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COMPARATIVE ANALYSIS OF MAMDANI AND SUGENO'S FUZZY INFERENCE METHOD ON ROOM LIGHT CONTROL PROTOTYPE

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ABSTRACT

Fuzzy Logic can be applied to the field of control systems. The advantage of using Fuzzy Logic is that it is easy to calculate because it combines mathematical equations and natural language. Therefore, Fuzzy Logic overcomes the weakness of the On/Off control system. Likewise, Fuzzy Logic overcomes the complexity of mathematical modeling on PID control. However, Fuzzy Logic is not suitable to be applied to control systems that require high accuracy. In this study, Fuzzy Logic will be applied to the control of room light, where in the room there are two light sources, namely lamp light and outside light. The problem is how the room light illuminance is always in the set point range with a tolerance of 25 lux and in steady state conditions. The application of light control is appropriate because it does not require high accuracy where a slight change in light illuminance has no effect. In this study, a comparison was made between the Mamdani and Sugeno inference methods. The limitation of control parameters is on the response of the control system to the set point. The results obtained are the control system response shows that there is a smaller error in the Sugeno method than the Mamdani method.

Keywords: room light, illuminance, fuzzy logic, mamdani, sugeno

1. INTRODUCTION

Fuzzy logic overcomes the weakness of the On/Off control system, which can only provide two output conditions, namely 0% or 100%. In the application of fuzzy to light control which does not require high accuracy, then the simple concept of fuzzy logic overcomes the complexity of mathematical modeling of "proportional-integral-derivative (PID)" control systems. PID control shows its limitations as light control management with sunlight contribution. By taking into account the random pattern of sunlight that is potentially available during the day and its rapid changes, the fuzzy control characteristics have proven to be an effective solution .

Fuzzy logic has several inference methods used, namely mamdani and Sugeno inference methods. In this study, a comparison is made between the two methods, especially in system response. The case study in this research is on controlling room light with the contribution of sunlight.

A good room should get enough and even sunlight, because sunlight can kill bacteria, viruses and eliminate mold. On the other hand, the room must have lighting. If the outside light that comes in is at its maximum (during the day) and the lights are still on, the room will be very bright and the room temperature will be hot. Each room has a need for different lighting levels, depending on the type of activity in the room. Lighting is the amount of radiation in a work area needed to carry out activities effectively [5]. For example, a workspace with computer operating activities requires a minimum lighting level of 300 Lux, a room with image-making activities requires a minimum of 500 Lux. By combining the need for incoming sunlight and the need for sufficient and stable lighting, it is necessary to set the lamp so that the light produced is proportional to the contribution of the incoming light. In the room light output obtained, it does not require high accuracy, meaning that the difference in light on the assumption of a range of 5 lux has no significant effect.

There have been many researches on light regulation using fuzzy logic. In this study, an external sensor was added, and an analysis was carried out on the past system response and error to the set point.

2. METHODS

Hardware Design

At the design stage of the room light control prototype, it is illustrated in the hardware design block diagram of Figure III-1. The Light Control System is applied to a rectangular box with the front having a cavity (window) for the entry of outside light.

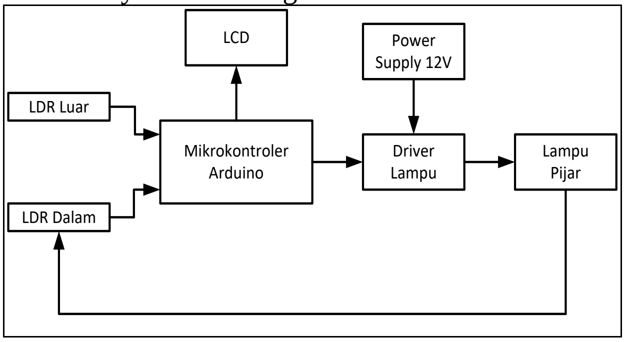

Figure 1 : Hardware design block diagram

It can be explained how the flow of the schematic diagram of the design that has been made in Figure III-1 can be explained.

