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Fuzzy logic control implementation on arduino uno based automatic window system

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A B S T R A C T

The window is the most important unit in building construction as a place for light and air circulation from inside and outside the building. Technological advances greatly affect everyday human life, humans are greatly facilitated by the presence of technology, one of which is the merging of windows with technology into Automatic Windows that can open and close automatically using Photodiode as input with Arduino Uno as a control system. Using fuzzy logic as a basis for decision makers in different circumstances at one time is very suitable as a method in this research.

I. Introduction

Windows are openings in the walls of buildings, cars and so on. To allow air and light to enter, windows are usually filled with sheets of glass. Regular windows have many different shapes, such as triangles, squares, circles or irregular shapes [1].

Advances in technology make people compete in creating the latest innovations in the use of technology so that in the current era it is known as the era of automation.

An automated system can be defined as a technology related to the application of mechanical, electronic and computer-based systems (computers, PLCs or micros). Everything is combined into one to provide a function to the manipulator (mechanics) so that it will have a certain function. So an automatic system is a tool that can do work by itself according to the program that has been given to the tool [1].

Merging windows that work manually with technology produces a system called an automatic window which we will discuss in this study.

This tool uses a photodiode as a sensor. Photodiode is a semiconductor light sensor that can convert light into electrical quantities. The photodiode is made of a p-n junction semiconductor, so the light absorbed by the photodiode will cause a shift in photons which will produce electron-hole pairs on both sides of the junction [2]. Processed using Arduino uno as a controller. Arduino Uno is a microcontroller board based on ATmega328[3]. Then, the output will drive the DC motor. DC motor is a device that converts electrical energy into kinetic energy or movement (motion) [4].

Using fuzzy logic as a research method is very suitable for different decision makers at one time in this study

II. Method

The research method used in this research is fuzzy logic. In classical logic it is stated that everything is binary, which means it only has two possibilities, "Yes or No", "True or False", "Good or Bad" and others. Therefore, this system can have a membership value of 0 or 1. However, fuzzy logic allows the membership value to be between 0 and 1. This means that a situation may have two values "Yes and No", "True and False". , "Good and Bad" simultaneously, but the value depends on the weight of the membership it has [5].

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However, in fuzzy logic it has a range of linguistic variables between 0-1 so that it can make decisions with more than two linguistic variables.

Several reasons that can be stated why we use fuzzy logic include being easy to understand, having tolerance for imprecise data, being able to model very complex nonlinear functions, being able to build and apply the experiences of experts directly without having to go through training process, can work together with conventional control techniques, and is based on natural language [5].

Figure 1. shows a block diagram that provides an explanation of how the system works as a whole.

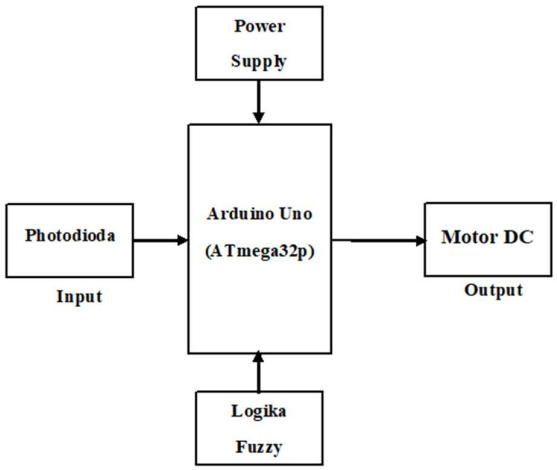

Figure 1. Block Diagram Tool

In this study, fuzzy logic is used as a decision maker by using two linguistic variables as decision makers, namely dark and light. The range of linguistic variables to be used are listed in Table 1.

Table 1. Fuzzy Set

No.	Variabel	Keterangan
1	Gelap	0
2	Terang	1

With this value, when the photodiode detects light (bright), the system will order the window to close automatically. Conversely, when the window does not detect light (darkness), the system will order the window to automatically open.

2.1. Mechanical Design

The automatic window mechanical design is shown in the following figure.

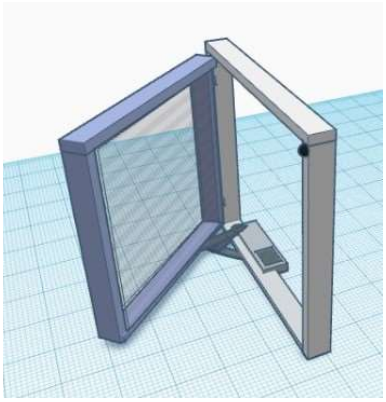

Figure 2. Overall View of the Automatic Window Mechanical Design

In Figure 2 the photodiode is placed in the upper right corner as a sensor, then the arduino microcontroller will be placed on the wall of the building. DC motor is placed in the lower left corner of the window to close and open automatically.

2.2. Electrical Design

Sub-headings do not need to be notated with the third heading level. Sub-chapters can be different, according to the type or research approach used.

