GREENATION PUBLISHER
International Journal of Advanced Multidisciplinary(IJAM)
https://greenpub.org/IJAM greenation.info@gmail.com +62 812-1046-7572
DOI: https://doi.org/10.38035/ijam.v4i2

Control and Monitoring System of Egg Hatching in Egg Hatching Incubator Based on Internet of Things (IoT)

Edy Supriyadi[1], Fivit Marwita[2], Iriandi Ilyas[3], Wira Dwicaksana[4]
[1]Institut Sains dan Teknologi Nasional, Jakarta, Indonesia, edy_syadi@istn.ac.id
[2]Institut Sains dan Teknologi Nasional, Jakarta, Indonesia, pipitsalman@istn.ac.id
[3]Institut Sains dan Teknologi Nasional, Jakarta, Indonesia, iriandi@istn.ac.id
[4]Institut Sains dan Teknologi Nasional, Jakarta, Indonesia, wiradwicaksana27@gmail.com

Corresponding Author: pipitsalman@istn.ac.id[2]

Abstract: Broodless egg hatching is often the choice of farmers when the mother does not incubate her eggs. However, to ensure hatching success, careful monitoring of temperature, humidity, and heat distribution in the incubator is essential. This thesis aims to develop an Internet of Things (IoT)-based automatic egg hatching control and monitoring system to improve the efficiency and success rate of broodless hatching. The system implements Sugeno fuzzy logic to regulate the incubator temperature dynamically and precisely, adjusting to the environmental variability that occurs during the hatching process. An ESP32 microcontroller is used as the control centre, which is integrated with temperature and humidity sensors (DHT11) as well as a Telegram application on mobile devices, enabling real-time monitoring and automatic notifications to users. The hatching test results of chicken eggs for 23 days showed a hatching success rate of 66.7% (4 out of 6 eggs), with controlled temperatures in the range of 36-39°C. Hatching failure in two eggs is indicated due to the position that is too close to the AC dimmer lamp, which causes uneven heat distribution. The implementation of Sugeno fuzzy in this system with an error of 0.01% proves the reliability of Sugeno fuzzy control method in maintaining temperature and humidity stability, which is very important in the egg hatching process. This system offers a practical and efficient solution for farmers in optimising the egg hatching process.

Keyword: Egg Incubation, Internet of Things (IoT), Fuzzy Sugeno Logic, ESP32, Temperature Control, Real-time Monitoring, Telegram.

INTRODUCTION

In the development of automatic egg hatching systems, various types of microcontrollers have been utilised as the main controller of the system. Some studies use the ESP8266 platform, as implemented by Rahman et al. (2020), Fivit, et al (2020) and Hamdani (2023). ESP8266 was chosen because of its capability in wireless connectivity that supports the implementation of the Internet of Things (IoT). In addition to ESP8266, the Arduino platform is also used in several studies, as reported by Jufril et al. (2015) and Nugroho et al. (2019). Further research, (Sayekti, 2023) used ESP32, a more advanced microcontroller platform than ESP8266, for an IoT-based egg hatcher system.

Automatic egg incubator systems rely heavily on sensors to monitor environmental conditions inside the incubator, especially temperature and humidity. Some studies use DHT11 (Fivit et al, 2020), DHT21 (Sayekti, et al, 2023), and SHT11 (Jufril et al, 2015) sensors. DHT sensors are popular digital sensors due to their ease of use and relatively affordable price. Apart from the DHT sensor, the LM35 temperature sensor was also used in the research of Fivit et al, (2020).

The control method determines how the system responds to changes in environmental conditions to maintain ideal conditions for hatching eggs. In some studies, Fuzzy Logic method is applied as a system controller (Jufril et al., 2015). Fuzzy Logic was chosen because of its ability to handle complex and non-linear systems, as well as its ability to process linguistic information or uncertainty. On the other hand, the PID (Proportional-Integral-Derivative) method is also used in some implementations of automatic egg hatching systems (Nugroho et al., 2019). PID control is a classic control method that is widely used because of its simplicity and effectiveness in controlling closed-loop systems.

The output of an automated egg incubator system includes various devices used to provide information and allow interaction with the user. Some systems utilise LCD (Liquid Crystal Display) to display temperature and humidity information locally (Fivit et al, 2020, Jufril et al., 2015 and Nugroho et al., 2019). The LCD allows users to monitor environmental conditions directly on the hatchery. In addition, the current trend of automated egg hatching systems is towards the implementation of IoT (Internet of Things), which allows monitoring and controlling the system remotely via the internet network (Sayekti et al., 2023 and Hamdani & Hastuti, 2023). IoT implementations often use platforms such as Blynk (Hamdani & Hastuti, 2020), LabView (Fivit et al, 2020), Firebase (Sayekti et al., 2023) or telegram as a user interface to monitor and control the system through a mobile device or computer. The I2C interface is also mentioned (Jufril al., 2015 and Nugroho et al, 2019), which is usually used for communication between components in embedded systems.

