Identitas Paper

Paper ID	Access-2022-34032
Judul Paper	Tsukamoto Fuzzy Inference System on Internet of Things-Based for Room Temperature and Humidity Control
Authors	SUNARDI, Anton Yudhana, Furizal*
Jurnal	IEEE Access
Penerbit	Institute of Electrical and Electronics Engineers Inc.
Negara	United States
Quartile dan SJR	Scopus Q1, SJR 0.93 https://www.scimagojr.com/journalsearch.php?q=21100374601&tip=sid&clean=0
Terbit	Vol 11 January 2023 pp 6209-6227
Link Paper	https://ieeexplore.ieee.org/document/10015014

Proses Pengelolaan Paper

Tahap	Tanggal	Proses/Aktivitas
1	15 September 2022	Submission
2	30 September 2022	Rejected, allow to resubmit
3	26 December 2022	Resubmit
4	05 January 2023	Accepted with minor revision
5	09 January 2023	Final Files Submitted
6	24 January 2023	Published

			Sep-22				Oct-22				Nov-22				Dec-22				Jan-23				Feb-23			
	Quartile	SJR	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
IEEE	Q1	0.93		15		30												26	5	9		24				

Bukti Korespondensi

Tahap 1
Submit Paper, 15 September 2022

IEEE Access - Manuscript ID Access-2022-24934 External Inbox ×

IEEE Access <onbehalfof@manuscriptcentral.com> Thu, Sep 15, 2022, 11:53 AM
to furizal1999, me, eyudhana

15-Sep-2022

Dear Mr. Furizal:

Your manuscript entitled "Tsukamoto Fuzzy Inference System on Internet of Things-Based Room Temperature and Humidity Control" has been successfully submitted online and is presently being given full consideration for publication in IEEE *Access*.

As a reminder, IEEE *Access* is a fully open access journal. Open Access provides unrestricted access to published articles via IEEE *Xplore*. In lieu of paid subscriptions, authors are required to pay an article processing charge of $1,850 (plus applicable local taxes) after the article has been accepted for publication.

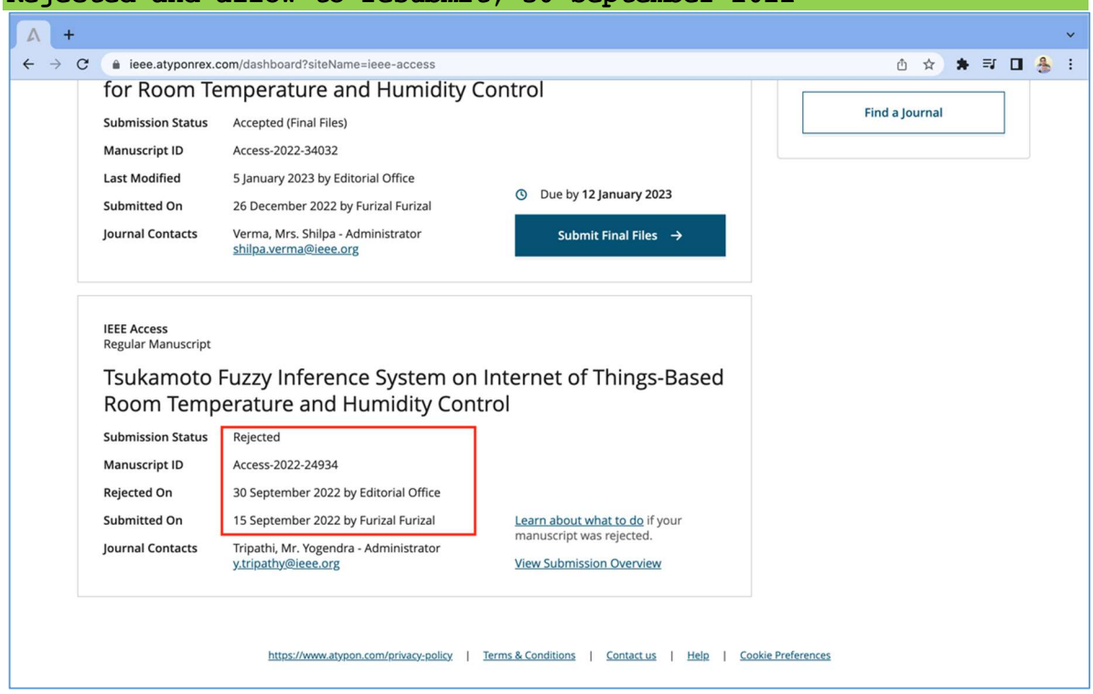
Your manuscript ID is Access-2022-24934. Please mention the manuscript ID in all future correspondence to the IEEE *Access* Editorial Office. Submitting authors can also view the manuscript status at any time by checking their author dashboard on the IEEE Author Portal.

Thank you again for submitting your manuscript to IEEE *Access*.

Sincerely,

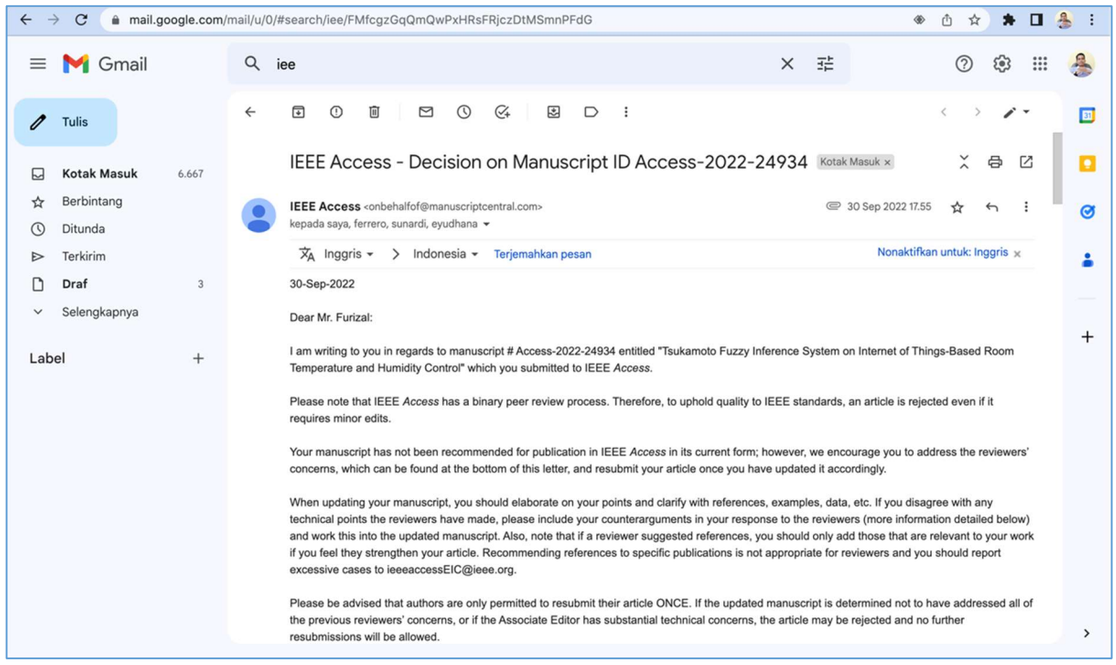
IEEE *Access* Editorial Office

Tahap 2
Rejected and allow to resubmit, 30 September 2022



Decision of Rejected with major revision: 30 September 2022

Pada submission yang bertama ini, manuscript ditolak karena membutuhkan major revision. Namun, IEEE Access tetap memberikan kesempatan pada Author untuk melakukan resubmit setelah major revision selesai diperbaiki



Review Comments

This paper covers the required structure in terms of headings and paper body. Basic concepts used in the paper are covered smartly. The research idea covered in the paper is a good contribution and is supported by results and a solid base of fuzzy inference system. However, literature review is missing in the paper and details about the research implementation are not sufficient. Graphical results can be added to improver the manuscript. Following are some concerns regarding this manuscript. 1. Authors have not provided literature review regarding their research work. Authors are suggested to provide a literature review of the related environment control systems. 2. Authors have not discussed related IoT technology and its use in the introduction part. 3. For equation 1 what about boundary values as for one condition x ≤ a and a ≤ x what value will be assumed in case of x=a, similar case for variable b and c. author have to justify these boundary conditions. 4. Authors are suggested to provide fuzzy rules they have mastered for their system. 5. Research stage image is not clear. Authors are suggested to discuss the steps mentioned in the research stage image. 6. Authors have not discussed what happens if the mobile application fails to response. In this case the fuzzy base control mechanism built into the fan will be working or fails. 7. There should be results and comparison section, or at least author have to show the effect of humidity and temperature on fan speed graphically rather than providing a simple and lengthy values table. 8. Authors have not discussed dimensions of the test case room in the implementations of the system. Authors are suggested to provide related measures of the room. 9. What happens if location of sensors is changed in the room. What would be the results. 10. Authors are also suggested to provide after effects of the system. i.e., when the fan speed was increased by their system how long it takes to reduce the room temperature. 11. Authors are suggested to provide some statistics or graphs regarding success measure. How many times system responded as per requirements and on the other way

Email Rejected dengan Major Revision (FULL)

30-Sep-2022

Dear Mr. Furizal:

I am writing to you in regards to manuscript # Access-2022-24934 entitled "Tsukamoto Fuzzy Inference System on Internet of Things-Based Room Temperature and Humidity Control" which you submitted to IEEE *Access*.

Please note that IEEE *Access* has a binary peer review process. Therefore, to uphold quality to IEEE standards, an article is rejected even if it requires minor edits.

Your manuscript has not been recommended for publication in IEEE *Access* in its current form; however, we encourage you to address the reviewers' concerns, which can be found at the bottom of this letter, and resubmit your article once you have updated it accordingly.

When updating your manuscript, you should elaborate on your points and clarify with references, examples, data, etc. If you disagree with any technical points the reviewers have made, please include your counterarguments in your response to the reviewers (more information detailed below) and work this into the updated manuscript. Also, note that if a reviewer suggested references, you should only add those that are relevant to your work if you feel they strengthen your article. Recommending references to specific publications is not appropriate for reviewers and you should report excessive cases to ieeeaccessEIC@ieee.org.

Please be advised that authors are only permitted to resubmit their article ONCE. If the updated manuscript is determined not to have addressed all of the previous reviewers' concerns, or if the Associate Editor has substantial technical concerns, the article may be rejected and no further resubmissions will be allowed.

When resubmitting, please submit as a new manuscript via our submission site, the IEEE Author Portal, and include the following 3 files:

1) A document containing your response to reviewers from the previous peer review. The "response to reviewers" document (template attached) should have the following regarding each comment: a) Reviewer's concern, b) your response to the concern, c) your action to remedy the concern. The document should be uploaded with your manuscript files as a "*Supplementary Material for Review*."

2) Your updated manuscript with all your individual changes highlighted, including grammatical changes (e.g. preferably with the yellow highlight tool within the pdf file). This file should be uploaded with your manuscript files as a "*Supplementary Material for Review*."

3) A clean copy of the final manuscript (without highlighted changes) submitted as a Word or LaTeX file, and as a PDF, both submitted as the "*Main Manuscript*."

****IMPORTANT:** Please see the attached Resubmission Checklist that details all the items listed above. Please utilize this checklist to ensure you have made the necessary edits to your manuscript, and to ensure you have all the necessary files prepared prior to resubmission.

We sincerely hope you will update your manuscript and resubmit soon. Please contact me if you have any questions.

Thank you for your interest in IEEE *Access*.

Sincerely,

Dr. Renato Ferrero

Associate Editor, IEEE *Access*
ferrero@ieee.org

Reviewers' Comments to Author:

Reviewer: 1

Recommendation: Reject (updates required before resubmission)

Comments:
The concept and idea of the paper is good but the author should update and give support to the following segments of the paper which have been pointed out by the reviewer during review.
1. The author has mentioned the this system will be developed using flutter framework but have not given the cycle of development using this framework. Kindly Explain the cycle of development using flutter framework in detail?
2. The country where this device will be implemented is economically not stable where electricity load shedding is at peak.
Can the author justified that how his wireless controlled system will store the cache of his pre-updated timers etc during load shedding?
3. The author has mentioned many mathematical equations which are not illustrated in detail that how and where it would be applicable during the execution of this system?

Additional Questions:
1) Does the paper contribute to the body of knowledge?: Yes, this paper is well composed and is relevant to the body of the knowledge.

2) Is the paper technically sound?: Some sections in this paper needs more focus of the author. For example, the author has mentioned mathematical equations but he doesn't elaborated each equation in detail like how it will be applied on the proposed IoT system.

3) Is the subject matter presented in a comprehensive manner?: No, It needs detailed revision of the author.

4) Are the references provided applicable and sufficient?: Yes, the references provided by the author is latest and relevant to paper subject.

5) Are there references that are not appropriate for the topic being discussed?: No

5a) If yes, then please indicate which references should be removed.:

Reviewer: 2

Recommendation: Reject (updates required before resubmission)

Comments:
This paper covers the required structure in terms of headings and paper body. Basic concepts used in the paper are covered smartly. The research idea covered in the paper is a good contribution and is supported by results and a solid base of fuzzy inference system. However, literature review is missing in the paper and details about the research implementation are not sufficient. Graphical results can be added to improver the manuscript.
Following are some concerns regarding this manuscript.
1. Authors have not provided literature review regarding their research work.

Authors are suggested to provide a literature review of the related environment control systems.
2. Authors have not discussed related IoT technology and its use in the introduction part.
3. For equation 1 what about boundary values as for one condition $x \leq a$ and $a \leq x$ what value will be assumed in case of $x=a$, similar case for variable b and c, author are suggested to justify these boundary conditions.
4. Authors are suggested to provide fuzzy rules they have mastered for their system.
5. Research stage image is not clear. Authors are suggested to discuss the steps mentioned in the research stage image.
6. Authors have not discussed what happens if the mobile application fails to response. In this case the fuzzy base control mechanism built into the fan will be working or fails.
7. There should be results and comparison section, or at least author have to show the effect of humidity and temperature on fan speed graphically rather than providing a simple and lengthy values table.
8. Authors have not discussed dimensions of the test case room in the implementations of the system. Authors are suggested to provide related measures of the room.
9. What happens if location of sensors is changed in the room. What would be the results.
10. Authors are also suggested to provide after effects of the system. i.e., when the fan speed was increased by their system how long it takes to reduce the room temperature.
11. Authors are suggested to provide some statistics or graphs regarding success measure. How many times system responded as per requirements and on the other way.

