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FUZZY LOGIC BASED INCUBATOR TEMP AND HUMID LEVEL CONTROLLER PROTOTYPE

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Abstract

Younger babies born with low body weight are increasingly critical and at risk for these babies. To overcome this problem, we need a device of medical equipment that can replace uterine function, whose condition is like that of a baby still in the womb of his mother. Temperature, humidity, oxygen, sound and light levels for the development of the most suitable low birth weight babies. Not only the temperature, humidity and noise factors that must be considered, but also pay attention to other problems that *can interfere with baby's health, among others; Factors such as skin that directly contact family members also contribute to disease in infants, because baby's skin is still very sensitive, and has the potential to become infected. Babies with very low birth weight have a very high risk, especially when they feel cold. When a baby experiences heat loss, creating a physiological response that exceeds that of a normal baby, physiological balance will be severely disrupted, this is because the baby needs to expend energy and metabolize oxygen to produce its own heat. The purpose of using an incubator is to create a very stable environment so that the birth of a baby with a low body weight can maintain a constant body temperature. In designing the incubator must pay attention to the condition of the humidity in the chamber, for the sensitivity of the chamber temperature is relatively easier but if the conditions of dry humidity will greatly affect the health of the baby. Ideal moisture loss will cause transepidermal water loss (TEWL) in premature infants. From the results of the Overall System Measurement and Research conducted in RSUP Dr. Sarjito on April 23, 2019. This location was chosen because the place has a temperature, humidity and noise level that is stable enough so that it is suitable for the location of the baby incubator.*

Keywords*: Microcontroller, Fuzzy Logic, Sensor noise, temperature and humidity*

1. Introduction

Digital image processing is growing rapidly in line with the younger babies born with low weight, the more critical and at risk for these babies. To overcome this, we need a medical device that is able to replace the function of the uterus, which is like a baby in his mother's womb. Temperature, humidity, oxygen, sound and light levels for the development of low birth weight babies are most appropriate. Not only factors of temperature, humidity and noise that must be considered, but also consider other problems that can interfere with the health of the baby, among others; Factors such as skins that are in direct contact with family members also contribute to causing illness in infants, because the baby's skin is still very sensitive , and has the potential to become infected [1].

Babies with very low birth weight have a very high risk especially will feel cold. When a baby experiences heat loss, creating a physiological response that exceeds a normal baby, the physiological balance will be greatly disturbed, this is because the baby needs to expend energy and metabolize oxygen to produce its own heat [2]. Temperature imbalance can cause heat loss in the baby's body and cause cascading conditions in the long run and cause effects such as hypothermia. Hypothermia can cause a decrease in systemic arterial pressure, decrease in plasma volume, decrease blood circulation to the heart, and increase peripheral resistance. If left unchecked, this condition can cause permanent tissue damage, brain damage, or death. For fragile neonates, an environment of less than one degree can mean the difference between success and setback [1].

The purpose of using an incubator is to create a very stable environment so that with the birth of a low-weight baby is able to maintain a constant body temperature. In designing the incubator must pay close attention to the humidity conditions in the chamber, for the sensitivity of the chamber temperature is relatively easier but if the conditions of dry humidity will greatly affect the health of the baby. An ideal loss of humidity will cause transepidermal water loss (TEWL) in premature babies [1].

The purpose of this study is to design an infant incubator is to investigate important parameters that affect the conditions and value limits, related to a good baby incubator. This work design and make intelligent baby incubators with temperature detectors, humidity detectors and noise detectors and then ppply Fuzzy logic to an intelligent baby incubator system. This work also doing measuring the accuracy of the stem.

In order to focus the research more , limiting the problem is to only control the temperature, humidity, and noise using Fuzzy Logic. From the foregoing, the researcher's questions are what parameters and limitations affect the condition of the incubator, then how to make intelligent control and monitor parameters of the Baby Incubator, and then how to apply fuzzy logic to control and monitor baby incubators. To evaluate the method then this work also measure the accuracy of the baby incubator control and monitoring system.