1) Inside LDR sensor as input 1 to read light illuminance, namely sunlight entering the room and indoor lights.
2) External LDR sensor as input 2 to read sunlight illuminance
3) Microcontroller to accept analog input in the form of voltage and convert it to digital. The digital input data is then processed based on fuzzy control logic algorithms and forwarded to the output in the form of a PWM signal.
4) Lamp Driver, to adjust the light dim level, the lamp driver gets input from the microcontroller.
5) Incandescent lamp, is an object whose light intensity will be controlled.
6) LCD, as a display to display information on the measured variables.

Software Design

The software design includes a program in C language that will be uploaded to Arduino. To make it easier to make the program, the algorithm below is made and the program flowchart is as shown in Figure 1.

Determine the set point

While there are people in the room If the illumination is between (setpoint)-25 And (setpoint)+25 Then Use pwm value to control the lights Else Use fuzzification to control the lights

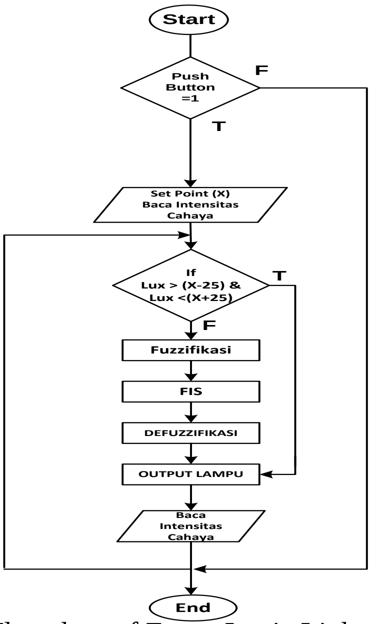

Figure 2: Flowchart of Fuzzy Logic Light Control System

a. Fuzzification

Fuzzification there are 2 parts, namely input and output. Input LDR Outside and LDR Room will be divided into 5 variables, namely: Dark, Somewhat Dim, Dim, Somewhat Bright, and Light with a measurement range of 0-350 Lux.

1) Input (Mamdani and Sugeno)

The LDR A and LDR B sensors have the same membership function form as in Figure 6.

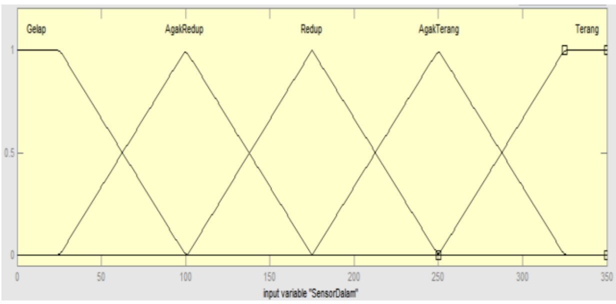

Figure 3 : Membership Functions of LDR A & LDR B Input Input

Dark Membership Function (G)

$\mu g(X) = 1 \quad ; \quad 0 \leq X \leq 25$ (6)

$\mu g(X) = (100 - X) / 75 \; ; 25 < X \leq 100$ (7)

Fungsi Keanggotaan Agak Redup (AR)

$\mu AR(X) = (X - 25) / 75 ; \quad 25 \leq X \leq 100$ (8)

$\mu AR(X) = (175 - X) / 75 \quad ; 100 < X \leq 175$ (9)

Slightly Dim (AR) Membership Function

$\mu R(X) = (X - 100) / 75 \; ; 100 \leq X \leq 175$ (10)

$\mu R(X) = (250 - X) / 75 \; ; 175 < X \leq 250$ (11)

Moderately Bright Membership Function (AT)

$\mu AT(X) = (X - 175) / 75$; $175 \leq X \leq 325$ (12)

$\mu AT(X) = (325 - X) / 75$; $250 < X \leq 325$ (13)

Light Membership Function (T)

$\mu T(X) = (X - 250) / 75$; $250 \leq X \leq 325$ (14)

$\mu T(X) = 1$; $325 < X \leq 350$ (15)

Mamdani Output

The output of the system is also divided into 5 variables, namely extinguished, somewhat dim, dim, rather bright, as shown in Figure 4.