METHOD

The data analysis technique used in this study can be described as follows:

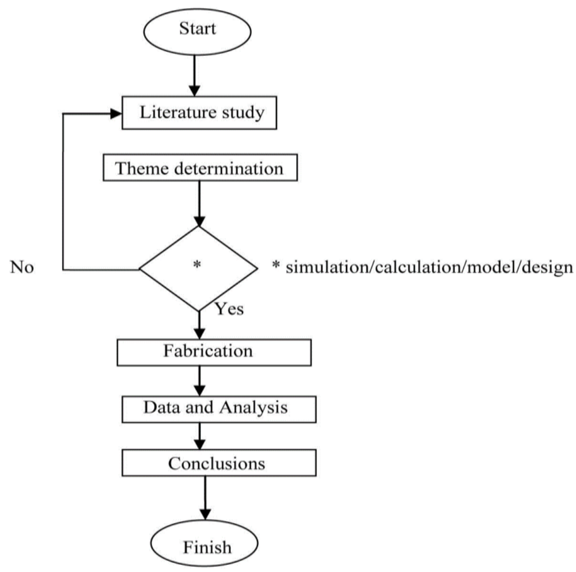


Figure 1. Research flow chart

In Figure 1, the research method carried out is a literature study and assembly of tools and components to design the tool from the prototype. The research conducted by the author focuses on the water filter monitoring and automation system. If there is a failure in the system or design made, then return to the literature for troubleshooting.

Planning Hardware

The hardware design of this Internet of Things-based Egg Hatching Monitoring and Control System aims to increase the efficiency and success rate of broodless hatching. This system implements Sugeno fuzzy logic to regulate the incubator temperature dynamically and precisely, adjusting to the environmental variability that occurs during the hatching process. The ESP32 microcontroller is used as the control centre, which is integrated with temperature and humidity sensors (DHT11) as well as the Telegram application on mobile devices, allowing real-time monitoring and automatic notifications to users. for more details can be seen in Figure 2.

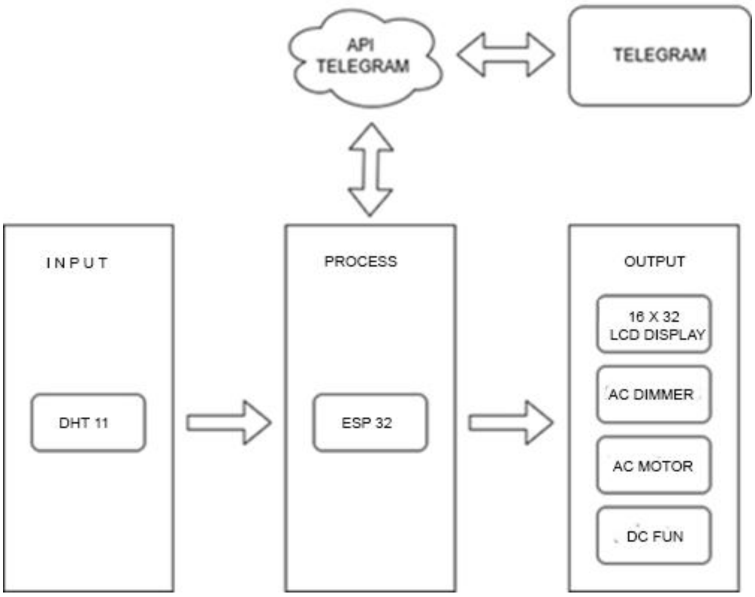


Figure 2. System design

The detailed explanation for the system design in Figure 2 can be adjusted as follows:

1. Input

In Figure 1 the DHT11 sensor will read the temperature and humidity values in real-time. This data will then be converted into digital signals that can be read by the ESP32 microcontroller.

2. Process

In Figure 2 the ESP32 receives the temperature and humidity data from the DHT11, then compares it with the programmed target values, and based on the comparison results, the ESP32 determines the control actions needed to keep the incubator in optimal condition. ESP32 also manages communication with the Telegram platform via an API, allowing the sending of notifications and receiving commands from the user via the Telegram app.

