Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 6, Number 2, April 2022
DOI : https://doi.org/10.33395/sinkron.v7i2.11346

e-ISSN : 2541-2019
p-ISSN : 2541-044X

# Monitoring System For Tillandsia Ornamental Plants Using Fuzzy Algorithm

**Meyti Eka Apriyani** [1)*], **Krisna Widianggara** [2)], **Ade Ismail** [3)]
[1)2)3)]Politeknik Negeri Malang, Indonesia
[1)]meytieka@polinema.ac.id, [2)] krisna.widi.kw@gmail.com, [3)]ismail@polinema.ac.id,

**Submitted** : Mar 14, 2022 | **Accepted** : Mar 21, 2022 | **Published** : Apr 1, 2022

**Abstract:** The national floriculture industry will continue to grow, along with the interest and demand for ornamental plants by the public the author intends to design a tool in the field of communication technology by utilizing the Internet of Thing (IoT) Platform so that it can be monitored remotely by covering the cultivated land of tillandsia ornamental plants. Temperature and humidity data will be analyzed using a fuzzy algorithm. Then the system gives a callback to the actuator (relay on the water pump) to work so that the temperature and humidity reach the expected conditions stably so that the care and maintenance of tillandsia plants is optimal and maintains the water conditions of tillandsia plants. In this research, found results with an average error of 0.4% on the temperature sensor with 7 tests, 0.83% on the light sensor with 3 trials. This system has succeeded in monitoring and controlling the prototype of the IoT-based mini greenhouse condition that can monitor remotely and automatically manage the conditions of temperature, humidity, and water light intensity to remain stable, making it easier for cultivation managers to monitor land or greenhouse conditions even though they are far away from the place of cultivation for the tools and pond managers are connected to the internet network.

**Keywords:** Fuzzy Sugeno, Green House, Internet of Thing, Ornamental plants, Tillandsia

## INTRODUCTION

Tillandsia is a featured plant in the Garneta Nursery Garden, Mampang, District. Pancoran Mas, Depok City in its cultivation with a land area of 480m2. The demand for ornamental plants in the world market tends to increase from year to year for both domestic and export needs, this positions ornamental plants as an important trading commodity in the domestic and global markets. In trade, Tillandsia has a relatively high selling price in Indonesia due to the scarcity of plants for tillandsia plant collectors, the benefits of being able to filter the air in the room, and the relatively long life of the plant. The value of trade, world floriculture reached more than 90 billion US$ in 2009, while Indonesia reached 15 million US$ with the 51st position in the world. The national floriculture industry will continue to grow, along with the increasing interest and demand for ornamental plants by the public. (Permana et al., 2020)

In the case of tillandsia cultivation in the Garneta Nursery plantation, Mampang, Kec. Pancoran Mas, Depok City for watering is still classified as manual so it spends more energy and time in the watering process and not a few when watering there are some plants that are not covered in watering, causing the plants to wither. A humidity level that is too dry can cause the plant to dry out, if the plant is at a wet humidity level but continues to water, the water content in tillandsia plants is excessive, causing the plant to wilt and rot. Tillandsia cannot tolerate direct sun exposure, but tillandsia plants still need light to survive. Tillandsia cultivators in carrying out plant care and maintenance are still classified as manual and monitoring must be carried out directly to determine the condition of the plant, to check the temperature and humidity are still checked visually, there is no specific data regarding the temperature and humidity. In the classification of tillandsia plants, we have to look at the condition of the plants manually based on the parameters of temperature and humidity. for various types of Tillandsia ornamental plants, the maintenance treatment is the same.

Based on these various problems, the author intends to design a tool in the field of communication technology by utilizing the Internet of Thing (IoT) Platform so that it can be monitored remotely by covering the cultivation of tillandsia ornamental plants in the Garneta garden Nursery, Mampang, Kec. Pancoran Mas, Depok

*name of corresponding author

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 6, Number 2, April 2022
DOI : https://doi.org/10.33395/sinkron.v7i2.11346
e-ISSN : 2541-2019
p-ISSN : 2541-044X

City with a land area of 480m2 in real time. Temperature and humidity data will be analyzed using a fuzzy algorithm. Then the system gives a callback to the actuator (relay on the water pump) to work so that the temperature and humidity reach the expected conditions stably so that the care and maintenance of tillandsia plants optimally and maintain the water content of tillandsia plants. The IoT concept can be applied to agriculture, both conventional agriculture and agriculture(Tajiri et al., 2017)

The purpose of this research is to design a system of "Monitoring Tools on Tillandsia Ornamental Plants" and implementation a temperature and humidity control system using the Fuzzy algorithm.