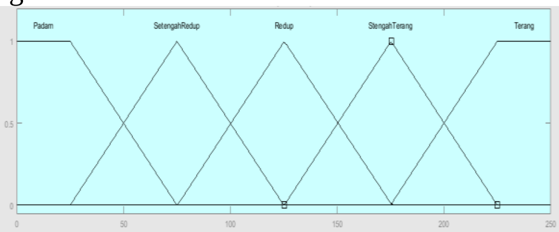

Figure 4: Mamdani Output Membership Function

membership function for each variable as follows:Variabel Padam (P)

$\mu P(X) = 1$; $0 \leq X \leq 25$ (16)

$\mu P(X) = (75 - X) / 50$; $25 < X \leq 75$ (17)

Variable Half Dim (AR)

$\mu SR(X) = (X - 25) / 50$; $25 \leq X \leq 75$ (18)

$\mu SR(X) = (125 - X) / 50$; $75 < X \leq 125$ (19)

Variable Dim (R)

$\mu R(X) = (X - 75) / 50$; $75 \leq X \leq 125$ (20)

$\mu R(X) = (175 - X) / 50$; $125 < X \leq 175$ (21)

Half Bright Variable (ST)

$\mu ST(X) = (X - 125) / 50$; $125 \leq X \leq 175$ (22)

$\mu ST(X) = (125 - X) / 50$; $175 < X \leq 22$ (23)

Bright Variable (T)

$\mu T(X) = (X - 175) / 50$; $175 \leq X \leq 225$ (24)

$T(X) = 1$; $225 < X \leq 250$ (25)

Sugeno Output

The output of the system is also divided into 5 variables, namely extinguished, slightly dim, dim, slightly bright, each of which is a constant state variable.

Figure 5: Membership Function Output Sugeno

b. Fuzzy Inference System (FIS)

Mamdani Rules Base

SL / SD	Dark	Slightly Dim	Dim	Slightly Bright	Bright
Dark	Bright	Bright	Half	Dim	Dim
Slightly Dim	Bright	Half	Bright	Dim	Half
Dim	Half	Bright	Dim	Half	Dim
Slightly Bright	Bright	Dim	Dim	Dim	Half
Bright	Dim	Dim	Half	Half	Dim

3. RESULTS AND DISCUSSION

Design Implementation

a. Schematic Diagram

From the block diagram in the image, it is implemented into a schematic diagram in the image

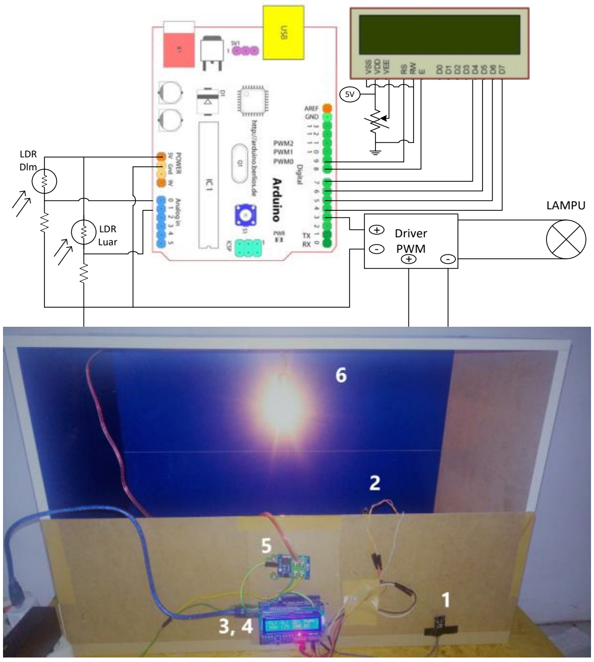

Figure 6: Schematic Diagram

Control System Response Test

The test was conducted to determine the response of the Mamdani and Sugeno fuzzy control system, u b. Method of Testing the illuminance set point is determined at 300 lux, based on Permenkes No. 70 of 2016, regarding workspace lighting. External light in the form of a flashlight or flash will contribute to the room (prototype) of outdoor light from around 0 Lux to 300 Lux. The response of the room light control system will be observed. Will calculate the illuminance error in the light, the error is calculated against the set point value. The tolerance value of the system response according to Cziker Andrei et al. (2007). error not more than 25 Lux or 8.3%.