3. Output (Hardware)

Based on figure 2, the results of ESP32's data processing and decision making, ESP32 sends control signals to various output devices:

a) 16x2 LCD Display: The ESP32 sends temperature, humidity, and system status information to the LCD screen, which then displays it visually to users around the incubator.

b) AC motor: The ESP32 activates the AC motor periodically to rotate the egg rack, ensuring that the heat received by the eggs is evenly distributed and preventing the embryos from sticking to the shell.
c) AC Dimmer: The ESP32 controls the power of incandescent bulbs connected to the AC dimmer to regulate the temperature of the incubator, increasing power if the temperature is too low, and decreasing power if the temperature is too high.
d) DC Fan: The ESP32 controls the DC fan to maintain air circulation inside the incubator so that the temperature and humidity are evenly distributed.

4. Telegram

Based on Figure 2, the ESP32 uses the Telegram API to send notifications to the user's Telegram application periodically regarding information inside the incubator in the form of temperature, humidity and light intensity values. Users can send control commands through the Telegram application, which are then forwarded through the API to the ESP32 which allows users to obtain information in the form of temperature, humidity and light intensity values in the incubator as well as remotely controlling DC motors to move the egg hatching racks.

Planning Software

The software design here consists of hardware initialization programs such as LCD, DHT, Dimmer, EEPROM, WiFi connection and NTP for time synchronization, and reading the stored day value. After completing the initialization process, it will then read the data from the DHT-11 sensor for the fuzzification process so that the light can be adjusted (room temperature) through the specified dimmer value and the fan is used for air circulation and can help reduce the temperature in the incubator, then the motor will turn off when the incubation period is complete. All changes in temperature data and light intensity values will be sent to the user via telegram.

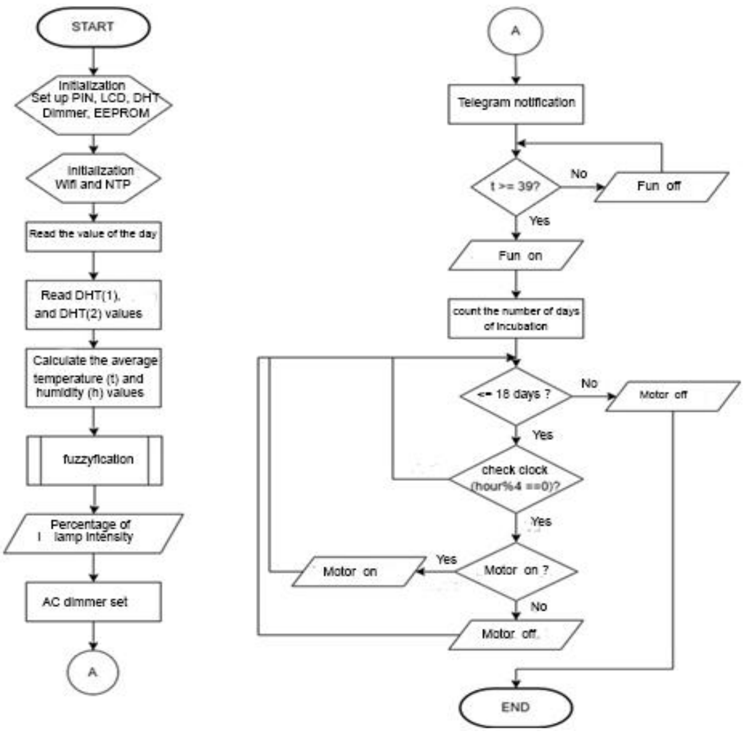


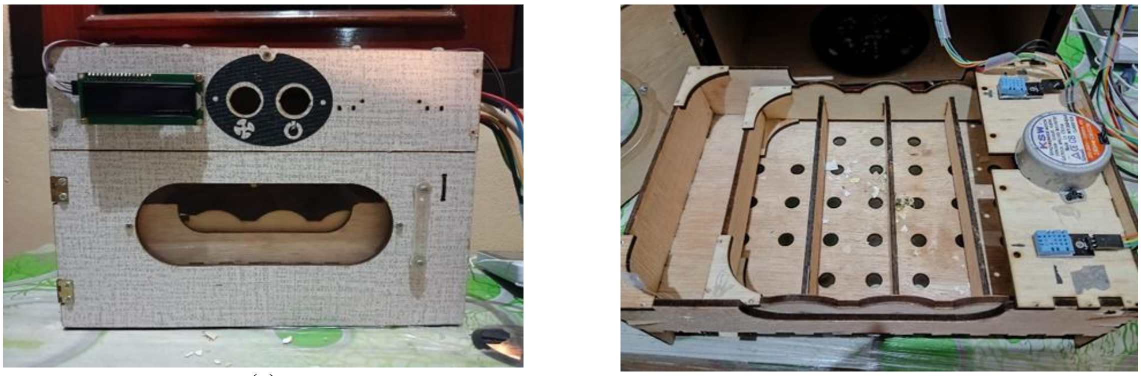
Figure 3. System flowchart

RESULT AND DISCUSSION

Hardware Result and Discussion

The design of the tool form used is a prototype with the original form of the reference tool. Egg hatching incubator with a rectangular box shape made of MDF and Multiplex material with a size of 22 cm high, 31 cm long and 21 cm wide.