2. Research Method

This study uses several stages including literature study, determination of parameters, architectural design, tool design, system design, testing and analysis. Here is a flowchart in research.

The results of previous studies are used as a reference in this study. Literature study is very important in the initial steps of conducting research because it will provide an initial overview of the steps to be taken, as well as gain an understanding in the research process, what has been done by its predecessor, and will find out its advantages and disadvantages. From some references obtained using Fuzzy logic method, it can be considered effective enough to be used in baby incubator control [2].

Most of the previous studies only control and monitor temperature and monitor humidity. So it is considered necessary to be developed in this study. In this research, in addition to controlling and monitoring temperature and humidity, it will also monitor and control the noise level in the incubator [3].

Parameters

Before designing the equipment, in this study the parameters will be determined first. The parameters that must be considered in the incubator are the parameters of temperature, humidity and noise in the incubator room. By getting ideal conditions, it is expected that the incubator room needs will be in accordance with what is needed, which in turn will improve the health of the baby.

To obtain the above conditions, the heat source is obtained from heating the filament which is flowed by an electric current controlled by the system, the moisture is obtained from the water in the container. Valve gas will open and drain the fresh air used if the temperature is too high exceeds the threshold determined by the setting, this happens if in a very emergency condition caused by factors outside the system that affect the incubator room, for example affected by outside air, so it requires decrease in temperature and humidity in the appropriate incubator chamber. Sensor noise would work if there is noise in the space incubator mele bihi 56 dB, the cause of the noise occurs due to factors lap main fan who work continuously, the fan rotation that are mechanically will potentially wear out, giving rise to noise that exceeds the prescribed limit is a maximum of 56 dB. If this happens the fan will turn off and be replaced by a second fan as a backup which in this study call a sprayer. In this condition the tool can function properly, but the indicator occurs as a concern that the fan is off and replaced by a sprayer, so that it will be marked with an indicator light on, informing the user or technician to repair or replace a damaged fan.

Architectural Design

The architectural design in this study was designed in several parts namely; temperature, humidity and noise in the incubator room, sensors as a detector with DHT 22 for temperature and humidity, sensor KY-037 for noise sensors, Arduino data processing, Fuzzy logic control system control, and displays[4]. The objects taken in this study are temperature, humidity, and noise in the baby incubator room. Furthermore, the data enters data acquisition to convert the signal from analog signals into digital signals and the data will enter the Fuzzy logic temperature control software. Results of the system of control will set the variable heat generated from working heater, to obtain the appropriate temperature with the set t ing, as well as to the level of humidity and ti incidence of noise in the room ink ubator, the results of such processing are shown in the display.

Tool Design

The design of the program in this study uses the Arduino Mega, in Figure 1 is a block diagram of the tool as a whole. Figure 2 show the design of physical view of incubator.