## LITERATURE REVIEW

Reviews of previous studies were obtained from the journal research results by Erfan Rohadi, et al. In 2017 which "Vegetable Plants Watering System" Aeroponics Based On Temperature And Humidity Based On Iot Using The Fuzzy Method "which resulted in the conclusion that an automatic plant watering system was successfully built consisting of a DHT22 sensor, the sensor module used to implement it was a 3rd generation Wi-Fi module named ESP8266. Information about high temperature then the longer the watering time. The highest temperature during the day is 33oC with low humidity level is 44%, then the longest duration of watering occurs under these conditions is 11 seconds. The results of this study are used as a reference in regulating information about the high temperature and duration of watering.

Journal of research results Saiful et al. in 2019 entitled "Design And Development Of Fire Detection And Fighting Systems On Smart Home Using The Fuzzy Method" shows that an automatic system by conducting fire simulations has been successfully built consisting of a DHT22 sensor, MQ-2 Smoke sensor, 5 Channel Fire Sensor as input and a water pump as output with esp8266 as a link to the internet by utilizing the Sugeno fuzzy logic control method with a system response of 15 trials, the average accuracy is 100%. (Saiful Anam et al., 2020) Journal of research results by Nurhasan et al. In 2018, entitled "Implementation of IoT in the Monitoring and Controlling System for Hydroponic Plant Water Circulation" succeeded in creating a system used for monitoring and controlling water circulation using a water pump in hydroponics automatically with fuzzy Sugeno through a website interface (Nurhasan et al., 2018)

## METHOD

### Block Diagram

Block Diagram system architecture consists of several sub-systems, which are as follows Plant Watering Control Sub System. The tillandsia plant control system was processed using the fuzzy Sugeno algorithm based on three data input from the NodeMCU ESP8266 Microcontroller sensor, namely: air temperature, air humidity, and light intensity shown in Fig 1 Block Diagram system architecture

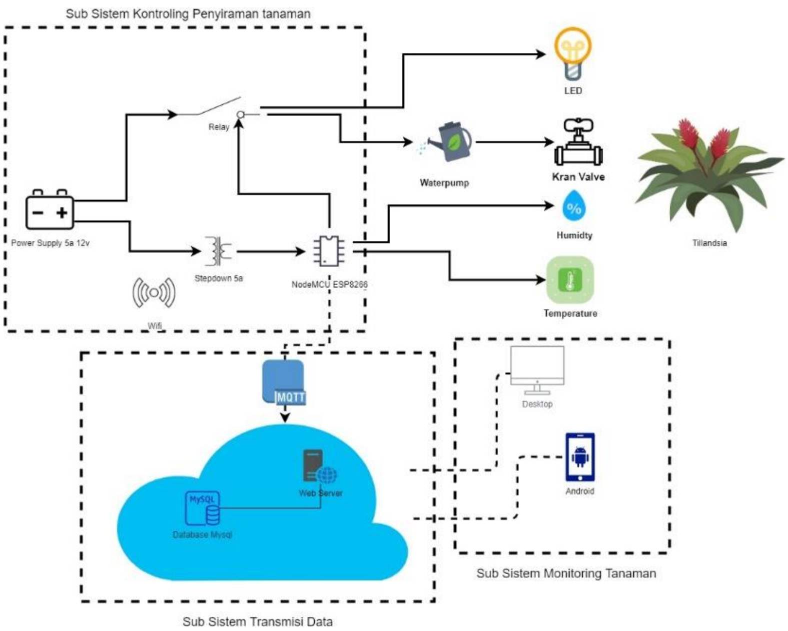


Fig 1. Block Diagram system architecture

*name of corresponding author

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 6, Number 2, April 2022
DOI : https://doi.org/10.33395/sinkron.v7i2.11346
e-ISSN : 2541-2019
p-ISSN : 2541-044X

The tillandsia plant watering control runs according to the Sugeno fuzzy algorithm with a pump power control output for digital commands via the relay board to turn the water pump off and on (watering using a hose with a nozzle at the end). Data Transmission Sub-System A data transmission system is a data exchange process in which microcontroller with Access Point as gateway and MQTT as communication protocol. Processed data will be stored into the web server database to be displayed in the monitoring system. • Tillandsia Plant Monitoring Sub System The tillandsia plant monitoring sub system displays data on air temperature, humidity, and intensity per time. Data communication is carried out between the NodeMCU ESP8266 and the website. Storage in MySQL database with PHP programming language.

