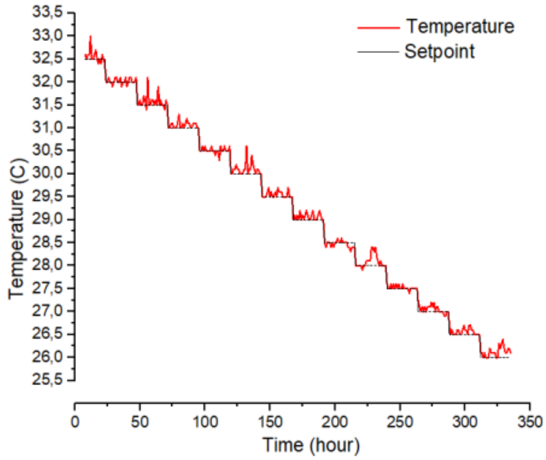

Figure 7. Graph of Temperature Changes During the Brooding Period

Based on Figure 7, on days 1, 3, 6 there was a significant increase in temperature this was due to the influence of rain during the day which made a significant increase in temperature in the cage. Based on the Meteorology, Climatology and Geophysics Agency (BMKG), the meteorological increase in temperature before the rain is due to the hot ambient air temperature accompanied by high humidity. In this case, it rains during the day making the ambient temperature hot with high humidity making the temperature rise in the cage quickly, but the increase in temperature that occurs will slowly decrease due to the influence of cold environmental temperatures so that after the rain the fuzzy system is able to stabilize again to maintain the temperature in the room. in the cage. In Figure 7 a significant increase in temperature in the cage occurred during the day, this was due to the rapid changes in outdoor temperature and humidity making the system need time to adapt to outside conditions that occurred early before the rain. If there is no change in temperature and humidity outside the room quickly, the system can still stabilize the temperature.

4. Conclusion

The temperature control fuzzy system is capable of maintaining the temperature at the set value. Because of the pattern of rounding numbers after the comma in the fuzzy systems in MATLAB and the microcontroller, the output of the fuzzy system on the microcontroller has an error ratio of 0.5 with the output of the fuzzy system in MATLAB. The application of fuzzy Mamdani can keep the temperature stable for 14 days based on a preset set point. A 100W heater and a cooling pad can be used to effectively raise and lower the desired temperature.

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