Additional Questions:
1) Does the paper contribute to the body of knowledge?: Yes, Their idea and research work is attractive and useful.

2) Is the paper technically sound?: No, it is required to provide some related work and details or their implementation work.

3) Is the subject matter presented in a comprehensive manner?: No, the paper summarizes every aspect even their research implementation and results are not explained properly.

4) Are the references provided applicable and sufficient?: Yes, but some related work regarding room environment control systems needed to be presented.

5) Are there references that are not appropriate for the topic being discussed?: No

5a) If yes, then please indicate which references should be removed.:

Reviewer: 3

Recommendation: Reject (updates required before resubmission)

Comments:
The paper presents a Room Temperature and Humidity Control IoT based system. The paper shows clearly the steps of designing and implementing the system. But, the work is missing the benchmarking of the solution compared to other

existing solutions. A comparative study based on specific parameters (precision, standard indicators, energy consumption...) should be presented and discussed.
The impact of fuzzy logic was not well analyzed and the author didn't show its advantage compared to existing similar application. Thus, the analysis and discussion part should be elaborated further.
No need to mention extra references about IoT because the work does not discuss the IoT architecture of the solution.
Table 3 is to be removed. no need to publish the data collection databases, instead I would recommend to use graphs and discuss the important results that you get from those data

Additional Questions:
1) Does the paper contribute to the body of knowledge?: Minor Contribution

2) Is the paper technically sound?: The technical strength of the paper is average. The literature review doesn't provide sufficient background and motivation for the work. The theoretical/experimental depth, strength of analysis, quality of supporting data and results are not well developed. The benchmarking and the validation of the solution are missing, which makes the result analysis so limited.

3) Is the subject matter presented in a comprehensive manner?: Yes, but depth is missing.

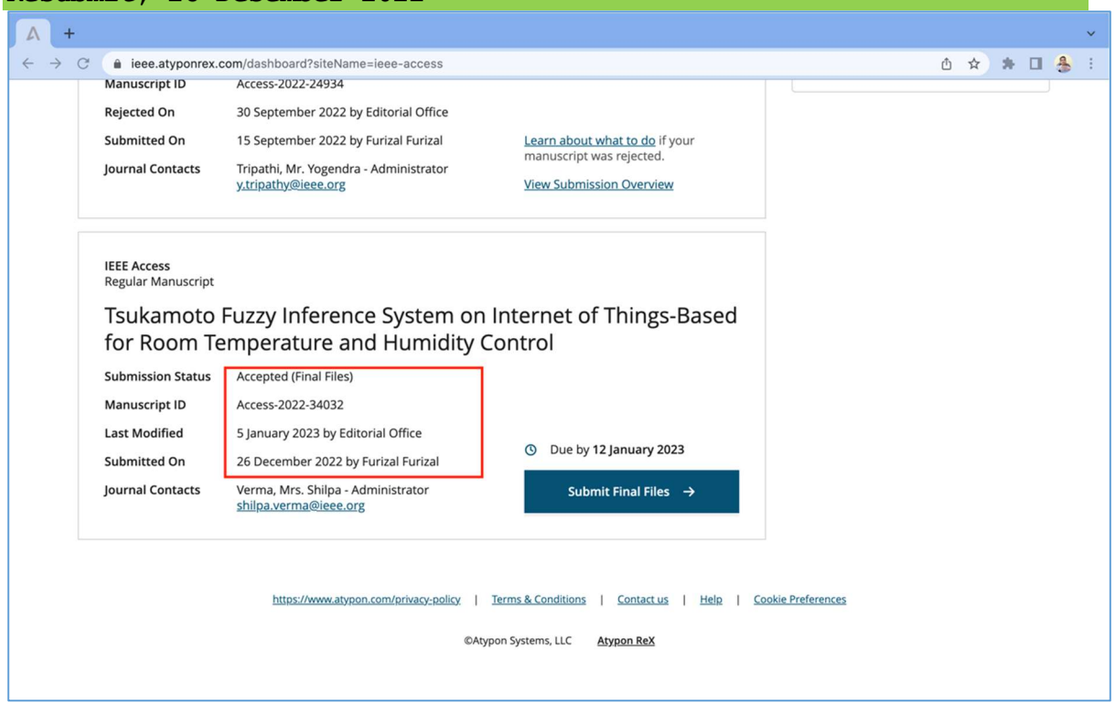
4) Are the references provided applicable and sufficient?: I think the author have used good references basically relevant papers to the Fuzzy logic fundamentals. Although the benchmarking of existing solutions could be better

5) Are there references that are not appropriate for the topic being discussed?: Yes

5a) If yes, then please indicate which references should be removed.: [10] W. Li, C. Yen, Y. Lin, S. Tung, and S. Huang, “Proceedings - 2019 IEEE International Conference on Smart Manufacturing, Industrial and Logistics Engineering, SMILE 2019,” Proc. - 2019 IEEE Int. Conf. Smart Manuf. Ind. Logist. Eng. SMILE 2019, pp. 43–47, 2019.
[11] K. Khujamatov, E. Reypnazarov, D. Khasanov, and N. Akhmedov, “Networking and Computing in Internet of Things and Cyber-Physical Systems,” 14th IEEE Int. Conf. Appl. Inf. Commun. Technol. AICT 2020 - Proc., 2020, doi: 10.1109/AICT50176.2020.9368793.
[12] I. Zhou et al., “Internet of Things 2.0: Concepts, Applications, and Future Directions,” IEEE Access, vol. 9, pp. 70961–71012, 2021, doi: 10.1109/ACCESS.2021.3078549.
[13] N. N. Misra, Y. Dixit, A. Al-Mallahi, M. S. Bhullar, R. Upadhyay, and A. Martynenko, “IoT, Big Data, and Artificial Intelligence in Agriculture and Food Industry,” IEEE Internet Things J., vol. 9, no. 9, pp. 6305–6324, 2022, doi: 10.1109/JIOT.2020.2998584.

If you have any questions, please contact article administrator: Mr. Yogendra Tripathi y.tripathy@ieee.org

Tahap 3
Resubmit, 26 Desember 2022



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Manuscript ID	Access-2022-24934
Rejected On	30 September 2022 by Editorial Office
Submitted On	15 September 2022 by Furizal Furizal
Journal Contacts	Tripathi, Mr. Yogendra - Administrator y.tripathy@ieee.org

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IEEE Access
Regular Manuscript

Tsukamoto Fuzzy Inference System on Internet of Things-Based for Room Temperature and Humidity Control

Submission Status	Accepted (Final Files)
Manuscript ID	Access-2022-34032
Last Modified	5 January 2023 by Editorial Office
Submitted On	26 December 2022 by Furizal Furizal
Journal Contacts	Verma, Mrs. Shilpa - Administrator shilpa.verma@ieee.org

Due by **12 January 2023**

Submit Final Files →

Original Manuscript ID: Access-2022-24934
Original Article Title: " Tsukamoto Fuzzy Inference System on Internet of Things-Based Room Temperature and Humidity Control**"**

To: IEEE Access Editor
Re: Response to reviewers

Dear Editor,

Thank you for allowing a resubmission of our manuscript, with an opportunity to address the reviewers' comments.
We are uploading (a) our point-by-point response to the comments (below) (response to reviewers), (b) an updated manuscript with yellow highlighting indicating changes (*Supplementary Material for Review*), and (c) a clean updated manuscript without highlights (*Main Manuscript).*

Best regards,
Sunardi, Anton Yudhana, and Furizal

Reviewer#1, Concern # 1: The author has mentioned the this system will be developed using flutter framework but have not given the cycle of development using this framework. Kindly Explain the cycle of development using flutter framework in detail?

Author response: Revised

Author action: We updated the manuscript by adding the app development life cycle included with the image. Changes to the text have been highlighted in yellow.

Reviewer#1, Concern # 2: The country where this device will be implemented is economically not stable where electricity load shedding is at peak. Can the author justified that how his wireless controlled system will store the cache of his pre-updated timers etc during load shedding?

Author response: Revised

Author action: We updated the manuscript by adding an explanation that the tools built in this study will still be able to access the data again after the data source is turned off because the data will still be permanently stored in the firebase database. The results of changes to the manuscript are listed in the experimental results and have been given a yellow highlight.

Reviewer#1, Concern # 3: The author has mentioned many mathematical equations which are not illustrated in detail that how and where it would be applicable during the execution of this system?

Author response: Revised

Author action: We updated the manuscript by providing an explanation regarding what each equation is used for. The explanation that we have added is in the form of placing the use of equations at each fuzzy stage (not calculation) listed before table 3. We have given changes to the text with yellow highlights.

Reviewer#1, Concern Additional # 1: Does the paper contribute to the body of knowledge?: Yes, this paper is well composed and is relevant to the body of the knowledge.

Author response: -

Author action: -

Reviewer#1, Concern Additional # 2: Is the paper technically sound?: Some sections in this paper needs more focus of the author. For example, the author has mentioned mathematical equations but he doesn't elaborated each equation in detail like how it will be applied on the proposed IoT system.

Author response: Revised

Author action: We updated the text by providing an explanation regarding what each equation is used for. The explanation that we have added is in the form of placing the use of equations at each fuzzy stage (not calculation) listed before table 3. Apart from that, we have also added many additions from previous submissions. Changes to the script have been given a yellow highlight.

Reviewer#1, Concern Additional # 3: Is the subject matter presented in a comprehensive manner?: No, It needs detailed revision of the author.

Author response:

Author action: We updated the manuscript with a more detailed revision. All revisions have been given a yellow highlight.

Reviewer#1, Concern Additional # 4: Are the references provided applicable and sufficient?: Yes, the references provided by the author is latest and relevant to paper subject.

Author response: -

Author action: -

Reviewer#1, Concern Additional # 5: Are there references that are not appropriate for the topic being discussed?: No
5a) If yes, then please indicate which references should be removed.:
Author response: -
Author action: -

Reviewer#2, Concern # 1: Authors have not provided literature review regarding their research work. Authors are suggested to provide a literature review of the related environment control systems.
Author response: Revised
Author action: We updated the manuscript by adding a literature study in the introduction. The additional literature study comes from several previous studies related to the research conducted in this paper, which is related to the room control system. The results of the update have been highlighted in yellow.

Reviewer#2, Concern # 2: Authors have not discussed related IoT technology and its use in the introduction part.
Author response: Revised
Author action: We updated the manuscript by adding a few paragraphs of discussion about IoT in the introduction section. The results of the update have been highlighted in yellow.

Reviewer#2, Concern # 3: For equation 1 what about boundary values as for one condition $x \leq a$ and $a \leq x$ what value will be assumed in case of x=a, similar case for variable b and c, author are suggested to justify these boundary conditions.
Author response: Revised
Author action: We updated the manuscript by changing the triangular curve equation error in the main text. Revision results have been highlighted in yellow.

Reviewer#2, Concern # 4: Authors are suggested to provide fuzzy rules they have mastered for their system.
Author response: Revised
Author action: We update the manuscript by adding fuzzy rules in this study, which total 25 rules formed from two input components and each input component has five fuzzy sets. The revised results have been highlighted in yellow.

Reviewer#2, Concern # 5: Research stage image is not clear. Authors are suggested to discuss the steps mentioned in the research stage image.
Author response: Revised
Author action: We updated the manuscript and improved the research stage drawings. After that, each stage in the picture has been explained in detail. The revised results have been highlighted in yellow.

Reviewer#2, Concern # 6: Authors have not discussed what happens if the mobile application fails to response. In this case the fuzzy base control mechanism built into the fan will be working or fails.
Author response: Revised
Author action: We update the script by testing a mobile application that is built against the response of a tool that has applied fuzzy logic. The application is tested by trying the application's response when obtaining a poor, stable network connection, and when the network is not connected. The revised results have been highlighted in yellow.

Reviewer#2, Concern # 7: There should be results and comparison section, or at least author have to show the effect of humidity and temperature on fan speed graphically rather than providing a simple and lengthy values table.
Author response: Revised
Author action: We updated the script showing the influence of humidity and temperature on fan speed graphically. Meanwhile, for tables with 100 data previously changed to less, namely 20 data. This data is a form or example of input and output generated from a fuzzy system.

Reviewer#2, Concern # 8: Authors have not discussed dimensions of the test case room in the implementations of the system. Authors are suggested to provide related measures of the room.
Author response: Revised
Author action We updated the script by adding an image showing the position of the sensors along with the size of the test chamber. The measurement results for each sensor position are listed in the main text with the measurement graph included. The revised results have been highlighted in yellow.

Reviewer#2, Concern # 9: What happens if location of sensors is changed in the room. What would be the results.
Author response: Revised
Author action: We updated the manuscript by conducting experiments at 3 sensor positions. Shows that the difference in sensor location affects the sensor reading of the temperature in the room. More details have been stated in the main text. The revised results have been highlighted in yellow.

Reviewer#2, Concern # 10: Authors are also suggested to provide after effects of the system. i.e., when the fan speed was increased by their system how long it takes to reduce the room temperature.
Author response: Revised
Author action: We updated the script with effect after the system was applied. Tests that have been carried out at the three fan positions show that the temperature will change if the fan is installed. Based on several tests carried out, temperature changes do not move down but move up. The explanation is already available in the main manuscript. The results of the revision have been given a yellow highlight.

Reviewer#2, Concern # 11: Authors are suggested to provide some statistics or graphs regarding success measure. How many times system responded as per requirements and on the other way.
Author response: Revised
Author action: We update the manuscript by providing a graph of the measurement of the fuzzy effect of the fan on the room. However, the measurement results are not in line with research expectations, so the authors suggest using an air conditioner or exhaust fan as a means of controlling room temperature.