**Research Stages**

This research aims to Temperature and humidity control system for the Fuzzy Sugeno method in controlling the on or off pump status uses input data of temperature, humidity, and light intensity that have been read using the DHT11 temperature & humidity sensor, BH1750 light sensor. The output of this method is in the form of control on the on or off status of the pump and UV lamp.

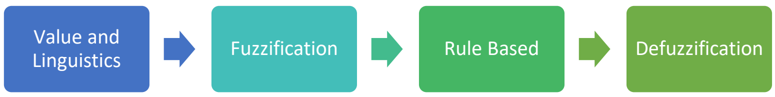


Fig 2. Research Stages

The following are the steps in the calculation of the Fuzzy Sugeno Method:

1. Value and Linguistics

   Linguistic value is a numerical interval that has linguistic values, whose semantics can be defined by the membership function. The linguistic value in this study can be seen in Table 1

Table 1. Linguistics value

| Variabel Value | Linguistic Value |
|---|---|
| Temperature | Cold, Normal, Hot |
| Humidity | Dry, Normal, Wet |
| Light Intensity | Dark, Light |
| Waterpump | Short, Medium, Long |
| Light status | On, Off |

2. Fuzzification

   The process is used to change the information from the input data from the sensor to the fuzzy linguistic set of data. Fuzzy Inference System is the key unit of a fuzzy logic system having decision making as its primary work. It uses the “IF…THEN” rules along with connectors “OR” or “AND” for drawing essential decision rules.

3. Rule Based

Rule Base is a rule that contains a number of fuzzy rules that map fuzzy input values to fuzzy output values. This rule is often expressed in the IF – THEN format. The rule is stated with a conditional statement: "If <fuzzy proportion> then <fuzzy proportion>". In Table 2 are the fuzzy rules used in this study.

Table 2. Rule Based

| Rule | Air Temperature | Air Humidity | Light Intensity | Light Status | Watering |
|---|---|---|---|---|---|
| **1** | Cold | Dry | Dark | ON | normal |
| **2** | Cold | Dry | Light | OFF | long |
| **3** | Cold | Normal | Dark | ON | normal |
| **4** | Cold | Normal | Light | OFF | normal |
| **5** | Cold | Wet | Dark | ON | fast |
| **6** | Cold | Wet | Light | OFF | fast |
| **7** | Normal | Dry | Dark | ON | normal |
| **8** | Normal | Dry | Light | OFF | long |
| **9** | Normal | Normal | Dark | ON | fast |
| **10** | Normal | Normal | Light | OFF | normal |

*name of corresponding author

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 6, Number 2, April 2022
DOI : https://doi.org/10.33395/sinkron.v7i2.11346
e-ISSN : 2541-2019
p-ISSN : 2541-044X

| | | | | | |
|---|---|---|---|---|---|
| **11** | Normal | Wet | Dark | ON | fast |
| **12** | Normal | Wet | Light | OFF | normal |
| **13** | Hot | Dry | Dark | ON | long |
| **14** | Hot | Dry | Light | OFF | long |
| **15** | Hot | Normal | Dark | ON | long |
| **16** | Hot | Normal | Light | OFF | normal |
| **17** | Hot | Wet | Dark | ON | fast |
| **18** | Hot | Wet | Light | OFF | fast |

4. Defuzzification

The last stage is defuzzification. Defuzification takes input in the form of predicate and z values for each rule. Defuzification is done by using an equation that calculates the value of the center of singleton, namely the sum of the multiplication between the membership value and the singleton value then divided by the total membership value. The result of defuzzification will determine the condition of the pump. The pump condition consists of ON or OFF.

$$Z* = \frac{\Sigma\mu_{c(z).(z)}}{\Sigma\mu_{c(z)}} \qquad (1)$$

$\bar{z}$ is a singleton value.

**Software Development Method**

In this study, the application design method used is the waterfall. The waterfall method is a sequential software development process, in which progress is seen as continuously flowing down (like a waterfall) through the phases of requirements analysis, design, implementation (construction), testing and maintenance.

**Analysis**

System requirements analysis is intended to describe the needs that must be provided by the system in order to meet user needs and in accordance with research objectives. This system design describes interface requirements, input data requirements and output data that shows the specifications of the system being run.
Functional requirements are types of requirements that contain processes or features that can be performed in an application. The process or feature in question is as follows monitor the conditions of temperature, humidity and light intensity in the prototype greenhouse, provide actions that must be taken on the condition of plants in the prototype greenhouse automatically and monitoring using the website dashboard
Non-Functional Needs Non-functional requirements are related to the ease of using the system or software by the user. The user interface on the system is made simple to make it easier for users (User Friendly).