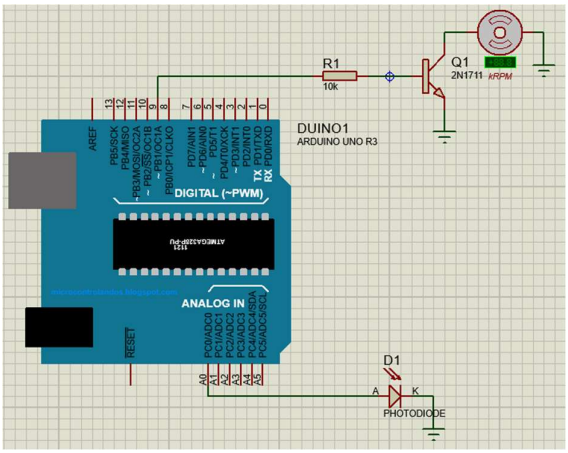

Figure 3. Schematic diagram

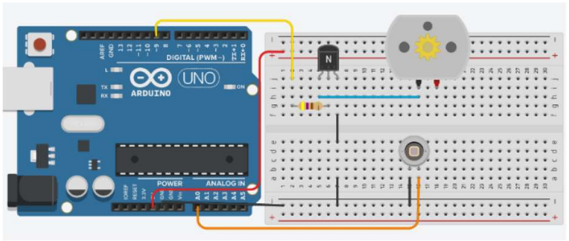

Figure 4. System Design

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In Figure 2. shows the results of a schematic diagram using the proteus application, while in Figure 3. shows the system design using the TinkerCAD application. There is one photodiode that is used as a sensor, then the brain of the system is arduino uno, a transistor as a DC motor amplifier, and a DC motor as a window driver to open and close automatically.

2.3. PIDs design

The following are the predetermined values of Kc, τI, and τD, namely:

$$Kc = \left(\frac{1}{K}\right)\left(\frac{\tau}{\theta}\right)\left(\frac{(16\tau+3\theta)}{12\tau}\right) \quad (1)$$

$$Kc = \left(\frac{1}{2.171875}\right)\left(\frac{706.5}{143.5}\right)\left(\frac{(16*706.5+3*143.5)}{12*706.5}\right)$$

Kc = 3.137593061

$$\tau I = \frac{\theta\left(32+\left(\frac{6\theta}{\tau}\right)\right)}{\left(13+\left(\frac{8\theta}{\tau}\right)\right)} \quad (2)$$

$$\tau I = \frac{143.5\left(32+\left(\frac{6*143.5}{706.5}\right)\right)}{\left(13+\left(\frac{8*143.5}{706.5}\right)\right)}$$

τI = 325.9425599

$$\tau D = \frac{4\theta}{\left(11+\left(\frac{2\tau}{\tau}\right)\right)} \quad (3)$$

$$\tau D = \frac{4*143.5}{\left(11+\left(\frac{2*706.5}{706.5}\right)\right)}$$

τD = 44.15384615

Sehingga nilai Kp, Ki, dan Kd adalah sebagai berikut:

Kp = Kc

Kp = 3.137593061

$$Ki = \frac{Kc}{\tau I} \quad (4)$$

Ki = 3.137593061/325.9425599

Ki = 0.009626215

Kd = Kc*τD

Kd = 3.137593061*44.15384615

Kd = 138.5368013

III. Results and Discussion

Fuzzy logic is generally applied to problems that contain elements of uncertainty (uncertainty), imprecise (imprecise), noisy, and so on. Fuzzy logic bridges precise machine language with human language which emphasizes meaning or meaning (significance). Fuzzy logic was developed based on the human way of thinking.

When compared to conventional logic, the advantage of fuzzy logic is its ability to process language reasoning so that its design does not require complicated mathematical equations. Several reasons that can be stated why we use fuzzy logic include being easy to understand, having tolerance for imprecise data, being able to model very complex nonlinear functions, being able to build and apply the experiences of experts directly without having to go through training process, can work together with conventional control techniques, and is based on natural language [5].

In Figure 5. Shows a flowchart that will explain how the system works clearly and briefly.