Reviewer#2, Concern Additional # 1: Does the paper contribute to the body of knowledge?: Yes, Their idea and research work is attractive and useful.
Author response: -
Author action: -

Reviewer#2, Concern Additional # 2: Is the paper technically sound?: No, it is required to provide some related work and details or their implementation work.
Author response: Revised
Author action: We updated the script providing some work and related details or implementation work. In the main manuscript, we have added the results of the implementation and testing of mobile applications and tools built. The revised results of the manuscript have been given a yellow highlight.

Reviewer#2, Concern Additional # 3: Is the subject matter presented in a comprehensive manner?: No, the paper summarizes every aspect even their research implementation and results are not explained properly.
Author response: Revised
Author action: We updated the manuscript to provide a more detailed breakdown of the previous one. We have added room dimensions, mobile and IoT application test results, provided graphs of measurement results while the fan was turned on in the test room and several other changes. Changes to the main manuscript have been given yellow highlights.

Reviewer#2, Concern Additional # 4: Are the references provided applicable and sufficient?: Yes, but some related work regarding room environment control systems needed to be presented.
Author response: Revised
Author action: We update the manuscript by providing literature studies from several previous studies related to this research. The results of changes to the manuscript have been given a yellow highlight.

Reviewer#2, Concern Additional # 5: Are there references that are not appropriate for the topic being discussed?: No
5a) If yes, then please indicate which references should be removed.:
Author response: -
Author action: -

Reviewer#3, Concern # 1: The paper presents a Room Temperature and Humidity Control IoT based system. The paper shows clearly the steps of designing and implementing the system.
But, the work is missing the benchmarking of the solution compared to other existing solutions. A comparative study based on specific parameters (precision, standard indicators, energy consumption...) should be presented and discussed.
Author response: Revised
Author action: We updated the manuscript by adding a literature study in the introduction section and adding sensor calibration with a standard thermometer indicator tool in the research results section.

Reviewer#3, Concern # 2: The impact of fuzzy logic was not well analyzed and the author didn't show its advantage compared to existing similar application. Thus, the analysis and discussion part should be elaborated further.
Author response: Revised
Author action: We updated the manuscript to provide the results of temperature measurements after use of the device. But the fuzzy results don't really have an impact on room temperature. Fuzzy can indeed provide a speed according to room conditions. However, the use of fans does not have a good effect, so in future research the authors suggest changing the device to an air conditioner or exhaust fan.

Reviewer#3, Concern # 3: No need to mention extra references about IoT because the work does not discuss the IoT architecture of the solution.
Author response: Revised
Author action: We updated the manuscript by providing a more detailed explanation regarding IoT, because according to **Reviewer#2 Concern#2**'s comments asked to discuss IoT technology and its use in the introduction section. The results of changes to the manuscript have been given a yellow highlight.

Reviewer#3, Concern # 4: Table 3 is to be removed. no need to publish the data collection databases, instead I would recommend to use graphs and discuss the important results that you get from those data.

Author response: Revised

Author action: We updated the manuscript by removing 80/100 data previously available in the manuscript. The remaining data in the script becomes 20 data to provide an overview of the input and output forms generated in the fuzzy system. While the results of temperature measurements have been made in graphical form. Measurements were made after the fuzzy system was applied to the test room. Submission changes have been highlighted in yellow.

Reviewer#3, Concern Additional # 1: Does the paper contribute to the body of knowledge?: Minor Contribution.

Author response: -

Author action: -

Reviewer#3, Concern Additional # 2: Is the paper technically sound?: The technical strength of the paper is average. The literature review doesn't provide sufficient background and motivation for the work. The theoretical/experimental depth, strength of analysis, quality of supporting data and results are not well developed. The benchmarking and the validation of the solution are missing, which makes the result analysis so limited.

Author response: Revised

Author action: We update the manuscript by providing a literature review of several previous studies. Theoretical depth has been deepened from previous submissions. We did our experiment by testing the results by testing the tool by placing sensors in three places. In addition, the mobile application has also been tested to ensure that the application can control the device properly. In addition, we have also added a measurement chart and a conclusion from measurements. The results of changes to the script have been given a yellow highlight.

Reviewer#3, Concern Additional # 3: Is the subject matter presented in a comprehensive manner?: Yes, but depth is missing.

Author response: Revised

Author action: We updated the manuscript to provide a more detailed breakdown of the previous one. We have added room dimensions, mobile and IoT application test results, provided graphs of measurement results while the fan was turned on in the test room and several other changes. Changes to the main manuscript have been given yellow highlights.

Reviewer#3, Concern Additional # 4: Are the references provided applicable and sufficient?: I think the author have used good references basically relevant papers to the Fuzzy logic fundamentals. Although the benchmarking of existing solutions could be better.

Author response: -

Author action: -

Reviewer#3, Concern Additional # 5: Are there references that are not appropriate for the topic being discussed?: Yes

5a) If yes, then please indicate which references should be removed.:

[10] W. Li, C. Yen, Y. Lin, S. Tung, and S. Huang, “Proceedings - 2019 IEEE International Conference on Smart Manufacturing,

Industrial and Logistics Engineering, SMILE 2019," Proc. - 2019 IEEE Int. Conf. Smart Manuf. Ind. Logist. Eng. SMILE 2019, pp. 43–47, 2019.
[11] K. Khujamatov, E. Reypnazarov, D. Khasanov, and N. Akhmedov, "Networking and Computing in Internet of Things and Cyber-Physical Systems," 14th IEEE Int. Conf. Appl. Inf. Commun. Technol. AICT 2020 - Proc., 2020, doi: 10.1109/AICT50176.2020.9368793.
[12] I. Zhou et al., "Internet of Things 2.0: Concepts, Applications, and Future Directions," IEEE Access, vol. 9, pp. 70961–71012, 2021, doi: 10.1109/ACCESS.2021.3078549.
[13] N. N. Misra, Y. Dixit, A. Al-Mallahi, M. S. Bhullar, R. Upadhyay, and A. Martynenko, "IoT, Big Data, and Artificial Intelligence in Agriculture and Food Industry," IEEE Internet Things J., vol. 9, no. 9, pp. 6305–6324, 2022, doi: 10.1109/JIOT.2020.2998584.

Author response: Revised

Author action: We updated the manuscript by removing all four references. And add some additional relevant reference.

Note: *References suggested by reviewers should only be added if it is relevant to the article and makes it more complete. Excessive cases of recommending non-relevant articles should be reported to ieeeaccesseic@ieee.org*

Date of publication xxxx 00, 0000, date of current version xxxx 00, 0000.

Digital Object Identifier 10.1109/ACCESS.2017.Doi Number

Tsukamoto Fuzzy Inference System on Internet of Things-Based for Room Temperature and Humidity Control

Sunardi[1], Anton Yudhana[2], and Furizal[3]
[1,2]Department of Electrical Engineering, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
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ABSTRACT The idea of the Internet of Things (IoT) is utilized to increase the advantages of internet connectivity. As long as the electrical device is still connected to the internet, IoT can be utilized to operate it. This study applies the concept of IoT as a fan control and monitoring of the humidity and room temperature through a mobile-based application, so that the room can be controlled remotely using a smartphone before use. It is necessary to always keep the room comfortable to use, so that users can increase productivity and always avoid potential disease attacks when the temperature is unstable. In addition, the IoT concept also makes it easier to turn off the fan if at any time you forget to turn it off. This fan is integrated with the ESP32 microcontroller which has been equipped with a Wireless Fidelity (WiFi) module to access data changes in the Firebase Realtime Database. Room temperature and humidity are measured with a DHT22 sensor and processed using Tsukomto's Fuzzy Inference System to produce the appropriate fan speed in the Duty Cycle unit. Tools and applications can work as predicted based on the findings of the research conducted. However, the impact of the fan on a closed room cannot cool the room temperature but the room temperature moves up with a change of 0.3 °C to 0.5 °C within 40-75 minutes. Therefore, in the next study it is recommended to use cooling devices such as Exhaust fans or Air Conditioners.

INDEX TERMS DHT22, Duty Cycle, ESP32, Fan Speed, Fuzzy Inference System Tsukamoto, Humidity, Internet of Things, Room Controllers, Temperature.

I. INTRODUCTION

Room temperature is an aspect that can affect the comfort and productivity at work [1]. Hot temperatures can reduce the body's immunity and enthusiasm in activities, especially indoor activities. In addition, hot temperatures can also bring disease to the body if it is felt for a long time [2]. Therefore, this problem must be a concern in an effort to maintain quality activities. This hot temperature cannot disappear in the absence of auxiliary tools to periodically stabilize it [3].

At this time, tools that are often used in cooling and stabilizing the heat temperature in the room are fans and Air Conditioners (AC). But often new problems arise, such as manual speed setting, forgetting to turn off and others. Therefore, an efficient alternative is needed to overcome this problem [4].

This study aims to solve the problems that have been described. The main tool used is a fan that is integrated with the ESP32 microcontroller which has been equipped with a WiFi module [5]. Meanwhile, the indicators in this study are temperature, humidity and human activity as measured by the DHT22 sensor and the Passive InfraRed (PIR) sensor. The results of this measurement were processed using the Tsukamoto Fuzzy Inference System (FIS) method to produce the appropriate fan speed in duty cycle units [6].

The development of technology in the world is increasingly progressing until now, including Indonesia. This rapid growth brings new breakthroughs that no one had previously thought of. IoT is a technology that has been developed for a long time, but in Indonesia the use of IoT is still relatively small and even many Indonesians are still unfamiliar with the term IoT.

IoT is one of the many technologies developed to face the digital era like now to make it easier for people to use it and to overcome digital-based difficulties. Researchers are always developing this technology in order to achieve optimal results in helping human needs.

As the name implies, IoT is the internet that plays an important role in carrying out all activities. This proves that the internet plays an active role in daily digital activities. Basically, IoT is a technological concept that connects other devices with internet media and can be controlled remotely. IoT is a concept in which technology is integrated into physical objects, such as sensors and software, with the aim of connecting, communicating, controlling, and sharing data while still connected to the internet.

IoT is one of the technologies that has a close relationship with the term machine-to-machine (M2M). M2M is a service that enables remote management and control of IT devices over IP and IoT networks is a closely related concept. The tools used in M2M are able to communicate so they are called smart devices. The purpose of creating smart devices is solely to help and become a solution to solving various problems or affairs and tasks owned by humans. IoT utilization can be applied in various areas of life, such as home automation, agriculture, health, transportation, and others [7]. There are several components in this technology but fundamentally there are only four components, namely sensors, connectivity, processed data, and user interface (UI).

A sensor is a tool that serves to retrieve data from an object. The data in question can be information such as temperature, humidity, sound, movement, and light. This data will be sent as information to the user. The process of sending data from sensor measurements requires connectivity in the form of an internet network as a medium. Many connectivity options include cellular networks and Wi-Fi. Each internet source has its own advantages and disadvantages. IoT requires a stable network connection so that the data exchange process can run properly. After going through a shipment that requires connectivity, the data will then go through a processing process before a command occurs. In order for the results of sending this data to be seen by users, users are equipped with UI as a monitoring and control medium. The UI used can be web, mobile, and other platforms.

The way this IoT technology works is very simple, namely by using program instructions. Each command can generate interactions on directly connected devices without the presence of intervention from the user. It can be said that this technology is arranged in such a way as to make it easier for users to carry out remote control of a control object. The main factor in smooth running is the stabilization of the connectivity network, while humans are only the supervisors of every activity of the device when it is executing commands.

Based on the description and comfort that will be obtained using IoT technology, this study will implement IoT by utilizing a mobile-based application to control and monitor room temperature conditions [8]. The application is developed using the flutter framework [9]. The WiFi module contained in the ESP32 is used to access data changes in the database in real time [10]. The database used is Firebase Realtime Database which is a product of the Google company.

The application of IoT in this study aims to make it easier for users to overcome the problems that have been described, such as making it easier to turn off the fan if at any time they forget to turn it off or control the temperature remotely via a smartphone before the room is used for activities [11].

Several IoT-based room temperature and humidity control systems have been created in previous studies with different utilization functions, some use on server rooms [12], greenhouse [13], thermal [14], and others [15]. The application of IoT can provide a great contribution in achieving convenience for its users. This statement is supported by previous researchers who show that the results of IoT implementation are very promising because they can improve the security, safety, intelligence, and comfort of users [16]

Other studies have shown that IoT systems are also a very suitable concept in providing convenience for digital technology users. Any device connected to electricity can be controlled by using the concept of IoT. Improved system efficiency drastically reduces electrical energy consumption by providing central control of the equipment [17].

The use of the ON/OFF concept in the control system can reduce the efficiency of the function of the tool built so that alternative control is needed to overcome this problem. Control systems with proven methods such as the Fuzzy Inference System (FIS) need to be implemented in the system and evaluated to improve the control system. This is supported by previous research that shows the use of fuzzy logic in control systems can provide a more optimal contribution when compared to the ON/OFF base [14]. The ON/OFF base will only give a value of 1 or 0, while the fuzzy base will give values of 0 through 1.

In other studies, a fan control system has also been built with fuzzy logic. The use of fuzzy logic concepts in this study is considered to be an energy-saving solution using artificial intelligence [18].

In one of the studies has applied fuzzy and IoT logic to web-based server rooms and provides notifications via Twitter. In this study, AC was used as a cooling media that was controlled using fuzzy logic and IoT. Based on research testing conducted through the Matlab application, fuzzy logic can be implemented into the microcontroller with the results of simulation testing using obtained values that correspond to the results on the microcontroller and the average value of AC Temperature Set output deviation 0.03500 and the average AC Mode Set output deviation 0.01225. Although there are differences in some output values, researchers claim that the function to control the air conditioner was successfully designed as desired [19].

The use of air conditioning in cooling the room is indeed fairly efficient. But basically, not everyone can use air conditioning due to cost limitations. AC is an electronic device that is fairly expensive in initial installation and in the consumption of electrical power needed in daily use. AC is also a modern air conditioner that is often used by the upper

middle class. Meanwhile, the lower middle class people use fans more often because they are considered cheaper so the use of fans needs to be optimized with future research.