**Tested**

Testing of this system will be carried out using the Black Box testing method. Black Box Testing or often known as functional testing is a software testing method used to test software without knowing the internal structure of the code or program. In this test, the tester is aware of what the program knowledge. (Peni Kurniawati, 2018) The things that are done in the testing of this system include several stages, Hardware and software testing, this test is carried out by running a plant condition monitoring system based on temperature, humidity, and light intensity in a cultivation greenhouse prototype system in the form of a mini greenhouse to determine the work of sensors and other devices so that sensor data can be processed well.

## RESULT

The implementation hardware design includes microcontroller circuits, sensors, relays and other devices interconnected run according to plan. The series of devices into one box containing the NodeMCU Sensor and Actuator. Sensor as input data for the system, then nodemcu with a relay that functions to turn on and off the water pump and led lights as actuators and 12v 5A power supply to provide voltage to the water pump and NodeMCU. and for led lights directly connected to 220v electricity.

In Fig 3 The system is made using a NodeMCU microcontroller. NodeMCU functions to read data from temperature, humidity and light intensity sensors. The NodeMCU circuit is connected to the DHT11 humidity temperature sensor and BH1750 sensor on a PCB (Printed Circuit Board). The NodeMCU requires 5V of power to run optimally using the XL4015 step down because the power is taken from the 12V 5A Power Supply. The

*name of corresponding author

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 6, Number 2, April 2022
DOI : https://doi.org/10.33395/sinkron.v7i2.11346
e-ISSN : 2541-2019
p-ISSN : 2541-044X

DHT11 sensor is connected to GPIO pin 14, ground pin and 3.3V power pin on nodemcu, while the BH1750 sensor is connected to GPIO 4 and GPIO 5 pins, ground pin and 3.3V power pin.

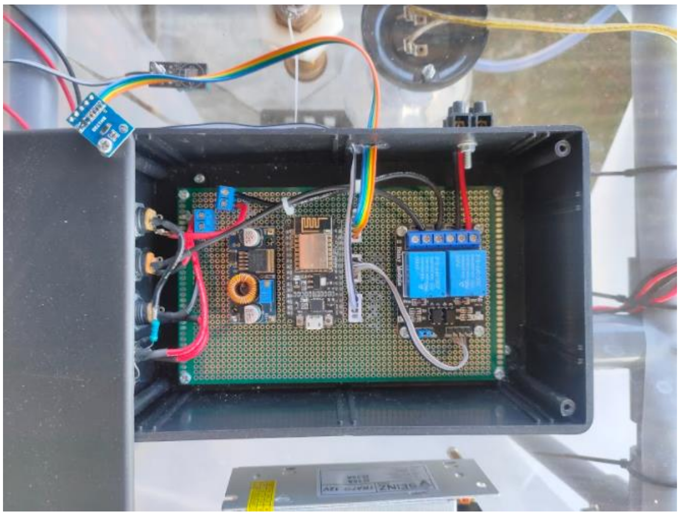

Fig 3. NodeMCU microcontroller

In Fig 4 The NodeMCU circuit is connected to a relay used to control the water pump and led lights. The 5V dual channel relay has 4 pins, namely the ground pin, the vcc pin, the IN1 pin and the IN2 pin. The relay is connected to the NodeMCU with pin ground to ground, pin vcc to vin, IN1 to GPIO 0 and IN2 to GPIO 2. The two relay slots are connected to two 12V water pumps powered by the power supply.

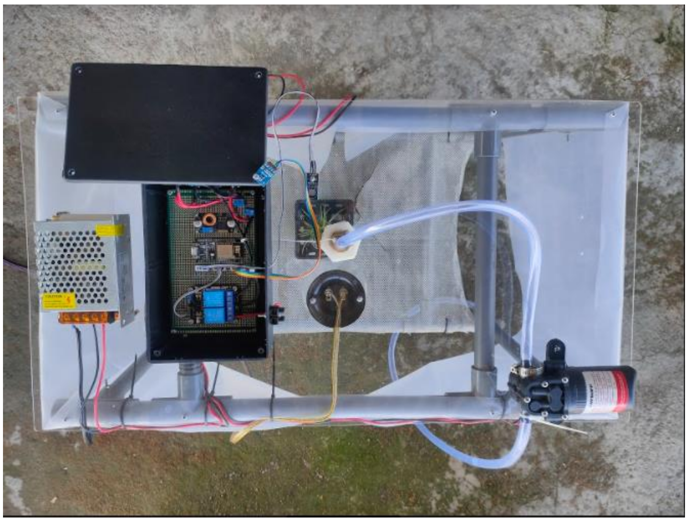

Fig 4. NodeMCU circuit

Result from the From the stages and methods that have been determined, the process's application at each stage.

