Prototype of Lighting Intensity Administration in Work Room With Sound Control and Fuzzy Logic Control

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Article Info	ABSTRACT
	The use of indoor and outdoor lighting systems that are still passive makes the use of electrical energy less efficient and classified as wasteful. From the problems that occur in the system that is running, the researchers need to develop a more dynamic system by utilizing the Tsukamoto FLC method and Arduino using voice control to adjust the intensity of the light in the room. After implementing as well as testing the system that has been made, namely the Prototype of Light Intensity Regulator in the Work Room With Voice Control and Fuzzy Logic Control using NodeMCU ESP8266, it is concluded that each component can function according to its function which can be controlled and monitored from the application, implements fuzzy logic control on nodemcu with time and activity input variables obtained from the android application while the room light intensity variable is obtained from the light sensor or LDR. The results of the fuzzy process will adjust the light which is controlled by nodemcu. With the fuzzy logic control in this system, it can adjust the light to the room conditions, making it much more efficient.

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1. INTRODUCTION

Each room has a different level of light needs, starting from a room that requires low light intensity to a room that really needs high light intensity. The workspace is one of the users of adaptive light levels, the light needed by the workspace has its own standards. Starting from the workspace needed for presentations, for meetings, reading and more. Therefore it is necessary to arrange good lighting in each room.

Regarding indoor lighting, the amount of energy consumption in a room is about 20-30% of the total energy load of the building, because the lighting system is still passive (only using the on – off button) making the use of electrical energy more wasteful. From this problem, a research was carried out to create a tool that can regulate the light intensity of the room properly with the application of fuzzy logic control and voice control methods, the aim is to optimize the use of electrical energy for lighting in a room.

2. RESEARCH METHOD

Fuzzy Logic is a logic that has a fuzzy value between true (1) and false (0). Fuzzy logic theory was developed by prof. Lotfi Zadeh around 1960 with the determination of fuzzy logic sets. The fuzzy logic controller (FLC) provides a tool that is able to change the linguistic control strategy derived from the way of thinking of an expert into an automatic control strategy (Setyo, 2010). The fuzzy logic reasoning process can be seen in Figure 1.
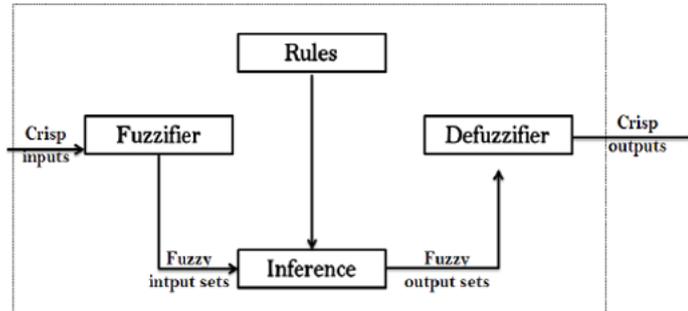

Figure 1. Fuzzy Logic Controller Architecture

The fuzzy membership function is a curve that shows the mapping of data input points into the degree of membership whose values range from 0 to 1. Several fuzzy membership functions are :
1. Linear Representation

Linear representation is the alignment of the input to the degree of membership described as a straight line. In linear representation there are two possibilities, namely:

a. The increase in the set starts at the domain value which has a membership degree of zero (0) moving towards the right towards the domain value which has a higher degree of membership. The depiction of an ascending linear curve can be seen in Fig 2.
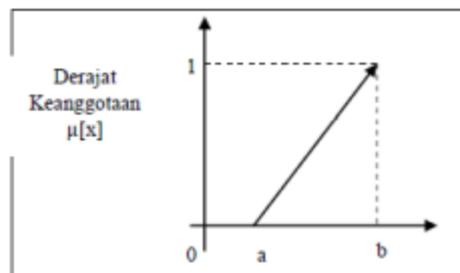