Based on the literature review that has been described, this study applies a fuzzy logic method to fan speed control to cool the room. This research is expected to contribute to optimizing fans in controlling temperatures that are a problem in tropical countries, one of which is in the country where this research was conducted, namely Indonesia.

II. THE BASIC CONSEPTS

A. IoT

IoT is a term that refers to the increasing use of the internet, the adoption of computing, mobile connectivity, and its integration into everyday life [20]. IoT is related to the DoT (Disruption of Things) and is used as an illustration of the change or conversion of Internet usage from the previous Internet of People M2M Internet.

B. FIS Tsukamoto

Each rule is supported by the same monotonous logic used by FIS Tsukamoto [21]. A fuzzy set with monotonous membership functions should be used to describe any result of the IF-THEN rule [22]. Based on the predicate, the output of the inference result of each rule is explicit (Crisp) [23]. Utilizing defuzzification and the idea of weighted averages, aggregation of the rules is carried out, and the results are then obtained [24].

1. Fuzzification

The fuzzification stage serves to convert the crisp value into a fuzzy value using a fuzzy curve [25]. This study applies two types of curves, namely the triangle curve and the shoulder model.

1.1. Triangular Membership Curve

A triangular curve is a combination of linear ascending and descending linear delimited by a single point of membership value 1 as in Figure 1 [26].

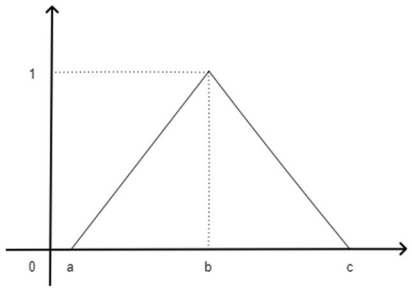

FIGURE 1 Triangular curve

Based on Figure 1, it can be concluded that the triangle curve has four conditions of the value of the agglomerate. The four conditions will only result in a membership value of 0 to 1. The representation of the triangle curve can be seen in Equation 1.

$$\mu[x] = \begin{cases} 0; & x \le a \quad or \quad x \ge c \\ (x-a)/(b-a) & a < x < b \\ (b-x)/(c-b) & b < x < c \\ 1; & x = b \end{cases} \tag{1}$$

1.2. Shoulder Membership Curve

The shoulder curve is used to end the variable of a blurred area that has its right or left side unchanged. This type of curve is divided into two models, namely the left shoulder curve and the right shoulder curve as shown in Figure 2 [27].

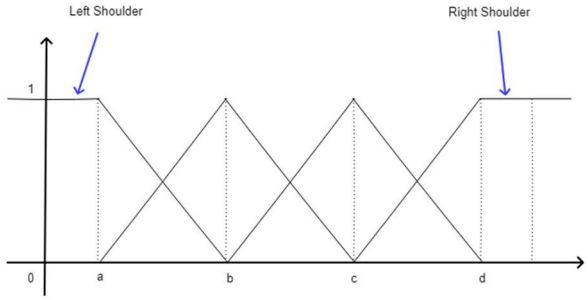

FIGURE 2 Shoulder Membership Curve

2. System Inference

At the inference system level, fuzzy rules based on the fuzzy set theory and fuzzy rules in the form of IF-THEN statements are both used to draw conclusions [22][28]. Zadeh divides into three basic operators, namely AND, OR, and NOT [29]. The AND is an operator that serves to obtain the minimum elements. While the OR operator is used to search for the maximum element and the NOT operator is used to subtract the value of 1 with the negated fuzzy element [30]. In this study was applied the AND operator to every fuzzy rule formed. The mathematical narrative of the AND operator as shown in Equation 2.

$$\mu A \cap B = \min(\mu A[x], \mu B[x]) \tag{2}$$

3. Defuzzification

Defuzzification is the final process of converting a fuzzy output into a crisp value [31]. The equation applied at this stage is the Weighted Average as Equation 3 [32].

$$Z = \frac{\sum \alpha_i z_i}{\sum \alpha_i} \tag{3}$$

C. ESP32

The ESP32 is the successor to the ESP8266 and offers several improvements in every way [33]. The ESP32

supports Bluetooth Low Energy as well as WiFi connections, making the ESP32 more flexible [34]. The ESP32 has 64MB of flash memory for storing programs and data [35].

D. DHT22 Sensor

The DHT22 sensor is a digital relative temperature and humidity sensor [36]. The DHT22 sensor uses capacitors and thermistors to measure ambient air and send signals to the data pins [37]. The DHT22 claims to have good read quality, judging by its quick response to data collection and its minimalist size, as well as its relatively low price compared to thermometers [38].

E. PIR Sensor

The PIR sensor is a motion detection sensor [39]. PIR sensors are widely used to determine the presence of human movement in the area that can be reached by PIR sensors [40]. These sensors are small, inexpensive, require little power, and are easy to use. This sensor is also widely used domestically and professionally [41].

F. PWM AC Dimmer

A dimmer is an electronic circuit that converts the shape of a pure AC signal into a truncated signal, which allows the output power to be adjusted [42]. AC signal clippings are useful for light dimming, motor deceleration, heating control and more [43].

G. Flutter

Flutter is an open-source framework or SDK developed by Google to create high-performance app interfaces that can be published for Android and iOS platforms from a single codebase [44]. The hot reload feature provided by Flutter eliminates the need to compile or rebuild all changes to see the results [45]. Flutter uses the Dart programming language which certainly feels familiar with the Java or Javascript programming language [46]. Darts is a popular programming language developed by Google [47].

H. Firebase

Firebase is a service from Google that is used to help with application development. Firebase Realtime Database enables users to create feature-rich collaborative apps by providing secure database access directly from client-side code [48]. Firebase provides a responsive experience to end users. Data changes occur continuously and in real-time offline. The real-time database synchronizes local data changes with remote updates that occur when the client is offline, so any differences are automatically resolved when device connectivity is restored [49].

III. RESEARCH STAGE

This research consists of several steps to produce the desired output. The research stage as shown in Figure 3.

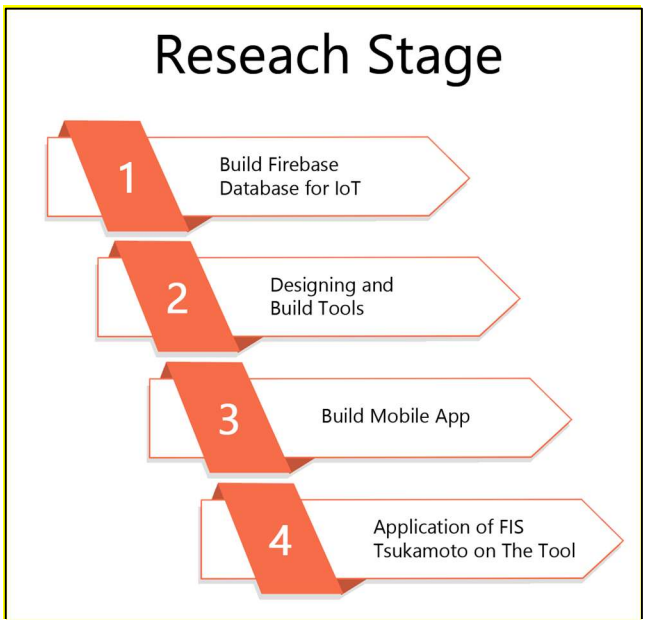

FIGURE 3 Research stage

Based on the research stage in Figure 3, broadly speaking, there are four stages carried out to produce the expected output. In the first stage, the database is designed and built using firebase database which is a realtime database service from the Google company. This database serves as a data center that will be an indicator of data changes from the tools and mobile applications to be built. These data changes will be accessed reciprocally by tools and mobile applications in real time over a network connection. In simple terms, the basic concept of data exchange is like Figure 4.

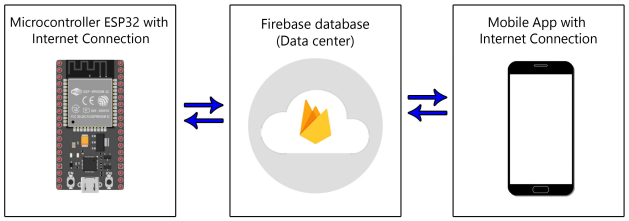

FIGURE 4 Basic concepts of data exchange

Based on Figure 4, data exchange does not occur directly between a mobile application and a microcontroller, but is mediated by a database that acts as a data center. Any changes to this database will be accessed by each device, both changes by the microcontroller and changes by the mobile application.

In the second stage, the tool is designed and built by utilizing one of the microcontrollers, namely the ESP32. The use of this mincrocontroller is based on the need for a network connection so that with its advantages that are already accompanied by a WiFi module, there is no need to

accompany additional WiFi modules anymore. This will save more on the use of the device.

In the third stage, the mobile application is designed and built using the Flutter framework. The flutter framework is one of the Open Source frameworks that is widely used in mobile development. Programmers simply visit, download, and install the flutter package from its official website. Google has provided documentation to be able to use the features that have been provided in this framework. In addition, the development of this application is also assisted by using the Flutter package in Visual Studio Code.

In the fourth stage, the research continued by implementing FIS Tsukamoto. This stage starts from discussing variables, talking universes, sets, and fuzzy domains. Each variable is represented in the form of a fuzzy curve used in the process on the Tsukamoto fuzzy.

Broadly speaking, Tsukamoto fuzzy consists of three stages, namely fuzzification, inference engine, and defuzzification. These stages are used to produce the output of the inputted variable values. The results of this processing are expected to be the most efficient value in controlling room temperature in the studies conducted.

After the discusion process is complete, a manual calculation process is carried out in the Microsoft Excel application. Then the coding or application of the fuzzy method is carried out on the built tool. The results of manual calculations that have been done will be compared with the results of calculations on coding tools. The tool is coded with a programming language with the ino extension using the Arduino IDE application.

After all stages of this research are carried out, the tools and applications are tested for feasibility so as to provide optimal results as expected. If the test results still have errors, they will be reviewed for correction. Based on what has been explained in the introduction section, the goal to be achieved is a tool that can control the temperature and humidity of the room using a mobile application by applying the IoT concept. The expected simulation as shown Figure 5.

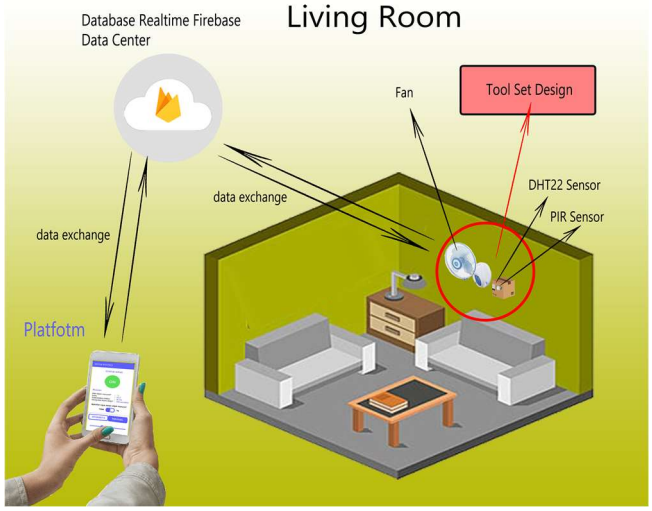

FIGURE 5 Simulation of expected results

A clearer decipherment related to the stages of research is described as follows:

A. Build Firebase Database for IoT

Based on the understanding that has been described, IoT has very important benefits for human life in building the concept of remote control. This control will also not be separated from data storage [50]. There are many ways that can be done, one of which is by utilizing the realtime database from firebase google [51]. The Firebase database data schema is built as in Figure 6.

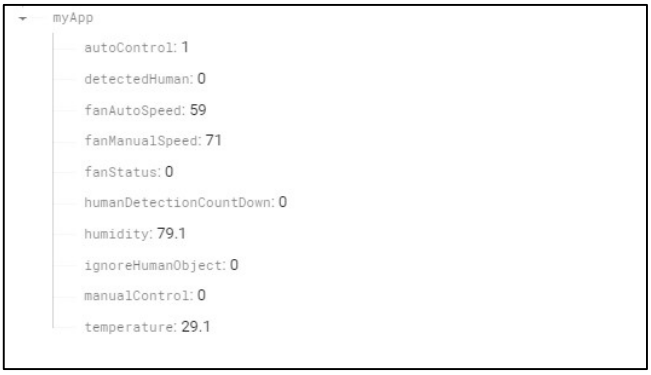

FIGURE 6 Firebase Database data schema

Figure 6 is a data structure in the firebase database that will be an indicator of changes in the action of the built tool. The variables listed on the Figure 6 have their own functions as in Table 1.

TABLE 1
Firebase data schema explained

No	Variable Name	*Data Type*	Function
1	autoControl	*Number*	If it is worth 1, then the fan is controlled automatically by the Fuzzy Tsukamoto algorithm.
2	fanAutoSpeed	*Number*	Stores the fan speed value (duty cycle) when the user selects the automatic control option.
3	manualControl	*Number*	If it is worth 1, then the fan is manually controlled by the user with a duty cycle input between 1 to 100.
4	fanManualSpeed	*Number*	Stores the fan speed value when the user

			selects the manual control option.
5	fanStatus	*Number*	Fan status indicator is on (1) or OFF (0).
6	temperature	*Number*	Stores temperature values read by the DHT22 sensor.
7	humidity	*Number*	Stores the humidity value of the air read by the DHT22 sensor.
8	detectedHuman	*Number*	A value of 1 indicates that there was a human object detected by the PIR sensor in the last 60 seconds.
9	humanDetection-CountDown	*Number*	Counting down 60 seconds since the last time a human object was detected. If before up to 60 seconds the human object has been detected again, then the value will be changed back to 60. If the countdown shows the number 0, then the value of the detectedHuman variable will be set to the value of 0 (no human object was detected in the last 60 seconds).
10	ignoreHumanObject	*Number*	An indicator that the fan is turned on by ignoring the presence of humans, meaning that the fan will still turn on even if no human object is detected by the PIR sensor.