a. Temperature and Humidity Sensor DHT11
   Testing the DHT11 Temperature and Humidity sensor through two stages, namelyfunctionality testing and temperature value testing. Functionality testingcan be seen in the test scenario as follows The test results on the DHT11 temperature sensor are compared withthe temperature value of the measurement results using a digital thermometer so thatobtained a comparison value between the two tools. Tests are carried out everyevery five minutes and carried out 7 times the experiment, so as to produce comparison as follows:

*name of corresponding author

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 6, Number 2, April 2022
DOI : https://doi.org/10.33395/sinkron.v7i2.11346
e-ISSN : 2541-2019
p-ISSN : 2541-044X

Table 3. DHT11, and termometer comparison

| No. | Sensor DHT11(ºC) | Termometer(ºC) | The calculation result MAPE (%) |
|---|---|---|---|
| 1. | 26 | 25.8 | 0.5 |
| 2. | 26 | 26.7 | 0.7 |
| 3. | 27 | 26.9 | 0.1 |
| 4. | 27 | 27.3 | 0.3 |
| 5. | 27 | 27.5 | 0.5 |
| 6. | 28 | 27.9 | 0.1 |
| 7. | 28 | 28.6 | 0.6 |
| | Average | | 0.4 |

The MAPE formula is obtained by the average error value between acquisition measurements DHT22 temperature sensor and digital thermometer is 0.4% from 7 times of testing.The results of digital thermometer measurements show the difference in temperature databigger. The range of the dht11 sensor has a range of up to 1 meter deepclosed room [13]

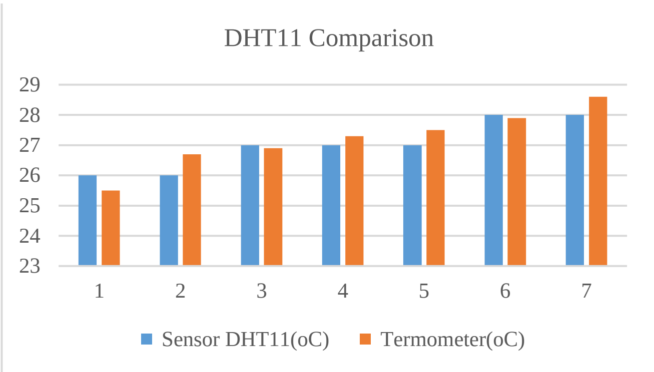


Fig 5. Chart DHT11 Sensor

From the comparison of temperature and humidity values using a temperature sensorDHT11 humidity and digital thermometers are measured 7 times so thatproduces an average error of 0.4%.

b. Light Sensor BH1750

BH1750 light sensor is used to capture intensity conditionslight from the prototype greenhouse that has been functioning properly, as evidenced bythe test results on the BH1750 light sensor obtained an average error levelof 0.83% which means the level of sensor measurement accuracy when comparedwith a light sensor digital lux meter, and the BH1750 light has high accuracypretty good. The test results are shown in the following graph for convenience analysis.

*name of corresponding author

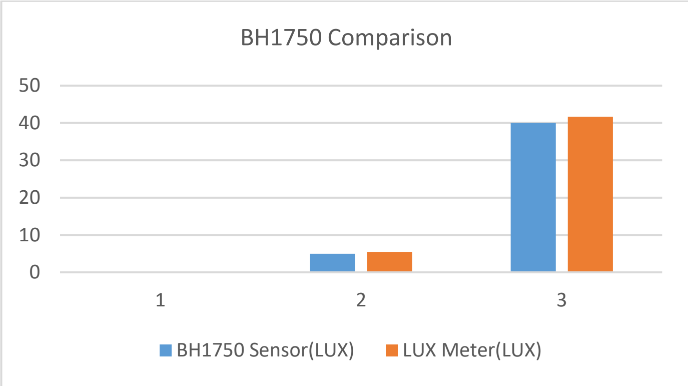

Fig 6. Chart BH1750 Sensor

From the comparison of light intensity values in Lux units usingBH1750 light sensor and digital Lux meter produce the lowest value rangeand the highest of the measurements are as follows:

Table 4. Comparison Table Light Sensor

| Light sensor measurement | Mark Lowest Test | Mark Highest Test |
|---|---|---|
| Lux Meter | 0 | 41,7 |
| BH1750 Sensor | 0 | 40 |

c. Databases

The results of testing the data input to the database have been successfully carried out without anyerror or data that does not enter the database. Insert data into databasecarried out after the Sugeno fuzzy calculation. The command data from each output read by NodeMCU isdefuzzification value of 1 to 3 which is the calculation of the time of watering agareasier to read in monitoring website.

d. Monitoring Website

Based on the planning and testing that has been done, the function. The main purpose of the website system is to display information on all the datahas been processed by NodeMCU. The data includes sensor data and condition statusoutputs. In addition to displaying output on the website, it is expected to be able to perform:control of the system actuators such as turning on the water pump and controllight. The results go according to plan so that the presentation of information can bedisplayed accurately and precisely.

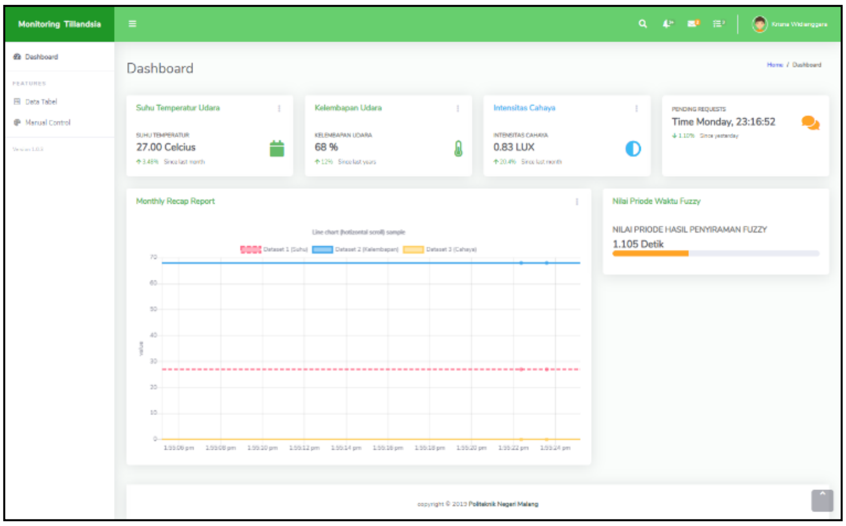

Fig 7. Dashboard Website Monitoring

*name of corresponding author

Here are pictures and tablescomparison of temperature, humidity, and light data read by the sensor withdata displayed on the monitoring website.

Table 5. Website Monitoring and DHT Sensor Comparison Table

| No. | NodeMCU | | Website | |
|---|---|---|---|---|
| | Temperature | Humidity | Temperatur | Humidity |
| 1. | 26 | 71 | 26 | 71 |
| 2. | 26 | 71 | 26 | 71 |
| 3. | 27 | 70 | 27 | 70 |
| 4. | 27 | 70 | 27 | 70 |
| 5. | 28 | 69 | 28 | 69 |
| 6. | 28 | 69 | 28 | 69 |

e. Fuzzy Method

In testing the Fuzzy Sugeno method, manual calculations through excel and calculations by the system on the monitoring website have implemented the Fuzzy Sugeno method. This test aims to compare the results of manual calculations with system calculations so that they can be used as benchmarks for success in implementing the Fuzzy Sugeno method. Tablecomparison of manual and system defuzzification results are as follows:

Table 6 Testing table Defuzzyficatioan and Actuator Output

| Temperature | Humidity | Light Intensity | Defuzzyfication | | Output | |
|---|---|---|---|---|---|---|
| | | | Light | Waterpump | Waterpump | Light |
| **25** | 73 | 5.41 | 1.0 | 1.0 | 1 | On |
| **23** | 73 | 30.32 | 0.5 | 1.0 | 1 | Off |
| **30** | 55 | 5.41 | 0.9 | 1.08 | 1 | On |
| **31** | 54 | 36.32 | 0.0 | 2.12 | 2 | Off |
| **41** | 40 | 5.41 | 0.9 | 3.0 | 3 | On |
| **41** | 40 | 33.32 | 0 | 3.0 | 3 | Off |

Based on the test results on the system response Fuzzy Sugeno . methodThe above shows the values of various conditions that arise in the range of values inVariable Water Pump AND Lights On starting from the deffuzification value 0 to1, variable Lamp On AND Water Pump Off from defuzzification value > 1until 2, variable Light Off AND Water Pump off from defuzzification value > 2up to 3.

f. Actuator

This test is carried out with the aim of knowing whether the series ofsystems from sensors to actuatorsthat are able to run as intendedexpected. The circuit is very important because every data that enters the system is very importantdatabase or data read from the database will be processed in a series.This actuatortest includes 2 existing outputs such as a water pump and a lamp.