At the front, there is a door that can be opened for access to the inside. The door has a transparent window that allows the user to observe the conditions inside the incubator without having to open the door. At the top of the incubator, there is an LCD display panel. On the inside of the device there is a sliding shelf that is designed to have 4 rooms for laying eggs and there is a hole under the shelf and there is a container that serves to maintain humidity. On the left side there is an incandescent lamp as a temperature regulator. And at the back of the tool there are 2 DC fans that function to regulate circulation in the incubator The following is the design of the tool shape that has been made in Figure 4.



(a) (b)

Figure 4. Prototype of egg hatcher front view and Top view of egg rack

Tool Testing

The purpose of this test is to find out whether the realized tool is appropriate (tool accuracy). Tests that have been carried out include sensor testing, Sugeno fuzzy method testing, and overall tool testing.

1. Sensor Testing

Sensor testing is carried out to determine whether the sensor performance is as expected and in accordance with the actual temperature and humidity. The sensor test carried out is the DHT11 sensor. DHT11 sensor testing is compared with test results using a hygrometer measuring instrument as a reference sensor. Testing is done six times with different temperatures and humidity. The following is a comparison table of sensors with hygrometer measuring instruments shown in table 1 and table 2.

Table 1. DHT 11 Sensor Testing (1)

No	Sensor DHT 11 (2)		Hygrometer		Correction Hygrometer		Difference		Error (%)	
	°C	RH (%)	°C	RH (%)	°C	RH (%)	°C	RH (%)	°C	RH (%)
1	30	62	30,8	66	0	8,3	0,8	12,3	2,6	16,55
2	28	63	28,5	62	0	8,3	0,5	7,3	1,75	10,38
3	37	35	37,3	31	-0,2	4,7	0,3	0,7	0,27	1,96
4	38	43	37,4	36	-0,2	4,7	0,6	2,3	2,15	5,65
5	41	36	41,3	26	-0,2	4,7	0,3	5,3	0,24	17,26
6	40	34	40,3	26	-0,2	4,7	0,3	0,3	0,25	10,75
Average									1,21	10,42

Table 2. DHT 11 Sensor Testing (2)

No	Sensor DHT 11 (2)		Hygrometer		Correction Hygrometer		Difference		Error (%)	
	°C	RH (%)	°C	RH (%)	°C	RH (%)	°C	RH (%)	°C	RH (%)
1	31	68	30,8	66	0	8,3	0,2	6,3	0,65	8,48
2	29	69	28,5	62	0	8,3	0,5	1,3	1,75	1,85
3	37	44	37,3	31	-0,2	4,7	0,1	8,3	0,27	23.25
4	37	41	37,4	36	-0,2	4,7	0,2	0,3	0,54	0,74
5	41	33	41,3	26	-0,2	4,7	0,1	5,3	0,24	17,26
6	40	31	40,3	26	-0,2	4,7	0,1	0,3	0,25	0,98
Average									0,61	8,76

In the DHT sensor testing table, it can be seen that the DHT11 sensor can work well with a small percentage of temperature error, namely at DHT 11 (1) of 1.21% and at DHT11 sensor (2) of 0.61%, but the percentage of humidity error of the DHT11 sensor on both sensors is relatively large, namely DHT 11 (1) of 10.42 and at DHT11 sensor (2) 8.76. This is because the sensitivity level of the DHT11 sensor is faster and higher than the manual measuring instrument.

2. Testing the Sugeno Fuzzy Method

Testing of fuzzy methods is compared with the results of calculations on simulations in matlab and the average sensor input data which includes temperature and humidity. Testing is carried out in 3 cold, normal and hot conditions. Comparison of fuzzy calculation results by the tool is shown in table 3.