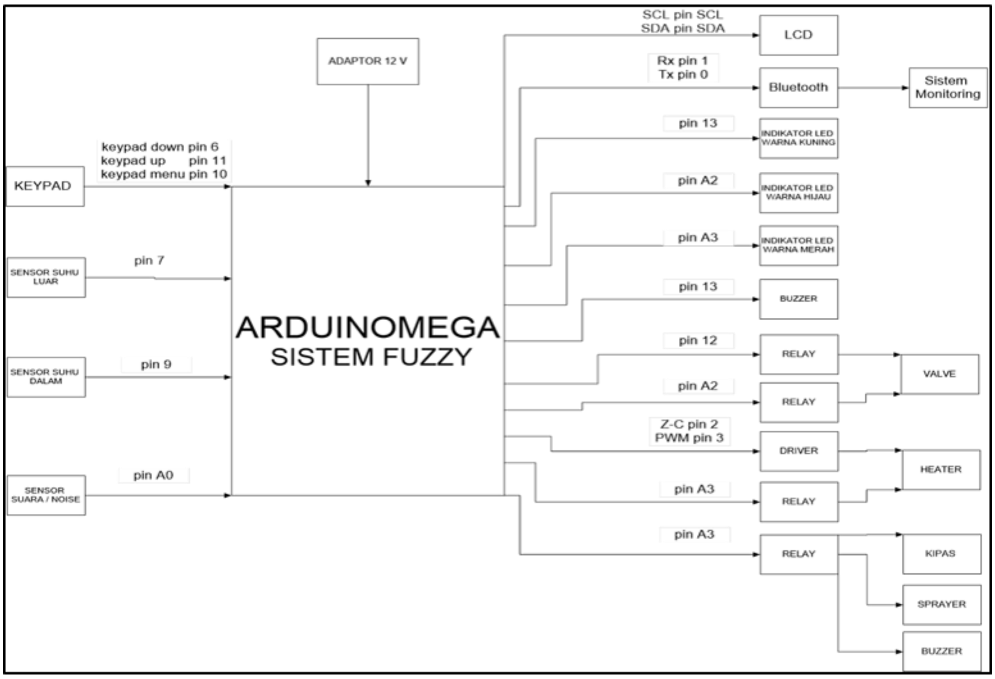

Figure 1. Baby Incubator Block Diagrams

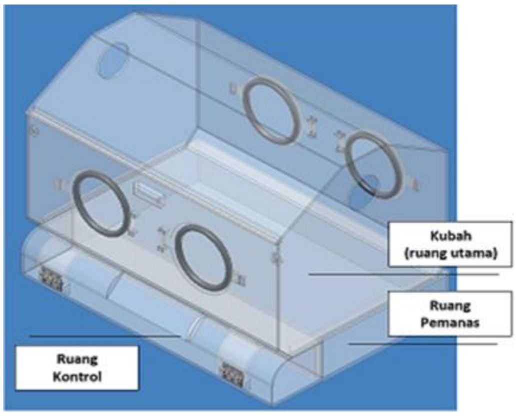

Figure 2. Physical Overview of the Incubator

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Fuzzy Mamdani Logic Method

The Mamdani method is also called the MAX-MIN method [5][6], to get output through 4 stages as follows:

1. Fuzzy set formation.
2. Application of Implication Functions (rules) Mamdani uses the Implications function Min
3. Composition of Mamdani Rules can use 3 compositions of rules, namely: max, additive, or

Confirmation (defuzzy) The result of a set of compositions, needs to be translated into crisp values as the final result.

There are several defuzzification methods:

a. The Centroid Method
b. Bisector Method
c. Mean of Maximum Method
d. Largest of Maximum Method
e. The Smallest of Maximum Method

Is an appropriate way to map an input space into an output space. In the fuzzy concept itself applies a value between 0 and 1. With the aim that the output of fuzzy matches the instincts or natural language according to human ability.

The next step is defuzzyfication which converts fuzzy output to crisp based on a predetermined membership function. If the temperature is not m encapai 36^{0}C then it will go back to detect the temperature and humidity, if the temperature ≥37 ° C then the heater will be off, fans ON and then back again to detect the temperature and moisture levels. Overview of Role Base Mode can be seen in Table 1.

Table 1. Role Base Mode

SUHU DALAM / SUHU LUAR	DINGIN	SEJUK	NORMAL	PANAS	SANGAT PANAS
DINGIN	P	H	AH	AH	D
SEJUK	H	H	AH	D	D
NORMAL	AH	H	D	D	SD
PANAS	AH	AH	D	SD	SD
SANGAT PANAS	D	AH	SD	SD	SD

INFORMATION

SD	: VERY COLD	0^{0}C-29^{0}C
D	: COLD	29^{0}C-32^{0}C
AH	: KIND WARM	32^{0}C-35^{0}C
H	: WARM	35^{0}C-37,5^{0}C
P	: HEAT	38^{0}C-44^{0}C