Figure 2. Linear Curve Representation Ascending

Function:

$$\mu[x,a,b] = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & x \geq b \end{cases} \qquad (1)$$

b. The decrease in the set starts from the domain value with the highest membership degree on the left side, then moves down to the domain value with the lower membership degree. The depiction of a descending linear curve can be seen in Fig 3.
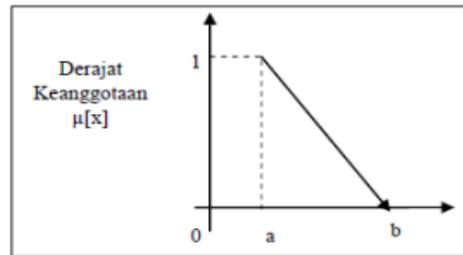
Figure 3. Descending Curve Representation Ascending

Function:

$$\mu[x, a, b] = \begin{cases} \dfrac{b-x}{b-a}, & a \leq x \leq b \\ 0, & x \geq b \end{cases} \qquad (2)$$

2. Triangle Curve Representation
    Triangle curves are basically formed from a combination of 2 lines (linear). The depiction of the triangular curve can be seen in Figure 4.
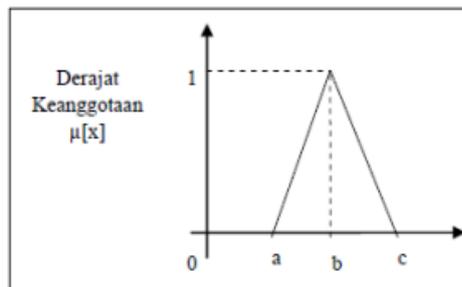

Figure 4. 11 Triangle Curve Representation

Function:

$$\mu[x, a, b] = \begin{cases} 0, & x \leq a \; atau \; \geq c \\ \dfrac{x-a}{b-a}, & a \leq x \leq b \\ \dfrac{c-x}{c-b}, & b \leq x \leq c \end{cases} \qquad (3)$$

a. Inference
    Once the membership functions for the input and output variables are determined, a control rule base can be developed to relate the controller output actions to the input conditions. This stage is referred to as the inference stage, which is the rule-setting part of the fuzzy logic system. A number of rules can be created to define the action of the fuzzy controller. Input and output variables can be related by the IF-THEN rules contained in the rule base. This IF-THEN rule will be represented as a fuzzy implication. In this inference process, we look for the minimum value (α-predicate) for each membership value based on the existing IF-THEN rule. Then look for the Z value based on the rule. In this case the value of Z is the price of gold to be forecast.

b. Defuzzification
    Defuzzification is a process that changes the action of a fuzzy set into a single value only (Kusumadewi & Purnomo, 2004). The input of the defuzzification process is a fuzzy set obtained from the composition of fuzzy rules, while the output produced is a number in the domain of the fuzzy set. So if given a fuzzy set within a certain range, it must be able to take a certain crisp value as the output (Cristiono, 2005). In the defuzzification process, the -predicate value will be multiplied by the Z value and then

totaled. This multiplication result is then divided by the sum of all -predicates to get the final Z value.

3.   RESULT AND DISCUSSION

In testing the prototype of the light intensity controller in the workspace with voice control and fuzzy logic control, it is done by trying to input veriable activities for light control with voice commands and displaying it. The activity variable has a set, namely work, presentation and rest. The prototype for controlling the intensity of the light in the workspace with voice control and fuzzy logic control uses control data, namely activities that function to input activity variables, timeInSecond functions to sync between the time on arduino and the time on android, and power which functions to turn the lights off and on. The results of testing the accuracy of control and object data can be seen from the following explanation.

3.1 System Planning

From the problems that occur in the current system, researchers need to develop a more dynamic system by utilizing the Tsukamoto FLC method and Arduino using voice control.
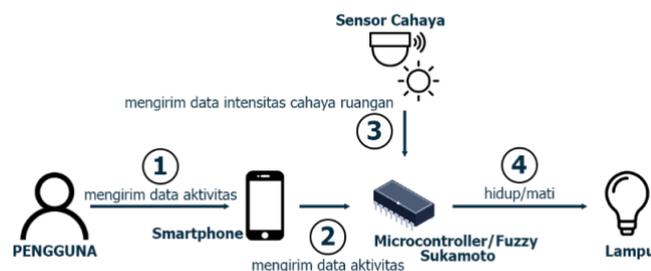

Figure 5. Planning System

In the analysis of the development of the new system, a system will be created where the user can control the lights with voice control. Control that can be done by the user on the lamp is to provide information on predetermined room activities such as "Work Mode", "Meeting Mode", "Presentation Mode" and "Break Mode".