Table 3 Testing the Sugeno Fuzzy Method

No	Average Sensor Input		Tool Defuzzification	Matlab Defuzzification	Error
	Temperature	humidity			
1	38,5	32	35	35	0
2	40,5	32	35	35	0
3	37	52	55,06	55	0,06
4	36,5	46,5	45	45	0
5	28,5	55	80	80	0
6	30	60,5	80	80	0
Average error					0,01

Table 3 presents the test results of the Sugeno fuzzy method that compares the defuzzification results of the device with Matlab simulation, using the average input data of the temperature and humidity sensors. The test results show that the Sugeno fuzzy method is successfully implemented accurately on the tested device. This is evidenced by the consistency of defuzzification results between the tool and Matlab simulation, where 5 out of 6 tests produced exactly the same value. Only one test showed a slight difference, which was 0.06. The average error generated from all tests was 0.01, indicating a very high level of accuracy. Tests were conducted under various conditions (cold, normal, and hot), and the results obtained remained consistent, indicating that the Sugeno fuzzy method can work well under various environmental conditions. Overall, this table proves that Sugeno fuzzy-based control systems are reliable for controlling temperature and humidity in various applications, such as in automatic egg hatching machines.

3. Implementation of Fuzzy Logic

The stages of the code to implement fuzzy which consists of 4 stages, namely:

1) Determine fuzzy variables and linguistic values
2) Fuzzification

3) Rule Composition
4) Defuzzification

a) Determining fuzzy variables and linguistic values

There are two variables entered in this study, namely temperature and humidity from the DHT11 detection results. Each input variable is then divided into three membership linguistic values. Fuzzy sets are used to represent conditions in a fuzzy variable, each fuzzy set formed has a domain. The following is table 4, which is the linguistic value.

Table 4 Linguistic Values

Fungsi	Variable	Linguistic Value	Domain
Input	Temperature	Cold	20, 20, 35, 37
		Normal	36, 37, 38, 39
		Hot	38, 40, 50, 50
	Humidity	Dry	20, 20, 40, 55
		Medium	50, 55, 55, 60
		Humid	55, 70, 90, 90
Output	AC Dimmer	Dim	35
		Medium	65
		Bright	80

The linguistic values in table 4 illustrate how the input (temperature and humidity) and output (AC dimmer) values are categorized into linguistic terms that are more easily understood by humans. The temperature input has three categories: “Cold” with a domain of 20°C - 37°C, ‘Normal’ with a domain of 36°C - 39°C, and “Hot” with a domain of 38°C - 50°C. Overlapping domains indicate a gradual transition between categories. For the humidity input, there are three categories: “Dry” with a value of 20%RH - 55%RH, ‘Medium’ with a value of 50%RH - 60%RH, and “Humid” with a value of 55%RH - 90RH. Similar to temperature, the humidity domain also has overlapping values. The AC dimmer output has three categories: “Dim” rated at 35%, ‘Medium’ rated at 65% and “Bright” rated at 80%. Which indicates the brightness level of the lamp. These values are used to determine the membership of a value in a particular linguistic category which will then be used in the fuzzy system as decision making.

b) Fuzzification

After the formation of fuzzy variables and determination of linguistic values, the next step is the fuzzification process. The fuzzification process is carried out by mapping the input data points in the fuzzy set into the value or degree of membership which has an interval from the interval 0 to 1. In this research, the linguistic fuzzy set data is obtained through input from sensor data. The function used is through curve representation.

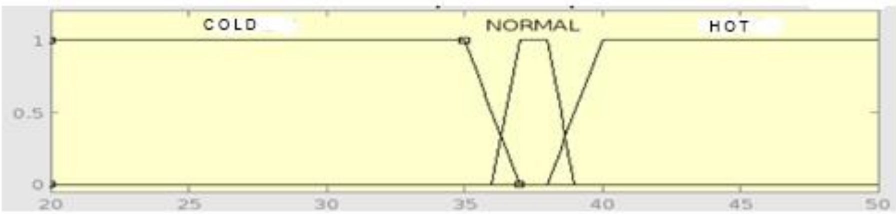


Figure 5. Membership Function of Temperature Variables

Figure 5 shows the fuzzy membership function of the temperature variable which has 3 fuzzy sets: “cold”, ‘normal’ and “hot”. Each fuzzy set is represented by a triangular or trapezoidal curve that shows the degree of temperature membership in each category.

c) Rule Composition

The next process is to determine the rule composition (rule based) which contains fuzzy rules to map fuzzy input values to determine fuzzy outputs. This rule is expressed in IF-THEN format. In this section, it will be illustrated with a FAM (Fuzzy Associative Map) table, the decision making for fuzzy output here is determined by the researcher by referring to the fuzzy knowledge base.

d) Defuzzification

The last stage is defuzzification using a linear or constant function that connects the membership values of the input variables with the output value. With weights that can be calculated from the output value based on the rules given and the degree of membership of the input variables.