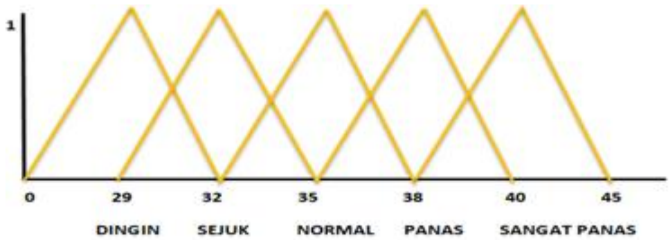

Figure 3. Temperature Graph

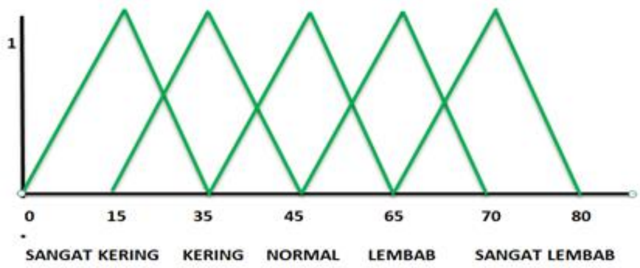

Figure 4. Moisture Graph

Inference

Fuzzy inference system is a calculation framework based on the concepts of fuzzy set theory, fuzzy if-then rules , and fuzzy thinking. System inference fuzz y has been successfully applied in various fields, such as kontrol automatic data classification, decision analysis, the stem expert, predicted time series, robotics and pattern recognition.

$$\mu_{suhu-panas[x]}\begin{cases}0 & x \le 30\\ \dfrac{x-30}{35}, & 30 \le x \le 36\\ 1 & x \ge 36\end{cases}$$

$$\mu_{suhu-dingin[x]}\begin{cases}1 & x \le 30\\ \dfrac{36-x}{35}, & 30 \le x \le 36\\ 0 & x \ge 36\end{cases}$$

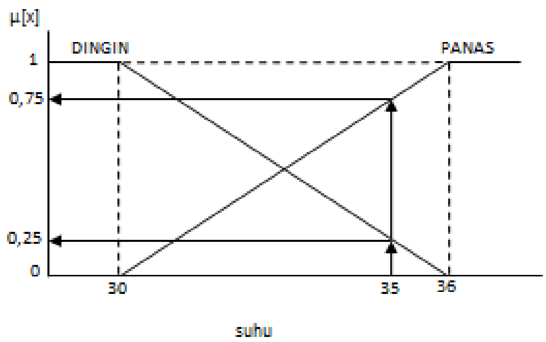

Figure 5. Temperature Graph

$$\mu_{kelembaban-kering[x]}\begin{cases}1 & x \le 30\\ \dfrac{90-x}{63}, & 30 \le x \le 90\\ 0 & x \ge 90\end{cases}$$

$$\mu_{kelembaban-lembab[x]}\begin{cases}0 & x \le 30\\ \dfrac{x-30}{63}, & 30 \le x \le 90\\ 1 & x \ge 90\end{cases}$$

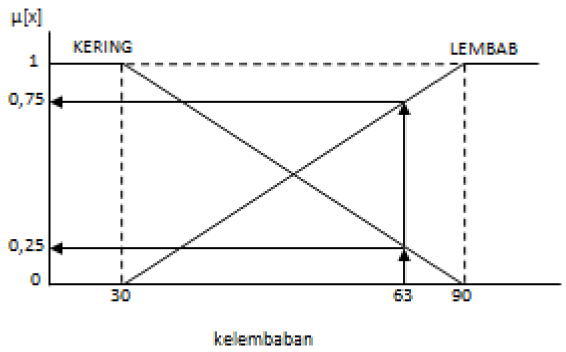

Figure 5. Temperature Graph

3. Results and Analysis

Prototype testing is carried out to determine the function of each hardware and software that has been designed. This is done to ensure the hardware and software can function properly in testing the prototype is divided into 3 parts, namely:

1. Hardware test,
2. Software (fuzzy logic) test
3. The whole system test

Hardware Testing includes :

a. Testing chamber, heater, fan, sprayer fan, buzzer and valve.
b. Testing of 12 V and 5 V power supplies for Arduino and Relay.
c. LCD circuit testing.
d. Calibration of Temperature Sensors and Sound sensors.
e. Testing the Temperature Sensor and Sound Sensor.
f. Testing LED indicators and push buttons.

When testing fuzzy logic includes:

a. Testing Fuzzy Logic Program at Fuzzyfication Stages (Coding Program on Identifying the Coding Program Temperature on the Membership Function).
b. Testing Fuzzy Logic Program on Rule Base Stages.
c. Testing Fuzzy Logic Program in Defuzzyfication Stages.

Testing Scenarios

Tests carried out at the Hospital Facilities Maintenance Installation (IPSRS), Dr. Sardjito Yogyakarta on April 23-24, 2019, aims to ensure that the components used function properly, according to equipment requirements. In the test room with a room temperature condition of 24ºC, with 60% humidity, it is conducted from 09.00 to 21.00 hours, and on the second day it is conducted from 12.00 to 18.00 WIB.

Testing of the chamber, heater, fan, sprayer fan, buzzer and valve

The incubator device consists of a heater, fan, sprayer fan, buzzer and valve installed in the control box. Placement of the heater on the left side in the right control box fan, fan sprayer, and valve. Placement of the fan, the sprayer fan to the left of the heater in the control box is intended to channel air to the heater and absorb moisture to the desired level. While the placement of the buzzer in the middle of the control box to produce the desired alarm sound. Figure 7. shows Test chamber, heater, fan, sprayer fan, buzzer and valve.

Figure 6. Chamber, heater, fan, fan sprayer, buzzer and valve

Testing of 12 V and 5 V power supplies for Arduino and Relay

The power supply for the mega Arduino supply and rails used in Figure 7..

Figure 7. 12 V and 5 V Power Supplies

Table 2. Testing the 12 V Power Suply

No	Time	*Output Supply*	*Datasheet*	Difference (V)
1	00 minutes 45 seconds	12,30	12	0,3
2	05 minutes 30 seconds	11,90	12	0,1
3	10 minutes 30 seconds	11,90	12	0,2
4	15 minutes 27 seconds	11,90	12	0,1
5	20 minutes 37 seconds	12,20	12	0,2
Average				0,26

Table 3. Testing of 5 V Power Supply

No	Time	*Output Supply*	*Datasheet*	Difference (V)
1	00 minutes 55 seconds	5,30	5	0,3
2	05 minutes 15 seconds	4,50	5	0,5
3	10 minutes 18 seconds	4,90	5	0,1
4	15 minutes 12 seconds	4,90	5	0,1
5	20 minutes 47 seconds	5,20	5	0,2
Average				0,34

Testing of 12 V and 5 V power supplies for Arduino and Relay, on a 12V power supply is carried out with a duration of 20 Minutes 37 seconds. By the time duration is done 5 times pengukura n gained an average difference between the power difference is only 0.26 V. test the 5V power supply to do with duration of 20 minutes 47 seconds. With a duration of time that is done 5 times the measurements obtained an average difference of 0.34 V.

Testing the LCD Circuit

Tests on the LCD series is performed to determine whether the LCD can work in accordance with the expected . Pengujian done by displaying characters in each row and column of the LCD , h al aims to determine whether there is damage to the LCD.

Temperature Sensor Calibration and Sound sensor

Censor calibration is intended to find an approach between the censor output used with the thermometer and dB meter. The following are the results of temperature censor and sound censor calibration. In the table below will display the results of the calibration of the temperature censor, humidity and sound censor.