a. Mamdani Inference Control System Response

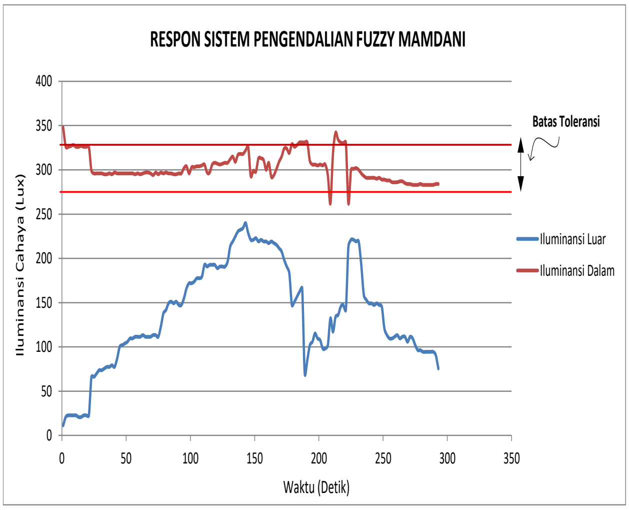

Figure 7: Mamdani inference system response graph

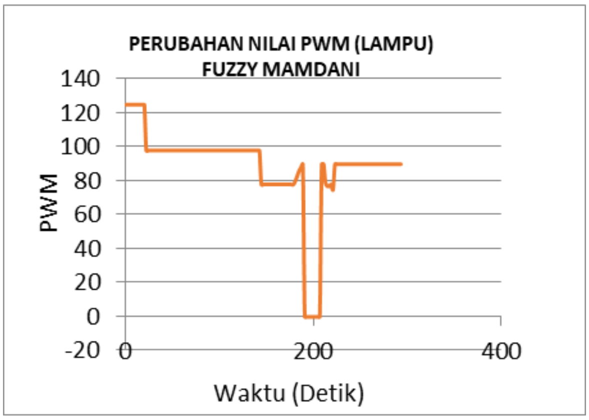

Figure 8: Changes in PWM . value

b. Sugeno Inference Control System Response

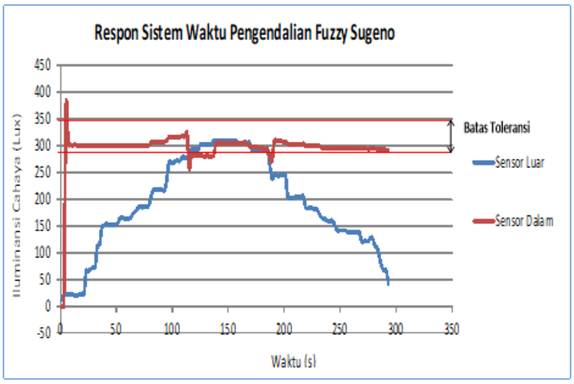

Figure 9: Sugeno inference system response graph

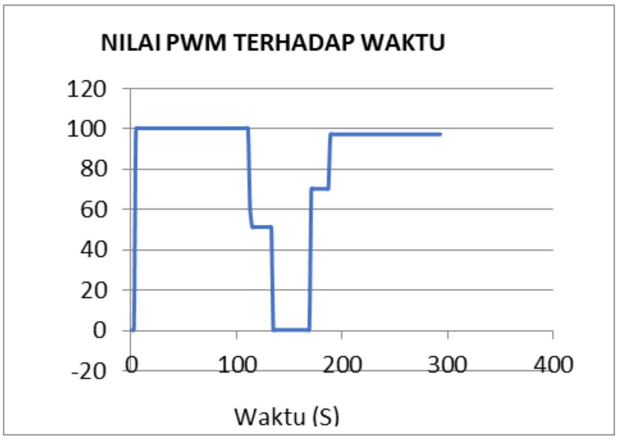

Figure 10: Changes in Sugeno Inference PWM value

4. Conclusions

For the prototype built, (hardware and fuzzy algorithm) has shown good performance, indicated by the accuracy of the fuzzy output (crisp value) compared to the matlab output as a reference. Average error of fuzzy output on prototype to matlab output: Mamdani method, the average error of this test is 1.06%. Sugeno method, the average error of this test is 1.65%. Comparison of Fuzzy Logic Mamdani and Sugeno methods Both inference methods can control light well, indicated by the average error of the set point below the tolerance limit of 8%. For the Mamdani method the average error is 4% and Sugeno is 2%. When there is a change in the external light illuminance (IL) value or the input signal interference occurs, the internal illuminance (ID) value overshoots for a while and is immediately at steady state (stable) in the set point range.

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