4. Implementation of Egg Testing on Egg Hatching Machines

Testing of the tool is done by taking the average day's input data which includes temperature and humidity data, while the output data includes defuzzification of ac dimmers (lights). Testing was carried out for 23 days with six eggs resulting in the data shown in table 5.

Table 5 Tool Implementation

Date	Day -	Description
30 January	1	Eggs are put into the egg incubator as many as 6 chicken eggs and placed on 3 partitions of 2 eggs each.
2 February	4	Egg checking, on day 4 the embryo in the egg begins to form and there are already a few hair-like blood vessels
6 February	8	The embryo in the egg is partially formed and the blood vessels or hair-like shape has begun to spread throughout the egg.
10 February	12	The embryo inside the egg is still visible
14 February	16	The baby chicks are starting to show
15 February	17	The embryo inside the egg is fully formed and the fertilizers have filled the space inside the egg
16 February	18	Motor stops moving the hatch rack
17 February	19	Two chicken eggs have started to crack
18 February	20	Two eggs have started to hatch
19 February	21	One chicken egg started to hatch and one egg started to crack
20 February	22	Another egg begins to hatch with the help of an open shell
21 February	23	There were 2 eggs that did not hatch.

Table 5 records the test results of hatching chicken eggs for 23 days. Of the six eggs inserted into the hatching machine, four successfully hatched, while the other two failed to hatch. The hatching process showed normal embryonic development in most of the eggs, with visible blood vessel and embryo formation in the early days. However, the two eggs that failed to hatch were thought to have been positioned too close to the air-conditioning dimmer, possibly causing unstable or excessively high temperatures. This shows the importance of positioning the eggs in the hatchery to ensure even and optimal heat distribution for embryo development. Nonetheless, the successful hatching of four eggs shows that the hatchers generally function well and are able to produce conditions that support embryo development.

Software Results and Discussion

1. **Flowchart Fuzzyfikasi**

In Figure 6 is the fuzzification process in the control system, which is used to convert input values (temperature and humidity) into outputs that can be used to regulate the system. The process starts with Fuzzification, which is the initial step in fuzzy logic. Next, temperature values and humidity values are taken as inputs. For each input value, the system calculates the degree of membership in a predefined fuzzy set. For temperature, the fuzzy set is [Cold, Normal, Hot], and for humidity, the fuzzy set is [Dry, Medium, Humid]. This membership degree shows how much an input value belongs to each fuzzy set. After the membership degree is calculated, Sugeno's Fuzzy Rule Base is used to determine the fuzzy output based on the rules that have been set. The Sugeno model is used because of its ability to produce a crisp output directly, which is suitable for system control. Finally, the fuzzification process ends the light intensity has been determined from the fuzzy rule base.

The fuzzyfication process of IOT-based automatic egg hatching can be seen based on Figure 6.

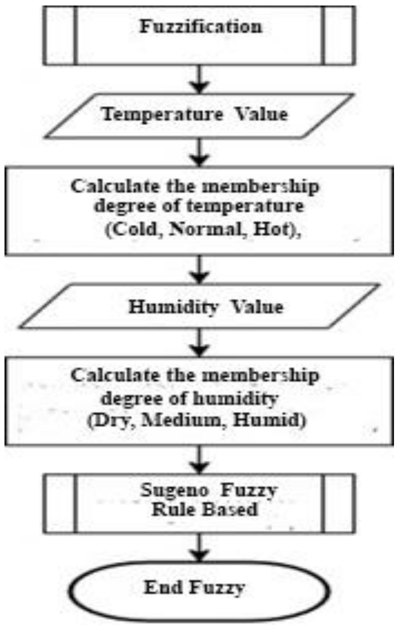


Figure 6. Fuzzification flowchart

2. **Flowchart of Fuzzy Sugeno Rule Base.**

Rulebase Fuzzy Sugeno on automatic egg hatching based on IoT can be seen based on Figure 7.

In Figure 7 is the decision-making process in the control system using Sugeno Fuzzy Rule Base. The process starts with the evaluation of predefined fuzzy conditions. The system checks the combination of temperature (Cold, Normal, Hot) and humidity (Dry, Medium, Humid) membership degrees to determine the appropriate light intensity.