Table 4. Termperature Sensor Calibration Table

No	Sensor Temperature (^{0}C)	hermometer (^{0}C)	Sensor Approach Temperature with Thermometer (^{0}C)
1	26	26	0
2	26,4	26,4	0
3	26,5	26,4	0,1
4	26,7	26,6	0,1
5	26,9	27	0,1
6	27,2	27,2	0
7	27,4	27,5	0,1
8	27,5	27,7	0,2
9	27,83	27,9	0,07
10	27,95	28,1	0,15

Table 5. Sound Sensor Calibration Table

No	Sound Sensor (dB)	dB meters (dB)
1	55	56
2	56	57
3	56	58
4	57	59
5	57	60
6	59	61
7	59	62
8	60	63
9	62	64
10	63	65

Table 6. Comparison table between Thermometer and Temperature Sensor

No	Temperature Sensor (^{0}C)	Thermometer (^{0}C)	Difference in Temperature Sensor with a Thermometer (^{0}C)
1	26,9	27	0,1

Error (%) on the Temperature Sensor = (0.1 / 27) x100% = 0.37%

Provision (accuracy)	= 100% - percentage of error
	= 100% - 0.37%
	= 99.63%

Table 7. Comparison table between dBmeter and Sound Sensor

No	Sound Sensor (dB)	dB meters (dB)	Difference in Temperature Sensor with a Thermometer (dB)
1	62	65	3

Error (%) on the Temperature Sensor	= (3/65) x100% = 4.61%
Provision (accuracy)	= 100% - percentage of error
	= 100% - 4.61%
	= 95.39%

From these results it can be seen that the temperature difference between the temperature sensor and the detected sound sensor is not too significant so the approach used can be said to be appropriate and the accuracy level of the temperature sensor to the thermometer is 99.63% and the accuracy level of the sound sensor to the dB meter is 95 , 39%.

Testing the Fuzzy Logic

Phase fuzzyfikasi is the stage of the formation of the membership function

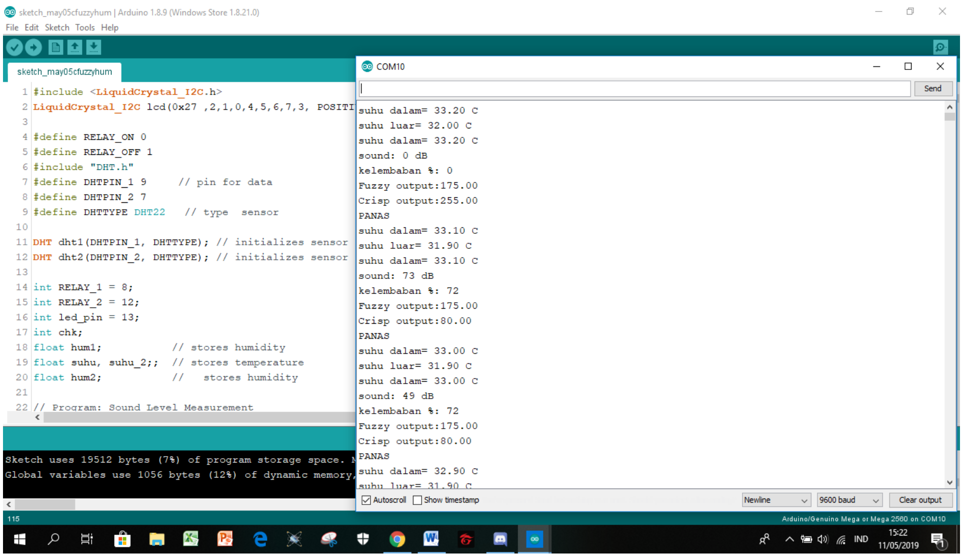

Figure 9. Fuzzyfication Coding

The above program is a program for creating *fuzzyfication* programs . *Fuzzyfication* process testing is done by providing assumption values for data input in accordance with the fuzzy set design. The next step is to enter the assumption values for the x data input into the equation from the results of the fuzzy set design representation.