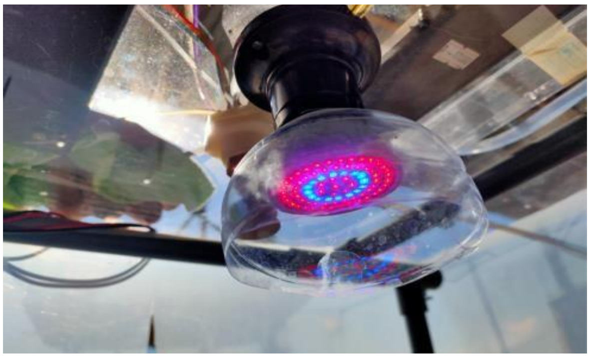

Fig 8. UV Lamp Actuator

*name of corresponding author

Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 6, Number 2, April 2022
DOI : https://doi.org/10.33395/sinkron.v7i2.11346
e-ISSN : 2541-2019
p-ISSN : 2541-044X

The test results of the actuator show that the circuit is capable ofcommunicates well without a short circuit and is in accordance with the rulesapplicable. This has been proven by testing every condition that has beenimplemented on the system. These conditions include the condition of the lights andthe water pump is on, the lights and the water pump are off and the lights are off and the water pump is off.The watering distance can reach 1-3m so that it can reach all plantsin the mini greenhouse . Besides that, the status on the network toosuccessfully displayed on the monitoring website in accordance with the conditions that occurred.The results of testing the system response are presented in the following table 7

Table 7. Condition and Actuator Testing

| Condition | Expected Output | | System Output | |
|---|---|---|---|---|
| | Waterpump | Light | Waterpump | Light |
| Cold AND Wet AND Dark | 1 second | ON | 1 second | ON |
| Normal AND Wet AND Light | 1 second | OFF | 1 second | OFF |
| Hot AND Normal AND Dark | 2 second | ON | 2 second | ON |
| Hot AND Normal AND Light | 2 second | OFF | 2 second | OFF |
| Hot AND Dry AND Dark | 3 second | ON | 3 second | ON |
| Hot AND Dry AND Light | 3 second | OFF | 3 second | OFF |

In this section, the researcher will explain the results of the research obtained. Researchers can also use images, tables, and curves to explain the results of the study. These results should present the raw data or the results after applying the techniques outlined in the methods section. The results are simply results; they do not conclude.

## DISCUSSIONS

The discussion section aims to describe the test results in more detail.This discussion includes a discussion of hardware and software testing as well asthe test results of the fuzzy Sugeno method. Tests carried out by simulating several conditions withchange the value of an existing variable in NodeMCU. Based on 6 timesThe test produces a system response value that matches the conditions on theFuzzy Sugeno method. The value of the defuzzification process from the calculation of the Fuzzy method Sugeno manually and system calculations yield the same value without difference. The calculation of the defuzzification produces several output values that arethe same but have different temperature and humidity conditions because the value ofthe condition is still within the specified set value range.

The concept of Internet of Things (IoT) has been successfully applied to domonitoring and controlling based on temperature, humidity, and intensitylight. The Fuzzy Sugeno method has been successfully applied to the controlling system(automation) to adjust the temperature, humidity, and light intensity on prototypes. The system can receive the result of the response or the output of the conditionthat happened. The system can detect several conditions which has been determined according to fuzzy rules. The system can provide response according to the conditions that occur. Based on the calculation results Sugeno fuzzy method manually or using a systemshow the same results so that it becomes a benchmark for successimplementation of the fuzzy Sugeno method. System response test results of 7 timesexperiments with different sensor data values show 100% resultsin accordance with the conditions in the Sugeno fuzzy method and without any outputwhich is not appropriate.

## CONCLUSION

From the overall results of the research that has been done, it can be drawnsome conclusions as follow as Design and build a monitoring and controlling system for temperature, humidity, andlight intensity was successful. The system uses a scalable prototypemini greenhouse which is used as an object for monitoring temperature, humidity, and light intensity. Thus, future research is needed extra module for simcard used to backup if the internet connection dies.