3.2 Prototype

Making a prototype of the light intensity controller in the workspace with voice control and fuzzy logic control has several stages of the design process. At this first stage is to prepare tools and materials that serve to arrange the location of all components so that the components are neatly and structured. The next stage is the preparation of the main components in making a prototype for controlling the intensity of the lights in the workspace with voice control and fuzzy logic control, namely nodemcu and light sensors or LDR. Based on the components that have been mentioned, the NodeMCU circuit schematic can be made in fig 6.

How it works nodemcu which functions as a server and controls the lights with fuzzy logic control. The fuzzy logic control has input variables of time, activity, and room light intensity. The time input variable is obtained by synchronizing the time between Arduino and the application. The activity input variable is obtained from the input from the android application. While the light intensity input variable is obtained from the LDR. After these variables are obtained, nodemcu calculates the fuzzy logic control so that the required light is obtained. These steps are repeated until nodemcu is turned off.
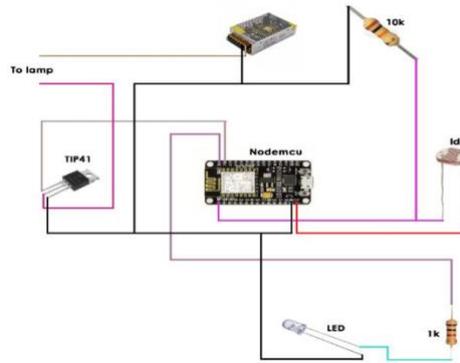
Figure 6. Prototype

3.3 Domain

The domain of the fuzzy set is the entire value that is allowed in the universe of conversation and may be operated in a fuzzy set. As with the universe of speech, the domain is a set of real numbers that always increases (increases) monotonically from left to right.

Table 1. Input Variable Domain

Variable	Set Input	Domain
Time	Morning	1-10
	Afternoon	9-16
	Evening	15 - 19
	Night	18 - 24
Activity	Presentation	100-300
	Break	250-450
	Work	300-750
Room Light Intensity	Dark	20-150
	Light	100-400
	Very Light	350-750

Table 2. Output Variable Domain

Light Intensity	Dark	20-150
	Light	100-400
	Very Light	350-750

3.4 Control Data Accuracy Test

The test below is carried out to measure the accuracy of the control of the system. The tests carried out are as follows:

Table 3. Control Data Accuracy Test

No	Control Data	Data	Arduino	Accuration
1	timeInSecond	11918	03.18.38	1
2	Mode	Presentation	107	1
3	Mode	Break	360	1

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4	Mode	Running	658	1
5	Power	On	Ligth On	1
6	Power	Off	Ligth Off	1

3.5 Fuzzy Logic Control Test

The test below is carried out to measure the accuracy of fuzzy logic control in the system. The tests carried out are as follows:

Table 4. Fuzzy Logic Control Test

No	Time	Activity	Light Room	Lamp Light	Accuracy
	(Time)	(Lux)	(Lux)	(Lux)	
1	00.23.09 (Morning)	400 (Break/Work)	129 (Light/Very Light)	230 (Light)	1
2	00:39:34 (Morning)	333(Break/Work)	129 (Light)	194 (Light)	1
3	00.47.10 (Morning)	134 (Presentation)	49 (Dark)	48 (Dark)	1
4	05:40:13 (Morning)	287 (Presentation/Break)	51 (Dark)	452 (Very Light)	1
5	05.45.58 (Morning)	516 (Work)	129 (Dark/Ligth)	420 (Very Light)	1
6	11:36:03 (Afternoon)	258 (Presentation / Break)	25 (Dark)	201 (Dark)	0
7	12:35:29 (Afternoon)	289 (Presentation / Break)	88 (Dark)	469 (Very Light)	1
8	13:47:52 (Afternoon)	420 (Work/Break)	715 (Very Light	113 (Dark)	1
9	15.12.46 (Afternoon/Evening)	525 (Work)	593 (Light/Very Light)	126 (Dark)	1
10	22.46.04 (Evening)	190 (Presentation)	277 (Light)	78 (Dark)	1