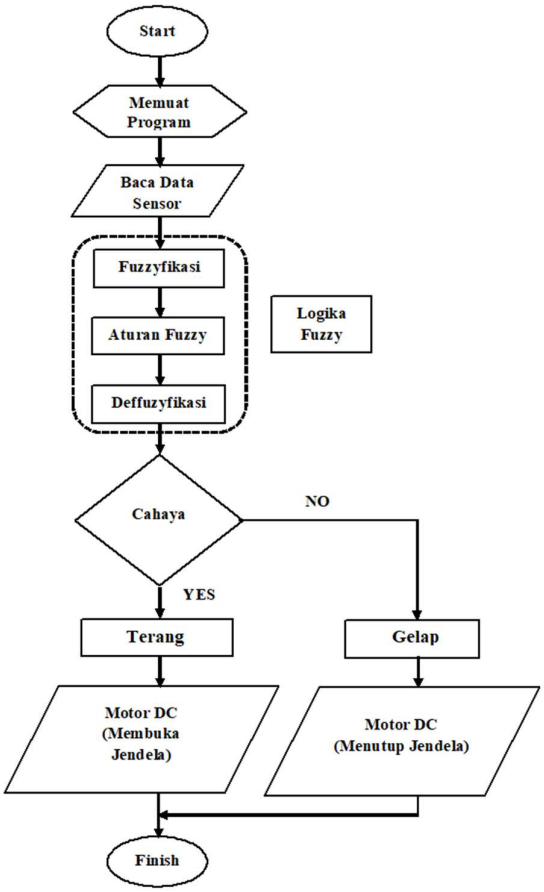

Figure 5. System Flowchart

This study has two linguistic variables namely "Dark" and "Light" as system input. In Table 2, Figures 6 and 7 show the fuzzy rules, input, and output systems used. The fuzzy control method used is Takagi-Sugeno.

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Table 2. Automatic Window Fuzzy Logic Rules

Photodiode input	DC Motor Outputs
Bright	Open
Dark	Close

The results of the fuzzy set have a process system, the process system includes fuzzyfication, which is the rule used by the fuzzy system which changes the input value or input whose truth value is definite (crisp input) into fuzzy, which is a linguistic value [6] that is used, namely " Dark and bright"

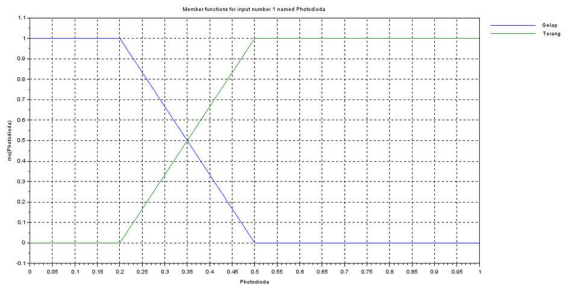

Figure 6. Membership Function Input from Scilab Simulation

Artificial neural network is a method of grouping and separating data whose working principle is the same as neural networks in humans. The fundamental element of this paradigm is the new structure of the information processing system. Artificial neural networks are formed to solve a particular problem such as pattern recognition or classification due to the learning process [7].

In Figure 9. A total network error graph is depicted from the results of the neural network training shown in Figure 8. according to the truth table in table 3.

Table 3. Truth Table

Input	Output
0	0
1	1

The working process of a neural network is to describe and classify different forms of several known populations, so that these populations are properly separated and can determine the distinguishing function between groups and classify new objects into classes or groups. In accordance with the working system above, the neural structure The network consists of three layers, namely input layer, hidden layer and output layer. Each layer is given a weight that will transform input values into output values. Each layer consists of several neurons and between these neurons will be connected with other neurons in the nearest layer [7].

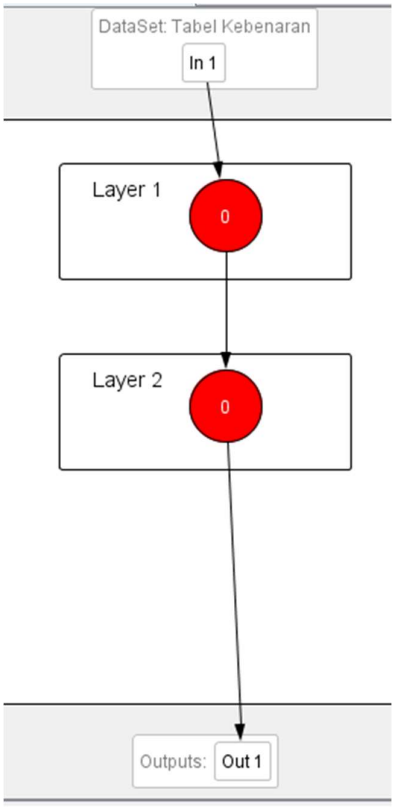

Figure 7. Figure 8. NN that has been simulated on Neuroph

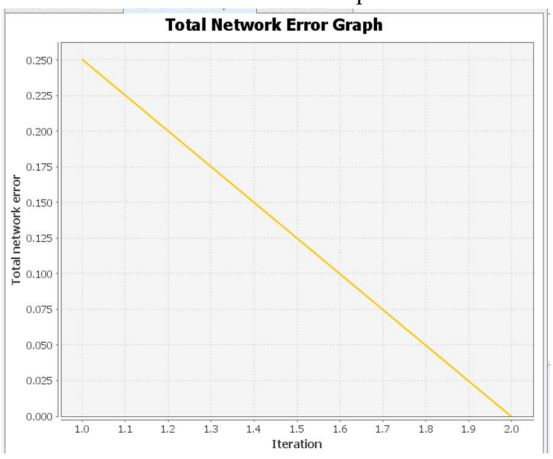

Figure 8. Figure 9. Total Network Error Graph

IV. Conclusion

From the research that has been done, this tool is designed as one of the benefits of technology in the era of automation by opening and closing automatically which helps human effectiveness. Process control on this tool using fuzzy logic method. This fuzzy logic method is very helpful in getting accurate decision results in a short time

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