## REFERENCES

Arianto, R., Gaol, F. L., Abdurachman, E., Heryadi, Y., Warnars, H. L. H. S., Soewito, B., & Perez-Sanchez, H. (2017). Quality measurement of android messaging application based on user experience in microblog. *Proceedings - 2017 International Conference on Applied Computer and Communication Technologies, ComCom 2017, 2017-January*. https://doi.org/10.1109/COMCOM.2017.8167099

*name of corresponding author

SinkrOn
JURNAL & PENELITIAN TEKNIK INFORMATIKA
Sinkron : Jurnal dan Penelitian Teknik Informatika
Volume 6, Number 2, April 2022
DOI : https://doi.org/10.33395/sinkron.v7i2.11346
e-ISSN : 2541-2019
p-ISSN : 2541-044X

Cahyaningtiyas, R., Arianto, R., & Yosrita, E. (2017). Fingerprint for automatic Door integrated with Absence and User Access. *2016 International Symposium on Electronics and Smart Devices, ISESD 2016*. https://doi.org/10.1109/ISESD.2016.7886686

Gandha, G. I., & Nurcipto, D. (2018). Fuzzy PID Algorithm-Based External Carbon Controller for Denitrification Process Enhancement in Wastewater Treatment Plant. *JURNAL INFOTEL*, *10*(4). https://doi.org/10.20895/infotel.v10i4.407

Gunawan, W., & Arifin, A. Z. (2017). Lokal Fuzzy Thresholding Berdasarkan Pengukuran Fuzzy Similarity Pada Interaktif Segmentasi Citra Panoramik Gigi. *JURNAL INFOTEL*, *9*(1). https://doi.org/10.20895/infotel.v9i1.162

Legino, S., & Arianto, R. (2018). Solving large scale unit dilemma in electricity system by applying commutative law. *Journal of Physics: Conference Series*, *974*(1). https://doi.org/10.1088/1742-6596/974/1/012037

Nurhasan, U., Prasetyo, A., Lazuardi, G., Rohadi, E., & Pradibta, H. (2018). Implementation IoT in System Monitoring Hydroponic Plant Water Circulation and Control. *International Journal of Engineering & Technology*, *7*(4.44). https://doi.org/10.14419/ijet.v7i4.44.26965

Permana, F. H., Nurwidodo, N., Chamisijatin, L., Zaenab, S., Pantiwati, Y., & Sulistiarini, D. (2020). PEMBELAJARAN KLASIFIKASI KLADOGRAM DENGAN METODE TAKSIMETRI UNTUK MEMPELAJARI KEKERABATAN TANAMAN GENUS TILLANDSIA & NEOREGELIA. *JINoP (Jurnal Inovasi Pembelajaran)*, *6*(1). https://doi.org/10.22219/jinop.v6i1.7084

Rochman, H. A., Primananda, R., & Nurwasito, H. (2017). Sistem Kendali Berbasis Mikrokontroler Menggunakan Protokol MQTT pada Smarthome. *Jurnal Pengembangan Teknologi Informasi Dan Ilmu Komputer*, *1*(6).

Rohadi, E., Apriyani, M. E., & Laili, N. H. (2019). Sistem Penyiraman Tanaman Sayur secara Aeroponik Berdasarkan Suhu dan Kelembapan Berbasis Iot Menggunakan Metode Fuzzy. *Jurnal Informatika Polinema*, *5*(2).

Saiful Anam, Indra Dharma Wijaya, & Ridwan Rismanto. (2020). RANCANG BANGUN SISTEM DETEKSI DAN PEMADAM KEBAKARAN PADA SMART HOME MENGGUNAKAN METODE FUZZY. *Jurnal Informatika Polinema*, *6*(4). https://doi.org/10.33795/jip.v6i4.298

Shleeg, A. A., & Ellabib, I. M. (2013). Comparison of Mamdani and Sugeno Fuzzy Interference Systems for the Breast Cancer Risk. *International Journal of Computer, Electrical, Automation, Control and Information Engineering*, *7*(10).

Tajiri, R., Ogawa, N., Fujiwara, H., & Kojima, T. (2017). Mechanical Control of Whole Body Shape by a Single Cuticular Protein Obstructor-E in Drosophila melanogaster. *PLoS Genetics*, *13*(1). https://doi.org/10.1371/journal.pgen.1006548

Verma, O., & Gupta, H. (2012). Fuzzy Logic Based Water Bath Temperature Control System. *International Journal*, *2*(4).

Yuhefizar, Y., Nasution, A., Putra, R., Asri, E., & Satria, D. (2019). Alat Monitoring Detak Jantung Untuk Pasien Beresiko Berbasis IoT Memanfaatkan Aplikasi OpenSID berbasis Web. *Jurnal RESTI (Rekayasa Sistem Dan Teknologi Informasi)*, *3*(2). https://doi.org/10.29207/resti.v3i2.974

*name of corresponding author