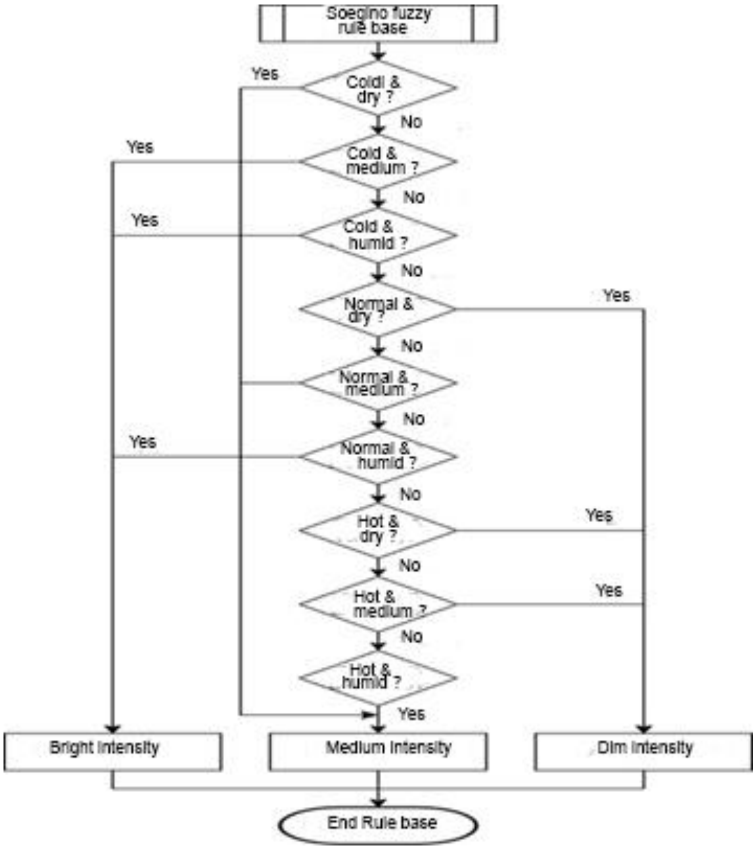


Figure 7. Rule base flowchart

Each combination of conditions is checked sequentially. If a combination of conditions is satisfied (Yes), then the appropriate light intensity is selected. For example, if the temperature "Cool" and humidity "Dry" are met, then the selected light intensity is "Bright". Otherwise (No), the system will proceed to the next combination of conditions.

This process continues until all combinations of conditions are checked. In the end, one of the three light intensities (Bright, Medium, Dim) will be selected based on the most suitable input condition. This process ends at End Rulebase, which signifies that the light intensity has been determined and is ready to be used in system control.

3. Telegram Notification Flowchart

The process of sending and receiving telegram notifications on the IOT-based automatic egg hatching system is shown in Figure 8.

In Figure 8 is the process of sending status notifications via Telegram. The system periodically checks whether it has entered the first minute of each hour. If it is, or if the system receives a status message request from the user, it will send a message containing incubator status information. This message includes temperature data from two sensors (T1 and T2), humidity data from two sensors (H1 and H2), and the light intensity value set by the dimmer. After the message is sent, the system will return to the beginning to wait for the next time check or status message request. This process keeps repeating itself to ensure the user gets up-to-date information on the condition of the incubator.

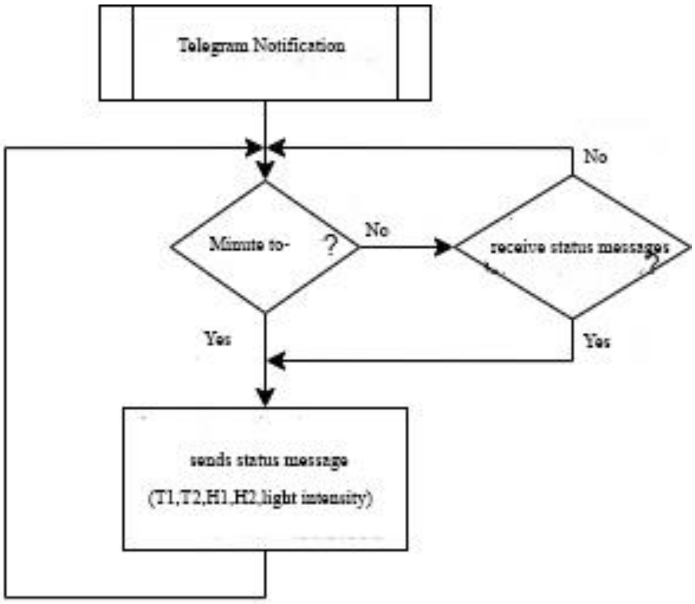


Figure 8. Telegram notification flowchart

Figure 8 shows the sensor data monitor from the device which processes data in the form of temperature, humidity and light intensity data that is lit via the Telegram application from a smartphone every day.