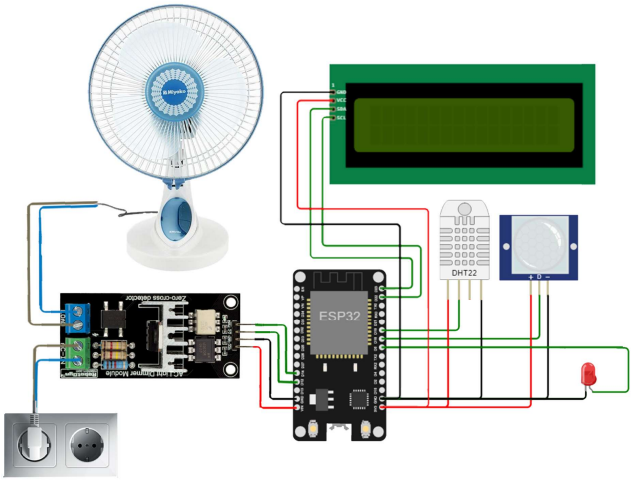

FIGURE 7 Tool design

The details of describing the schema of relationships between devices are described in Table 2.

TABLE 2
Scheme of relationships between devices

Relationship Start		Destination	
Device Name	**Port**	**Device Name**	**Port**
ESP32	GND	LCD	GND
ESP32	3V3	LCD	VCC
ESP32	IO D22	LCD	SCL
ESP32	IO D23	LCD	SDA
ESP32	GND	DHT22 Sensor	GND
ESP32	3V3	DHT22 Sensor	VCC
ESP32	IO D19	DHT22 Sensor	SDA
ESP32	GND	PIR Sensor	GND
ESP32	3V3	PIR Sensor	VCC
ESP32	IO D18	PIR Sensor	OUT
ESP32	IO D5	LED	+
ESP32	GND	LED	-
ESP32	GND	PWM AC Dimmer	GND
ESP32	3V3	PWM AC Dimmer	VCC
ESP32	IO D12	PWM AC Dimmer	Z-C
ESP32	IO D14	PWM AC Dimmer	PWM
Power source	(+ & -)	PWM AC Dimmer	AC-IN
Fan	(+ & -)	PWM AC Dimmer	LOAD

B. Designing and Build Tools

This research tool is built using the ESP32 which overall functions almost the same as other microcontrollers such as Arduino, Wemos Mini, and others [52][53][54]. The concept of application as a whole is the same, because Arduino code can also be used on ESP32 [55]. In addition, hard tools such as sensors can also be used on the ESP32 using the same source code [56]. The design of the tool is built as in Figure 7.

C. Building Mobile App

The mobile application is an application that can be paired and used on a smartphone [57]. Many frameworks and technologies can be utilized in building mobile applications, including react native, sencha, ionic, flutter and others [58]. In this study, the mobile application was built using the flutter framework. The development cycle starts from collecting and analyzing the data needed to be applied to the application. After that, the application is designed according to the needs needed so that the features in the research can

be fulfilled in the application to be built. Once the design is complete, the application begins to build by coding using the flutter framework. The development of this application is adapted to the pre-designed design. After the application has been developed, then the application is then carried out a testing process to ensure that all interfaces and functionalities of the application can run properly as expected. Furthermore, the application will be deployed and maintained during use. To be clear, the lifecycle steps of mobile application development are built as in Figure 8.

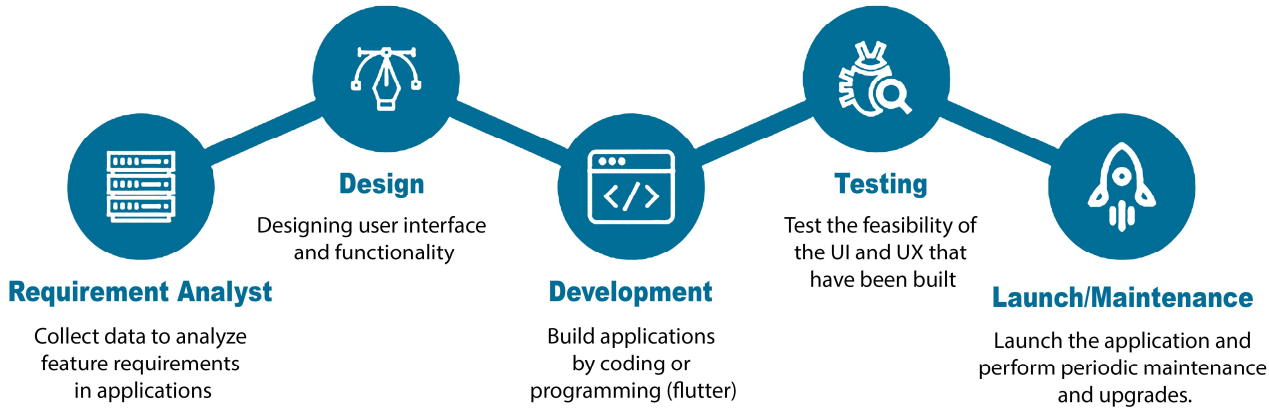

Figure 8 Mobile Application Development Lifecycle

This application was created to control and monitor the temperature and humidity conditions around the device that has been built. This application is integrated with the tool through the internet network, so that users can monitor anytime and anywhere as long as the tool and smartphone used are still connected to the internet. The mobile application interface has been built as in Figure 9.

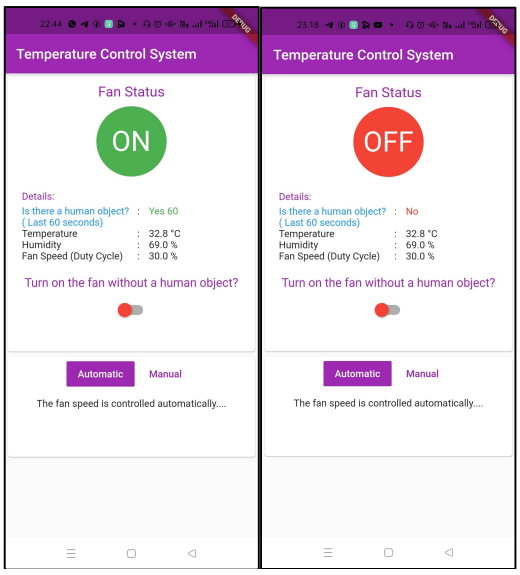

FIGURE 9 Mobile app interface

This built application consists of one interface according to the design of the application that has been designed. At the time of controlling the tool, the user can choose several options, namely:

1. Enabling the option "Turn on the fan without a human object?" is that the fan can be turned on by ignoring the detection of human presence through the PIR sensor. Because, if you don't activate this option, then the fan will only turn on when the PIR sensor detects human presence.
2. Selecting the "Automatic" control option is that the fan speed will be set based on the temperature and humidity read and processed using fuzzy logic.
3. Selecting the "Manual" control option is that the fan speed is controlled manually by entering the desired speed value.

D. Application of FIS Tsukamoto on the Tool

Fuzzy Tsukamoto has three important stages in producing output, namely fuzzification, machine inference, and defuzzification. The illustration is like Figure 10.

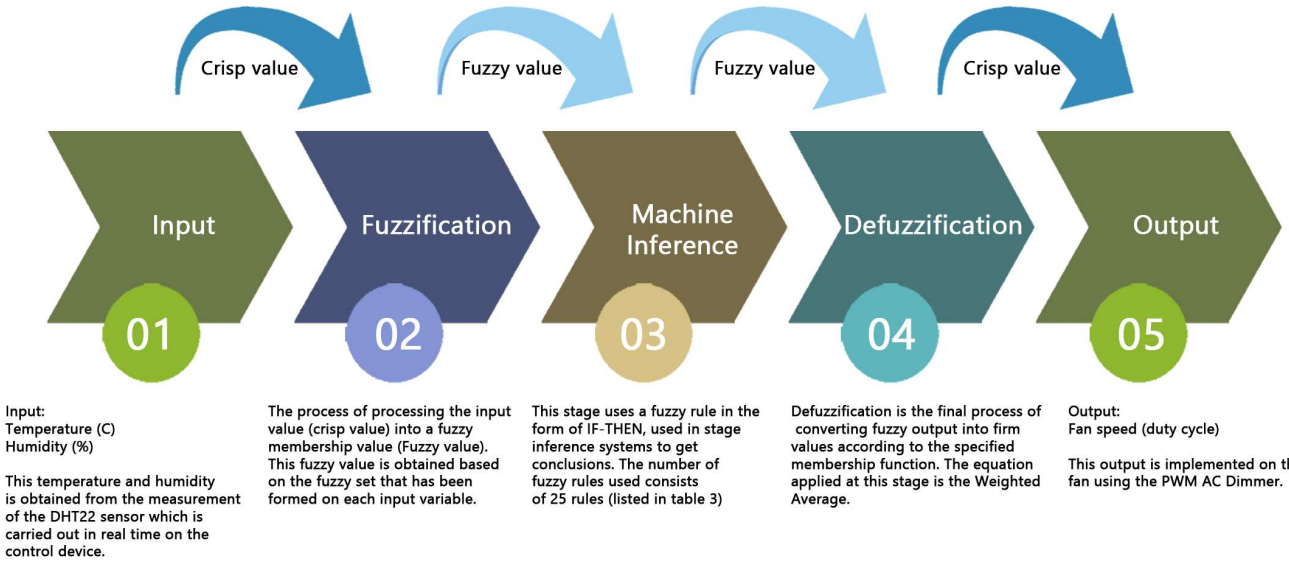

FIGURE 10 Stages of FIS Tsukamoto

The Fuzzy stage in Figure 10 shows that the input in the fuzzy system is a crisp value. This crisp value will be converted into a fuzzy value in the form of a fuzzy membership value through the fuzzification stage using Equation 1. After the fuzzification stage is complete, the output of this fuzzy membership value will then be processed at the machine inference stage. At this machine inference stage, fuzzy rules are needed to process the fuzzy membership value obtained from the fuzzification stage. The fuzzy rules used are already listed in Table 3. These fuzzy rules will be processed using Equation 2. After the machine inference stage is complete, the process continues at the last stage, namely defuzzification using Equation 3. At this stage of defuzzification, crisp value will be obtained as the final output of the process on Fuzzy Tsukamoto.

TABLE 3
Fuzzy Rule Base

Rule		Temperature		Humidity		Fan Speed
[R1]	IF	QUITE WARM	AND	DRY	THEN	SLOW
[R2]		QUITE WARM		NORMAL		SLOW
[R3]		QUITE WARM		PRETTY WET		SLOW
[R4]		QUITE WARM		WET		SLOW
[R5]		QUITE WARM		VERY WET		SLOW
[R6]		WARM		DRY		SLOW
[R7]		WARM		NORMAL		SLOW
[R8]		WARM		PRETTY WET		SLOW
[R9]		WARM		WET		MEDIUM
[R10]		WARM		VERY WET		MEDIUM
[R11]		QUITE HOT		DRY		MEDIUM
[R12]		QUITE HOT		NORMAL		MEDIUM
[R13]		QUITE HOT		PRETTY WET		MEDIUM
[R14]		QUITE HOT		WET		FAST
[R15]		QUITE HOT		VERY WET		FAST
[R16]		HOT		DRY		MEDIUM
[R17]		HOT		NORMAL		MEDIUM
[R18]		HOT		PRETTY WET		FAST
[R19]		HOT		WET		FAST
[R20]		HOT		VERY WET		FAST
[R21]		VERY HOT		DRY		MEDIUM
[R22]		VERY HOT		NORMAL		FAST
[R23]		VERY HOT		PRETTY WET		FAST
[R24]		VERY HOT		WET		FAST
[R25]		VERY HOT		VERY WET		FAST

Tsukamoto's fuzzy calculation by applying 25 fuzzy rules produces the output as expected [59]. These rules are obtained from a combination of two input variables, namely temperature and humidity. These two input variables each have five sets. The set of temperature variables is Quite Warm, Warm, Quite Hot, Hot, and Very Hot. While the set of humidity variables are Dry, Normal, Pretty Wet, Wet, and Very Wet. The combination results of these two variables produce a fan speed output consisting of three sets, namely Slow, Medium and Fast. An example of some of the speed outputs produced by this fuzzy calculation can be seen in Table 4.

TABLE 4
Fan speed decision-making test data

No	Input		Output
	Temperature (°C)	Humidity (%)	Fan Speed (Duty Cycle %)
1	29.8	79.0	47.88
2	29.8	78.7	47.88
3	29.9	78.9	48.67

4	29.9	78.5	48.67
5	29.9	78.4	48.67
6	29.9	78.2	48.67
7	30.0	78.2	49.50
8	30.0	78.3	49.50
9	30.0	78.4	49.50
10	30.0	78.1	49.50
11	30.0	78.0	49.50
12	30.0	77.8	49.50
13	30.0	77.9	49.50
14	30.1	77.9	50.37
15	30.1	76.6	50.37
16	30.1	77.8	50.37
17	30.1	77.7	50.37
18	30.1	77.6	50.37
19	30.2	76.1	50.33
20	30.2	76.3	50.70

4. EXPERIMENTAL RESULT

A. DHT22 sensor calibration

In this study, the temperature sensor used was the DHT22 sensor. However, this sensor is made and designed for measurement at the location conditions under which it is created that will cause deviations in results at other locations. Therefore, it must be known how the characteristics of this DHT22 sensor in tropical Indonesia and need to be calibrated at the desired local conditions. Sensor calibration is a feasibility test of the sensor to achieve results in accordance with the desired indicators, namely accuracy and precision with the addition of an equation model, so that this goal is achieved. This calibration is done by comparing the temperature and humidity values on the sensor with the temperature and humidity values obtained from manual measurements from the thermometer and hygrometer taken at the same time.

The comparison tool used in this calibration process is the Digital HTC-2 Thermometer Hygrometer as in Figure 11.