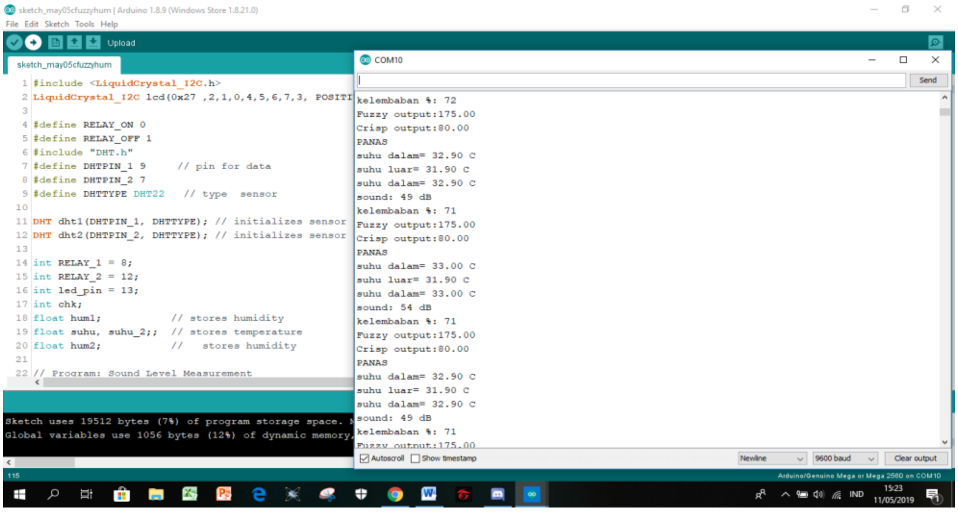

Figure 11. Fuzzyfication Coding

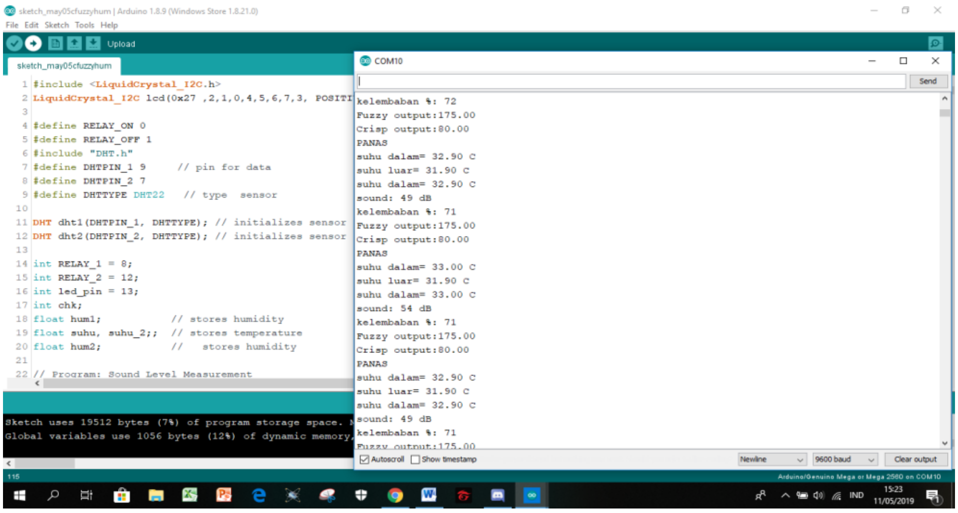

Figure 12. Fuzzyfication Coding

The output from the rule evaluation stage will be used as the Rule Base and multiplied by the value of the degree of membership. The method digunaka n defuzzyfication is the enter of Gravity (COG) or centroid. Namely the sum of the membership functions multiplied by the singleton of each action. The results are then averaged by fuzzy outputs. In this program, it is the output value that will be used to control the ignition delay of the heater.