Based on the comparison table below, it can be analyzed and concluded that if using fuzzy the light intensity will vary, such as if the light is very dark, the light intensity will be brighter, while without using fuzzy the light intensity will always be the same from morning to night. The comparison efficiency that can be taken from the table above is 22.7%, which means the light intensity with fuzzy is more efficient than the light intensity without fuzzy. Here's a comparison table:

Table 5. Room Light Intensity Comparison

Time	Activity	Light Room	Light Room Intensity	
			Fuzzy	Without Fuzzy
07:00 (Morning)	Break	76 (Dark)	361 (Very Light)	500 (Very Light
08:00 (Morning)	Work	33 (Dark)	438 (Very Light)	500 (Very Light)

09:00 (Morning /Afternoon)	Work	94 (Dark)	394 (Very Light))	500 (Very Light)
10:00 (Morning /Afternoon)	Kerja	179 (Light)	466 (Very Light))	500 (Very Light)
11:00 (Afternoon)	Work	212 (Light)	578 (Very Light))	500 (Very Light)
12:00 (Afternoon)	Break	130 (Dark/light)	194 (Light)	500 (Very Light)
13:00 (Afternoon)	Presentation	143 (Dark/light)	116 (Dark)	500 (Very Light)
14:00 (Afternoon)	Presentation	33 (Dark)	75 (Dark)	500 (Very Light)
15:00 (Afternoon / Evening)	Presentation	69 (Dark)	112 (Dark)	500 (Very Light)
16:00 (Afternoon / Evening)	Break	66 (Dark)	524 (Very Light))	500 (Very Light)
17:00 (Evening)	Work	254 (Light)	738 (Very Light))	500 (Very Light)
18:00 (Evening)	Break	150 (Light)	118(Dark)	500 (Very Light)
19:00 (Evening)	Work	30 (Dark)	418 (Very Light))	500 (Very Light)
20:00 (Evening)	Work	35 (Dark p)	482 (Very Light))	500 (Very Light)
21:00 (Evening)	Work	33 (Dark)	550 (Very Light))	500 (Very Light)
22:00 (Evening)	Work	32 (Dark)	618 (Very Light))	500 (Very Light)

3.6 Analysis of Test Results

In the prototype of the light intensity controller in the workspace with voice control and fuzzy logic control, overall testing has been carried out which can function as expected. This system is made using NodeMCU ESP8266 as a microcontroller. This prototype is also equipped with fuzzy logic control to determine the light as needed.

After implementing as well as testing the system that has been made, namely the prototype of the light intensity controller in the workspace with voice control and fuzzy logic control using the NodeMCU ESP8266, it is concluded that each component can function according to its function which can be controlled and monitored from the application.

The following is the roof side of the design of the prototype tool for controlling the intensity of the lights in the workspace with voice control and fuzzy logic control:

Fig 7. Roof Side

The following is the indoor side of the design of the prototype tool for controlling the intensity of the lights in the workspace with voice control and fuzzy logic control:

Fig 8. Indoor Side

4. CONCLUSION

From the results of the prototype design of the light intensity regulator in the workspace with voice control and fuzzy logic control, it can be concluded as follows:

1. Implementing fuzzy logic control on nodemcu with time input variable and activities obtained from the android application while the room light intensity variable is obtained from the light sensor or LDR. The results of the fuzzy process will adjust the light which is controlled by nodemcu
2. With the fuzzy logic control in this system, it can adjust the light to the room conditions, making it more efficient

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