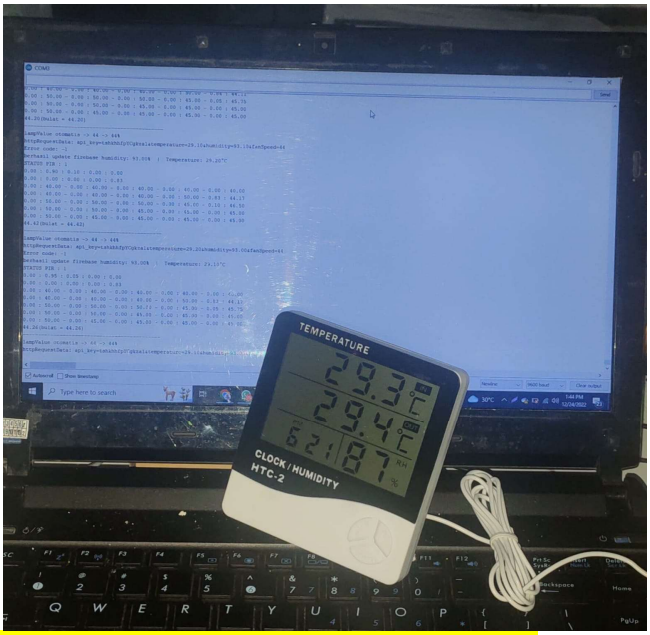

Figure 11 Digital HTC-2 Thermometer Hygrometer

This calibration to test the precision level of the DHT22 sensor is done by taking 60 data simultaneously. The results of this test showed a temperature difference of 0.18°C and humidity of 7.78%. The comparison chart of DHT22 and Digital HTC-2 Thermometer Hygrometer temperature measurements is shown in Figure 12. As for the humidity, it is listed in Figure 13.

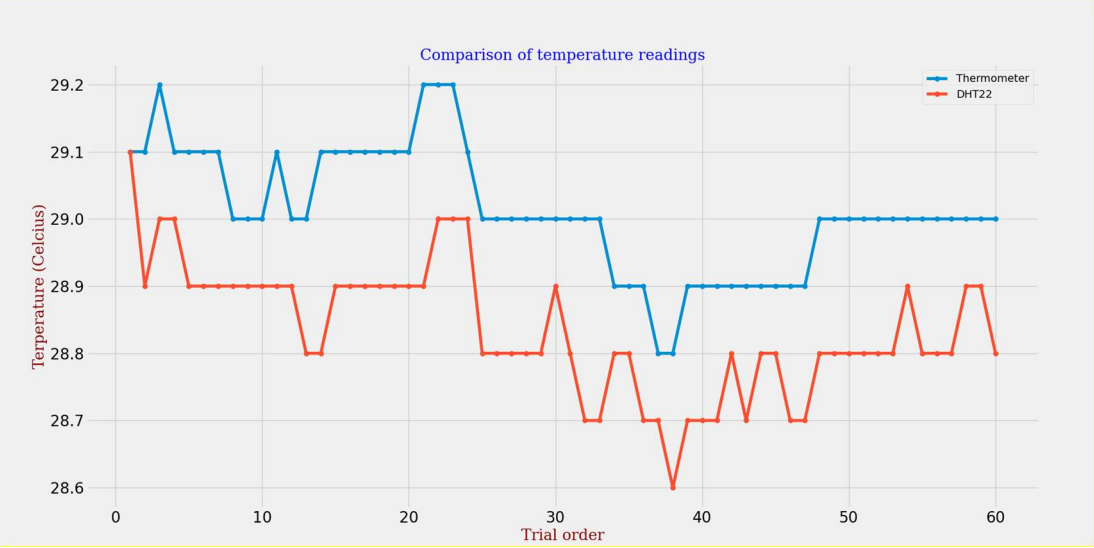

Figure 12 Comparison of temperature measurements

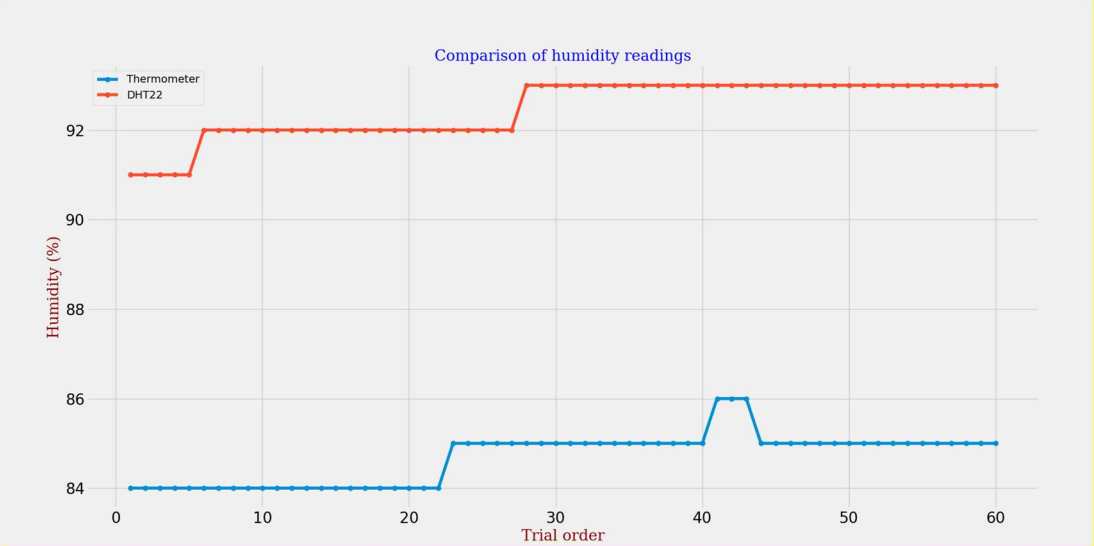

Figure 13 Comparison of humidity measurements

B. Response of tools and mobile applications

The tools in this study have been applied to rooms that are not too spacious. The area of the room tested measured 400 cm x 400 cm wide, while the height was 350 cm. The area of the room can affect the control system that is built. The more spacious the room implemented, the more difficult it is to control its temperature, unless a control fan is implemented in large quantities.

While the mobile application as a control medium has been tested with a fairly good success rate. The results of some tests are listed in Table 5.

TABLE 5
Pengujian respon aplikasi mobile

No	Connection Source	Internet Speed	Response Time
1	WiFi	30 Mbps	<200 ms
2	WiFi	29 Mbps	<200 ms
3	Mobile data	6.8 Mbps	<292 ms
4	Mobile data	5.8 Mbps	<301 ms
5	Mobile data	2.4 Mbps	<656 ms
6	Mobile data	70 Kbps	11918 ms
7	Mobile data	25 Kbps	10653 ms
8	Mobile data	18 Kbps	20071 ms
9	Mobile data	13 Kbps	13589 ms
10	No Connection	Loss	Not Response

Table 5 shows the mobile application's response to changes in data on the server. The mobile application response test is carried out by providing two connection sources, namely WiFi and mobile data. Based on the tests conducted, the mobile application can communicate well as long as it is connected to a network that has stable speed. The fastest result, the application can provide a response of <200 ms with an internet network speed of 29 Mbps. While on an unstable network, the application still provides a response even with a long response time. This application response test is also performed against a missing network connection. If the connection is dropped then the application will not give a response until the connection is available again. Based on this description, it can be concluded that the internet network connection greatly affects the application's response time in accessing data on the server, both when updating data and reading data. Not only mobile applications, the response of built-in ESP32 devices is also affected by network speed conditions. Networking is a major influencing factor when interacting with IoT because all connected devices communicate over the network.

In addition to the internet network, the component that is also needed by the device or tool that is built is the availability of electrical power sources. In Indonesia, the availability of electricity is often a challenge because there are frequent power outages, especially for areas far from urban areas. The duration of these power outages usually varies, ranging from just a few minutes, a few hours and even a few days. When the power source is off, the tool will automatically turn off. However, the cached change data will still be stored in google's firebase database. Therefore, when the power source is available again, it will access the latest data changes to firebase to give the room action. When the tool accesses data on firebase, it must still reconnect to the internet network connection. The results of the experiment are shown in Table 5, while the results of its execution are as shown in Figure 14.

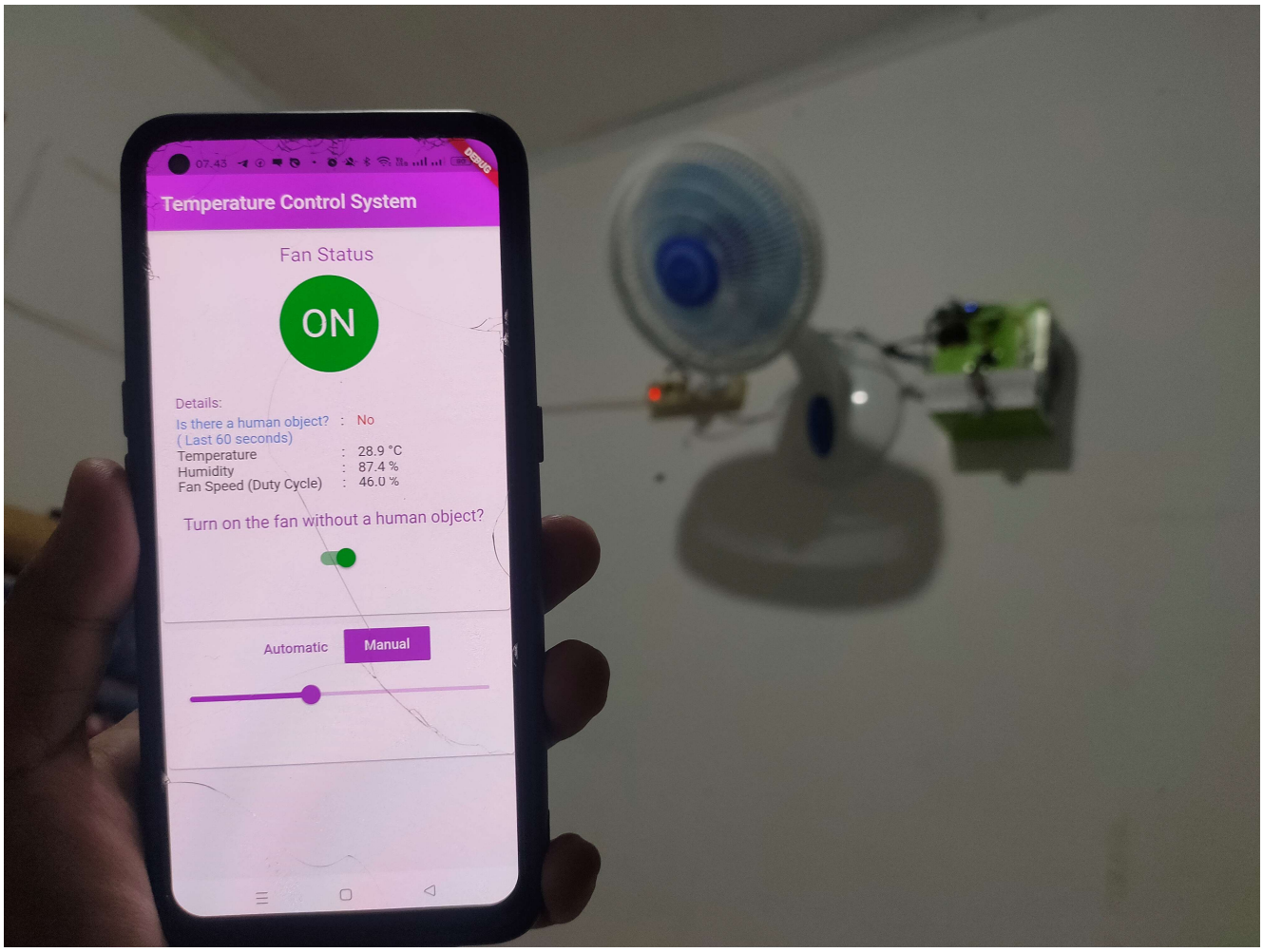

FIGURE 14 Application to the room

These control tools are designed and built by applying the needs to network connections. If the ESP32 device is not connected to the internet network, the tool automatically cannot access data changes in the database. However the flow chart on the program code of the tool is created independent of the internet connection. When the internet connection on the tool is lost, the tool will turn off the "Turn on the fan without a human object" mode and the "Manual Control" mode. After that, the tool will check the presence of humans and check the temperature and humidity of the air in the room offline / locally. If in the room there are human activities and temperature conditions above normal conditions, then the tool will activate the "Automatic Control" mode by applying fuzzy logic calculations to produce the ideal fan speed in controlling temperature needs in the room.

In this condition, users cannot monitor the device remotely on a smartphone / mobile application because the tool cannot update data changes in the database. Therefore, indirectly the mobile application also cannot be synchronized with the tool. Even so, users can still see the fan status (ON/OFF), fan speed, temperature, and humidity in real time on the LCD attached to the device set. This condition is not permanent, because if the tool is connected to the network, the tool will be able to access data changes on the database again. The tool's working flow chart is found in Figure 15.