Overall System Measurement Result

This test aims to determine the performance of the whole series. Measurement between two Temperature Sensors for control system response at RSJ Dr. Sarjito on April 23, 2019.

Table 9. Table of Measurement Result on Full System Response

No	Time (Seconds)	Suhu (^{0}C)	Humidity (%)	Fuzzy Output	Crisp Output
1	00 minutes 5 seconds	32,9	71	175	50
2	3 minutes 30 seconds	33,2	71	175	50
3	4 minutes 30 seconds	33,7	70	175	50
4	5 minutes 30	34,6	70	175	50

	seconds				
5	6 minutes 30 seconds	35,4	68	168,45	56,55
6	7 minutes 30 seconds	35,4	68	168,45	56,55
7	8 minutes 30 seconds	36	66	162,86	62,14
8	9 minutes 30 seconds	36,8	65	143,65	81,35
9	10 minutes 30 seconds	36,3	60	125,28	99,72
10	11 minutes 30 seconds	35,8	61	123,33	101,67
11	12 minutes 30 seconds	35,5	62	122,42	102,58
12	13 minutes 30 seconds	35,3	62	120,45	104,55
13	14 minutes 30 seconds	35,1	63	120,19	104,81
14	15 minutes 30 seconds	35,1	63	120,19	104,81
15	16 minutes 30 seconds	35,1	63	120,19	104,81
16	17 minutes 30 seconds	35,1	63	120,19	104,81

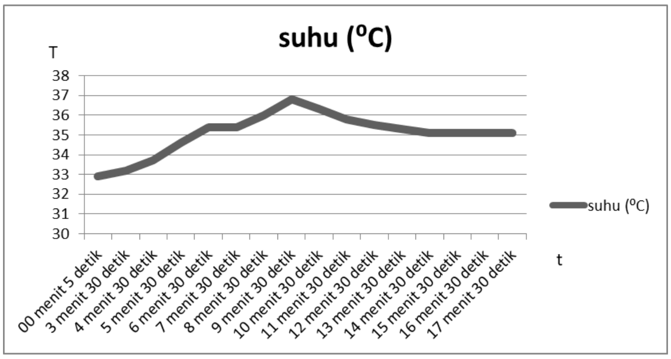

Figure 12. Fuzzy control response to temperature

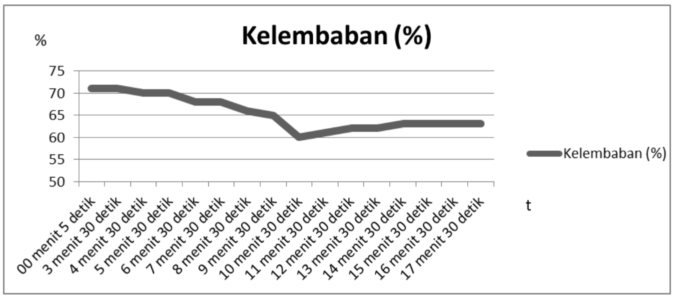

Figure 13. Fuzzyfication Coding

Table 3.7 Table of measurement results on the Full System Response for 17 minutes at 10.30-10.47 WIB. Time 00 minutes 5 seconds with a Temperature Sensor 32.9 0 C and 71% humidity at Crisp output 50 ie heater and fan fault while Fuzzy output 175 ie sprayer does not turn on. While the fuzzy control response in Figure 3.6. The fuzzy control response to temperature is running well and Figure 13. Fuzzy control response to humidity Fuzzy control response to humidity is going well.

4. Conclusion

From the results of Overall System Measurement and Research conducted at Sarjito Hospital on April 23, 2019. This location was chosen because the place has a temperature, humidity and noise level that is quite stable so it is suitable for the location of the baby incubator.

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