Figure 7 Sensor monitor with telegram app on mobile

CONCLUSION

From the results of the design of this tool to the findings and discussion, the following conclusions can be drawn:

1. The test results on each DHT 11 sensor showed a reading error on the sensor, namely on the DHT 11 sensor (1) there was a temperature reading error of 1.21% and humidity of 10.42%, and on the D HT 11 sensor (2) there was a temperature reading error of 0.61% and humidity of 8.76%. This is because DHT11 has limited accuracy specifications, which are ±2°C for temperature and ±5% for humidity.
2. The test results with the Sugeno fuzzy method show a very low error of 0.01 which shows that this Sugeno fuzzy method is one of the effective fuzzy methods for making egg incubators.
3. The results of this egg hatching experiment set the temperature between 36-39°C and obtained a hatching success of 66.7%. The chicken egg hatching experiment was carried out for 23 days, from 6 eggs tested, there were 4 eggs that hatched and 2 eggs that did not hatch due to the position of the eggs too close to the lamp.

REFERENCES

Hamdani, A., & Hastuti, D. (2023). Rancang Bangun Sistem Monitoring Dan Kontrol Smart Inkubator Telur Ayam Berbasis Internet of Things (IoT) Menggunakan Esp8266 Dan Modul Timer Delay Relay (TDR). In Seminar Nasional Teknologi Industri (Vol. 1, No. 1, pp. 219-228).

Ilham Sayekti, Sonia Audira, Yohan Wahyu Pradana, Khaerul Umam, Rafif Naufal Nugroho, Mela Wulan Dari (2023). Penerapan Teknologi Penetas Telur Otomatis Dengan Sistem Pendeteksian Kerusakan Alat Berbasis Internet of Things. ORBITH Vol. 19 No. 3 November 2023 : 290 – 298.

Jufril. (2015). Implementasi Mesin Penetas Telur Ayam Otomatis Menggunakan Metode Fuzzy Logic Control. Jurnal FTUMJ. ISSN: 2407 – 1846.

Marwita, Fivit .(2020). Rancang Bangun Alat Ukur Kondisi Ruang Inkubator Bayi Berbasis Komputer PC dan Aplikasi Android.Jurnal Saintech, Vol 30, No: 2 , 2020.

Muhamad Cahyo Ardi Prabowo, Ilham Sayekti , Sri Astuti , Septiantar Tebe Nursaputro , Supriyati (2024). Development of an IoT-Based Egg Incubator with PID Control System and Mobile Application. JOIV : Int. J. Inform. Visualization, 8(1) - March 2024 465-472

Rahman, F., Sriwati, S., Nurhayati, N., & Suryani, L. (2020). Rancang Bangun Sistem Monitoring Dan Kontrol Suhu Pada Mesin Penetas Telur Otomatis Berbasis Mikrokontroler Esp8266. ILTEK: Jurnal Teknologi, 15(01), 5-8.

Ridwan Nugroho, Sugeng Santoso, Rizki Firmansyah,Hardika Alip Bazari, Rico Agung F,S.Kom (2019). Rancang Bangun Mesin Penetas Telur Otomatis Berbasis Microcontroller ATMEGA16 Menggunakan Sensor LM35. JOISM : Jurnal Of Information System Management ISSN : Vol 1, No 1 (2019)

Risandriya, S. K., dkk. (2024). Pengendalian Suhu Terhadap Proses Penetasan Telur Ayam dengan Kendali Logika Fuzzy Menggunakan IoT sebagai Monitoring. Journal Of Applied Electrical Engineering Vol.8, No.1. Hal.51- 57

Salsabila. M., dkk. (2022). Alat Penetas Telur Sederhana. GRAVITASI Jurnal Pendidikan Fisika Vol (5) No (1) Edisi Juni Tahun 2022

Setyawan, D. Y., dkk. (2023). Internet of things ESP8266 ESP32 web server. Jejak Pustaka: Yogyakarta

Shafiudin. S., Kholis. N. (2017). Sistem Monitoring Dan Pengontrolan Temperatur Pada Inkubator Penetas Telur Berbasis PID. Jurusan Teknik Elektro. Volume 06 Nomor 03 Tahun 2017, 175 –184.

Supriyadi, E. (2020). Rancang Bangun Alarm Pedeteksian Kebakaran Pada gedung Bertingkat Menggunakan Metode Logika Fuzzy Berbasis Mikrokontroter Serta

Terintegrasi IoT.Jurnal Sinuoida, Vol. 22, No. 2, April 2020 ISSN 1411 – 459310, Hal 10-20.