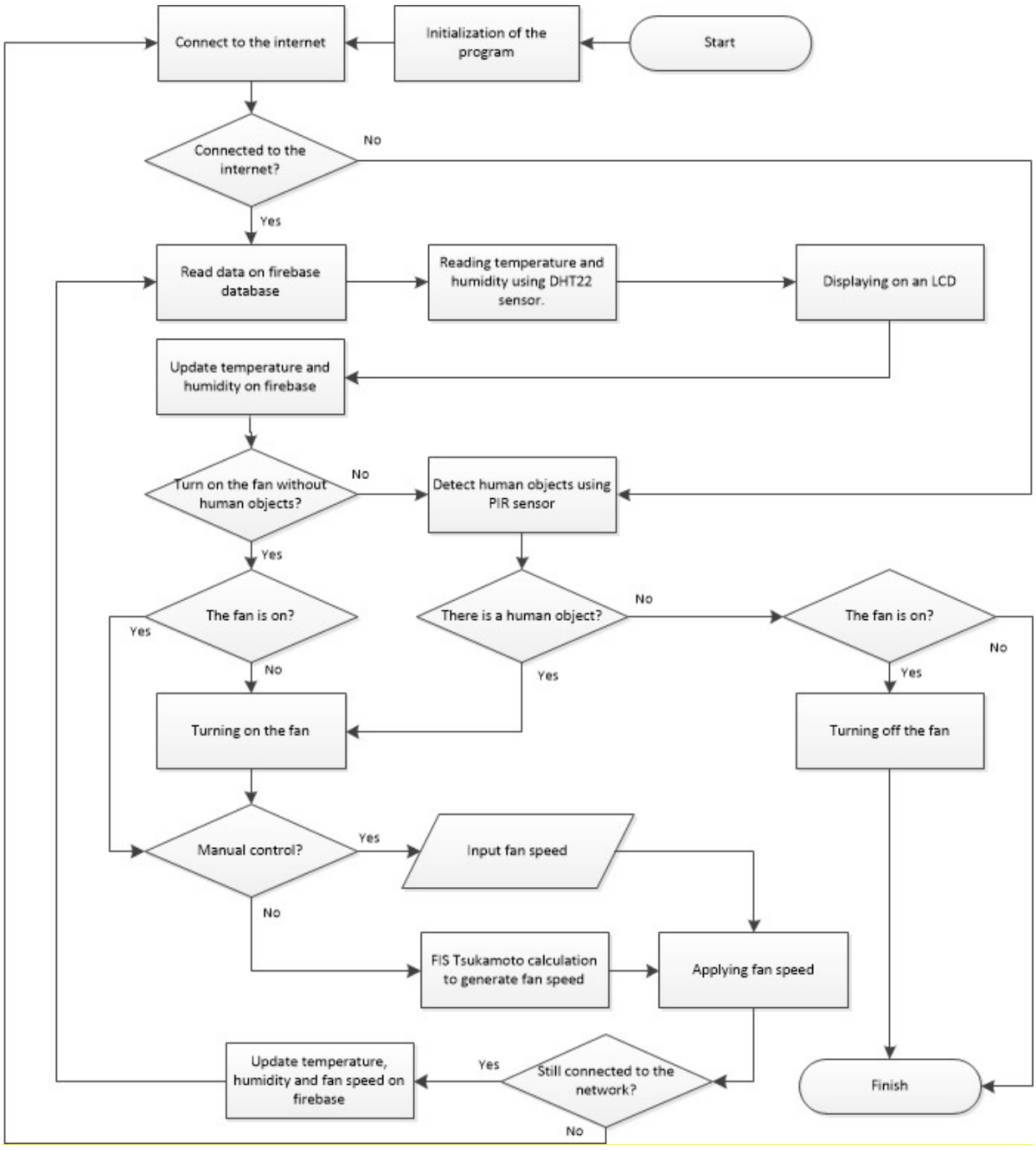

FIGURE 15 Tool working flowchart

An internet connection not only affects the control tools built in, but also affects the mobile applications that are designed. If the smartphone connection is lost, the user is also unable to monitor and control the device remotely. This condition will end when the application reconnects to the network. The mobile app flowchart is listed in Figure 16.

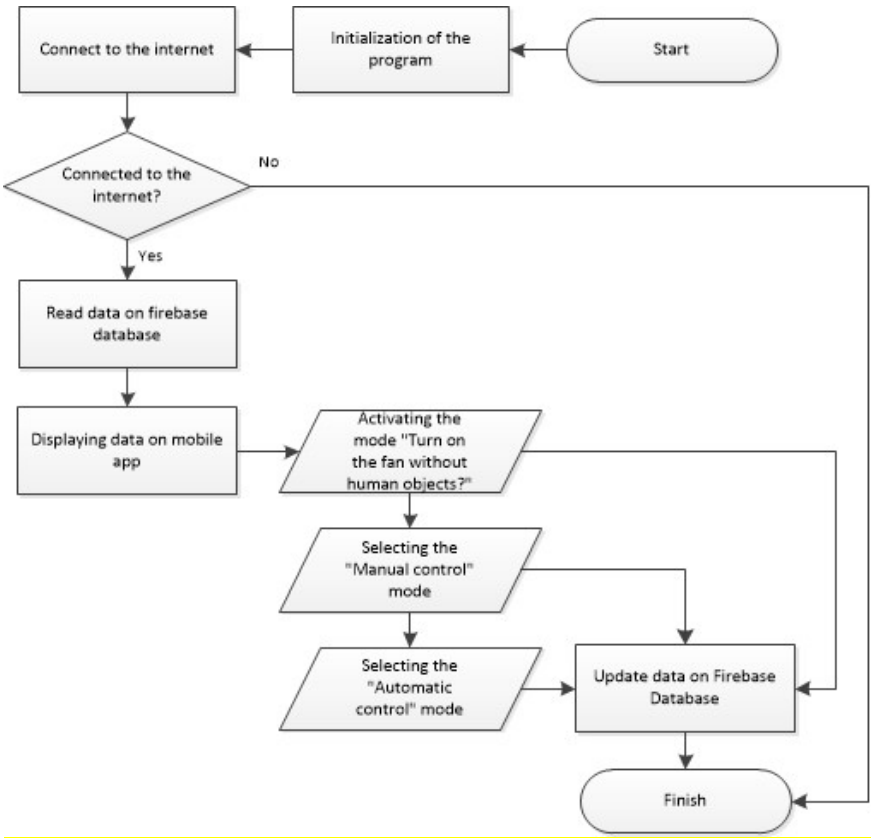

FIGURE 16 Mobile app working flowchart

C. Testing the impact of the tool on the room

This temperature and humidity control device is tested by placing a DHT22 sensor (temperature and humidity gauge) in three different places. This pegujian aims to provide information related to the influence of the device expecting a decrease in heat temperature on the room. Visually, the placement position can be seen in Figure 17.

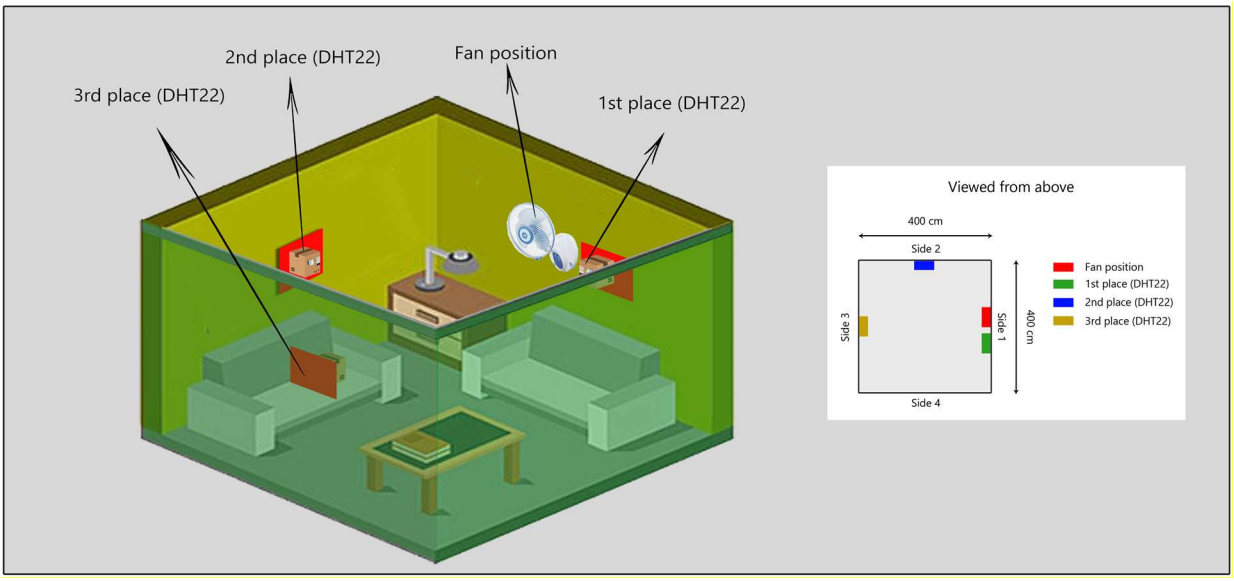

FIGURE 17 Simulated position of the fan and DHT22 sensor

These three DHT22 sensor positions will be tested to determine the effect of this control device on room temperature, whether exposed to fan blowing or not. For more details, Figure 15 is an illustration of the position of the fan and DHT22 sensor which is included with the size of the room on each side of the room which is viewed through the 4th side based on the illustration listed in Figure 18.

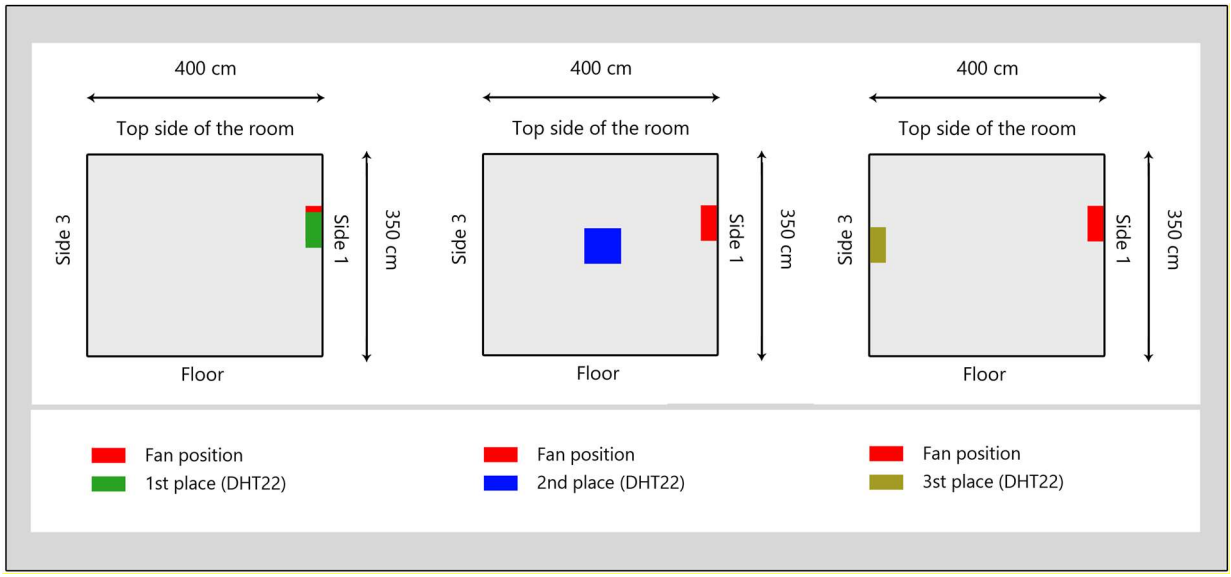

FIGURE 18 Position of the DHT22 sensors and fan when viewed from side 4.

These three sensor positions are exposed to different wind gusts of force, ranging from those that are hardly exposed to the slightest wind to those that are directly exposed to the wind. The DHT22 sensor at each of these positions will be tested to provide information regarding the effect of fan rotation that has been set with fuzzy logic on room temperature and humidity. A description of the wind touch at each position of the DHT22 sensor is shown in Table 6.

TABLE 6
Description of the position and wind touch of the fan

DHT22's Positions	Description of the position and wind touch of the fan
1st place	This position is a position that is almost not exposed to gusts of wind from the fan, either directly or indirectly (the reflection of surrounding objects). The position is right next to the fan leg stuck in the wall, which is on the same side (side 1).
2nd place	This position is the position that is not exposed to gusts of wind from the fan directly. But it is only exposed to the reflection of the wind from the walls of the room and surrounding objects. The position is on the wall to the right of the fan (side 2).
3rd place	This position is the position that is directly exposed to gusts of wind from the fan. The position is right opposite the position of the fan (side 3).

The test is carried out in the conditions of a closed room, so that there is no air cycle in and out of the house. Testing in the first position, the rotation of the fan did not make a significant impact. The test results show the temperature graph of some tests cannot be inferred. Because some tests show the temperature is moving up. Meanwhile, several other tests showed temperatures moving down. The temperature changes in rise and fall are also not very significant, which only ranges from 0.3-0.5°C. The graph of the first few test positions is shown in Figure 19.

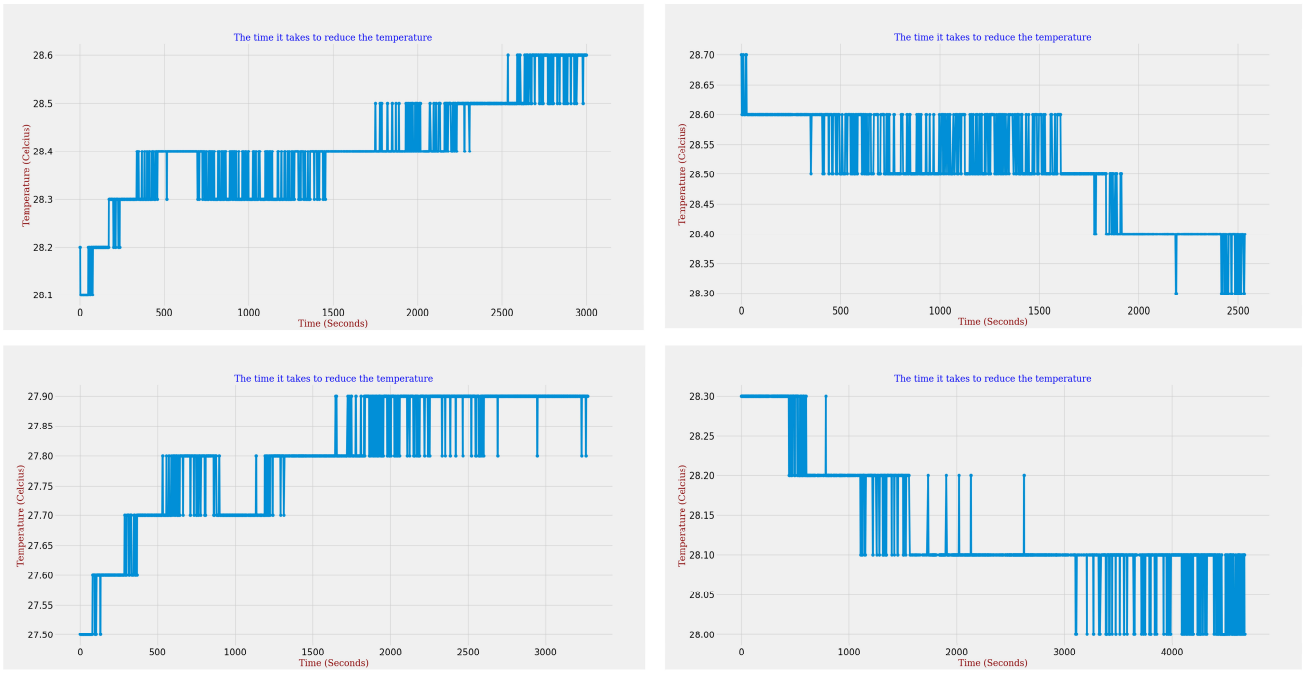

FIGURE 19 First position test (behind the fan)

The test at the second position showed that the temperature continued to rise as evidenced by the form of its test graph. This temperature rise ranges from 0.3-0.4°C only. If it is rotated for a longer time, the temperature decreases again. But this temperature drop is not too drastic. This second position test chart is as in Figure 20.

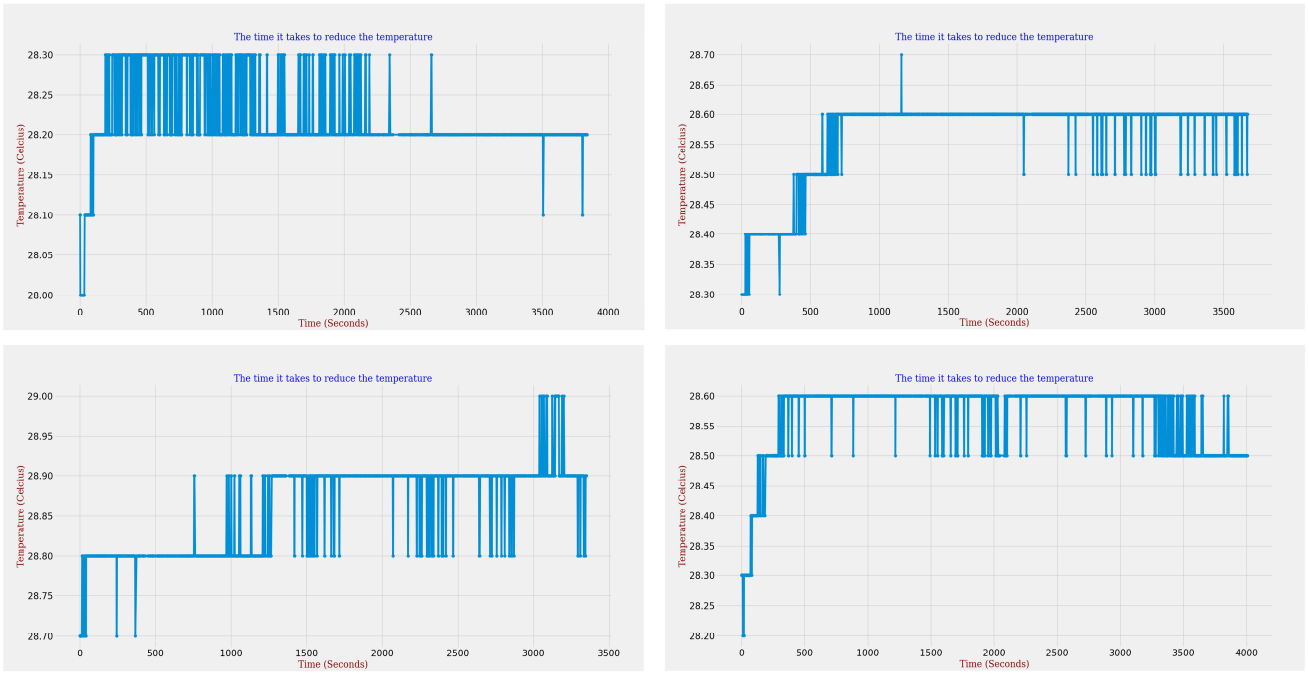

FIGURE 20 Second position test (next to the fan)

In the third position, the results of all tests show that the temperature continues to rise, which results are almost the same as those in the second position. The temperature changes that occur also range from 0.3-0.5°C. The third position testing graph is shown in Figure 21.

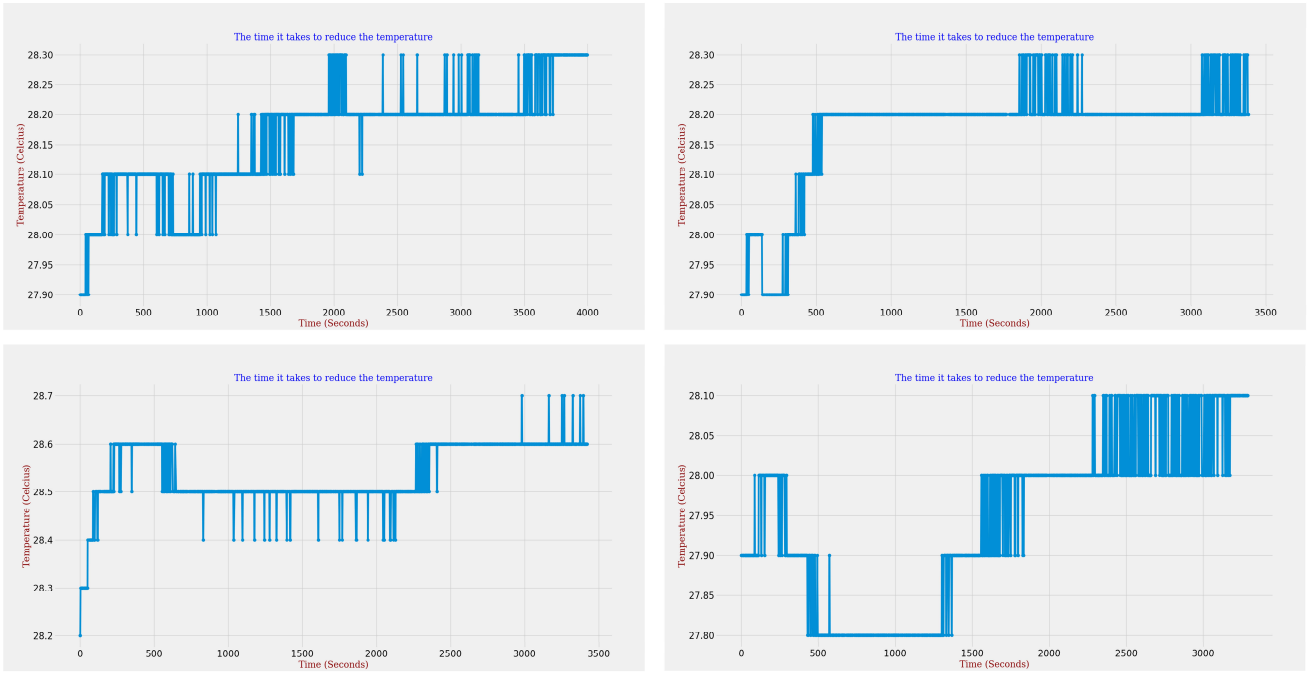

FIGURE 21 Third position test (facing the fan)

Tests that have been carried out on the three fan positions show that the temperature will change if a fan is applied. Based on several tests carried out, the temperature changes that occur are contrary to the objectives of this study. The temperature does not move down but moves up. The time used in this test ranged from 40-75 minutes. The results obtained from the test within 40-75 minutes showed a temperature change of only around 0.3-0.5°C.

Overall, this study shows that the temperature will move up when the closed room is fanned by a fan. This is caused by air circulation which does not change with fresh air from outside so that only the air in the room is continuously fanned by the fan. Therefore, a new problem arises, namely to provide a change in hot temperature to decrease and fresh, air circulation is needed so that outside air can enter the room. This can be done by using ventilation or using an exhaust fan. However, if the room is difficult to reach the temperature from the outside, using an air conditioner may be more efficient than using a fan in a room without air circulation.

A. CONCLUSION

In this study, the fuzzy method can play a good role. The fan speed output can be adjusted according to the temperature and humidity conditions of the room in real time. However, the results of the fan fan are not able to reduce the room temperature but the temperature rises. These results indicate that a room that is fanned in a closed state without ventilation or air circulation will make the temperature hotter. Tests carried out within 40-75 minutes showed an average temperature rise of 03-05°C. Even though the temperature increase is not very significant, this result gives an output that is not as expected. So with that, through this research the authors suggest in further research to replace the cooling media using exhaust fans or air conditioners. Meanwhile, the IoT-based mobile applications that are built can function properly as long as the tools and applications are still connected to a stable internet network.

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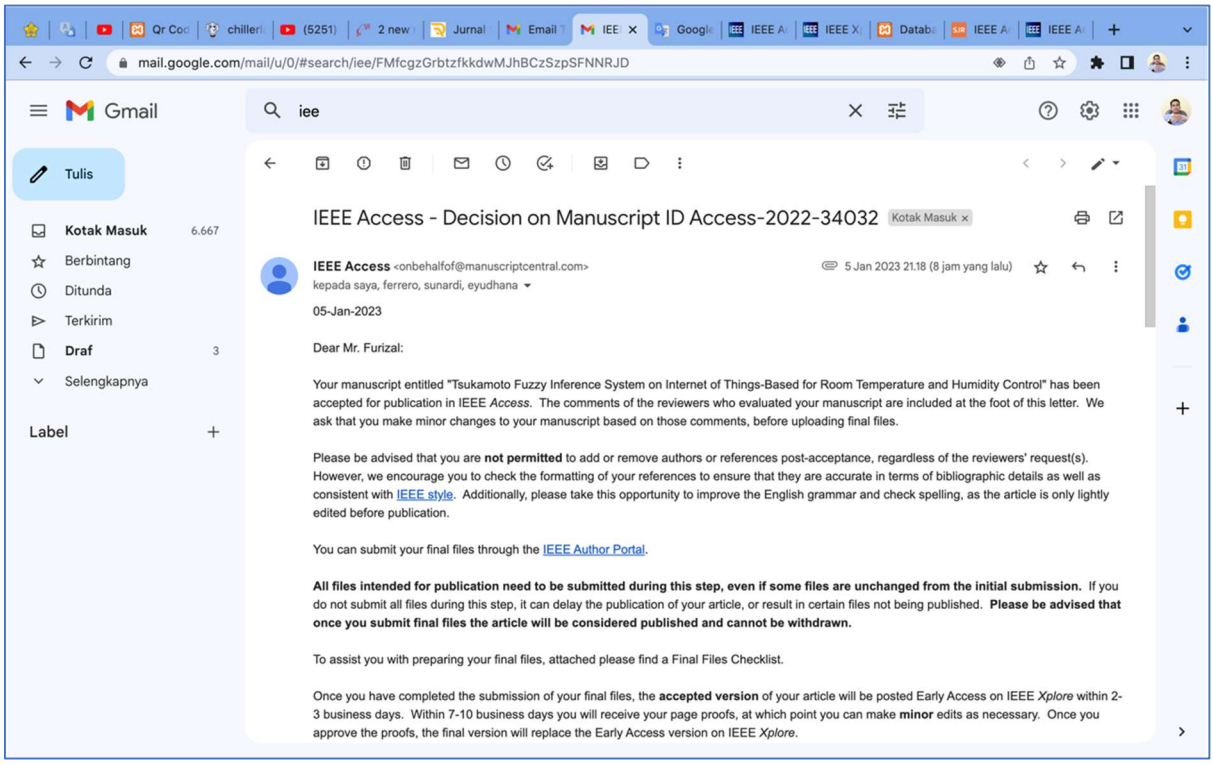
Tahap 4
Accepted with minor revision, 05 January 2023

Decission of **Accepted with minor edits:** 5 Januari 2023

Pada submission kedua ini dapat diterima untuk diterbitkan dengan minor revision



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05-Jan-2023

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Reviewer(s)' Comments to Author:

Reviewer: 1

Recommendation: Accept (minor edits)

Comments:
The authors have improved the manuscript and they have incorporated the changes suggested by the reviewers. This manuscript is now worth for the publications in the

journal. Following are some suggestions regarding the manuscript.
1. Provide the how much data limit is acceptable for the firebase, as the IoT devices tend to generate continues data and this might overwhelm the firebase.
2. Flowchart in the figure 15 is a messy, authors can handle this using module concept to make it precise and summarize and presentable.
3. Provide a separate membership curve for both inputs of the fuzzification process i.e., Temperature and Humidity.
4. Text written inside the images is hard to read, improve the quality of images or increase the size of text written inside the images.
5. Correct typing and English mistakes like write 4th instead of 4th and others related mistakes.
6. What is meaning of word pegujian present at page 14 in section “C. Testing the impact of the tool on the room”

Additional Questions:
1) Does the paper contribute to the body of knowledge?: Yes, the improved version contributes to the body of knowledge.

2) Is the paper technically sound?: Yes, the updated manuscript is technically good.

3) Is the subject matter presented in a comprehensive manner?: Yes.

4) Are the references provided applicable and sufficient?: Yes, the references provided are relevant to the paper.

5) Are there references that are not appropriate for the topic being discussed?: No

5a) If yes, then please indicate which references should be removed.:

Reviewer: 2

Recommendation: Accept (minor edits)

Comments:
Please review some minor typos. example Line 12 "THE BASIC CONCEPTS" not CONSEPTS"

Additional Questions:
1) Does the paper contribute to the body of knowledge?: Yes, given the improvements, it can lead to further advanced research.

2) Is the paper technically sound?: Yes.

3) Is the subject matter presented in a comprehensive manner?: yes, given the

improvements applied by the author, it's now much clearer

4) Are the references provided applicable and sufficient?: yes

5) Are there references that are not appropriate for the topic being discussed?: No

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Tahap 5
Final Files Submitted, 09 January 2023

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Tahap 6
Published, 24 January 2023

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