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Simulation and design of smart clothesline using fuzzy for weather forecast

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Abstract. Information about weather is very important for human life. For this reason, a weather prediction system is needed that can read predictions correctly. One of the correct prediction systems is fuzzy systems. Fuzzy systems are used because they can make accurate and accurate weather predictions like human logic. The system used needs to be simulated to obtain the right model. The right software to simulate is Simulink MATLAB. In this study will take the DHT 22 and LDR (Light Dependent Resistor) sensor data from Arduino which will be processed by Simulink MATLAB using the Fuzzy Mamdani system. From the experiments conducted, we managed to make a simulation of predicting the weather using Mamdani fuzzy logic. The defuzzification results from this study can be used to control motors, heaters, etc.

1. Introduction

Human activity is strongly influenced by weather conditions in the region. For example, information about climate can represent agricultural conditions in the region, especially if a country is very dependent on agriculture as one of national security. Seasonal changes can affect farmers' cropping patterns in growing crops. In addition to agriculture, tourism and aviation require information about weather conditions [1]. Information about weather conditions is very important in human life because it can be useful to know the upcoming weather conditions so that we can anticipate the impact. Therefore, information about weather forecasting is very necessary for decision making in carrying out activities or human work [2]. Meanwhile, climate change is currently very difficult to predict. One solution is to predict the weather with a fuzzy logic system, because it is more effective and accurate [3],

There are several examples of systems that use fuzzy applications such as heat exchanger [4], cameras, camcorders, washing machines, microwave ovens for industrial process control, medical instrumentation, decision support systems, and portfolios selection [5].

The advantages of fuzzy logic compared to classical logic are in fields such as artificial intelligence where simple true or false statements are not enough, and it can model ordinary linguistic variables which may be imprecise or vague in nature at a cognitive level [6]. In addition, Fuzzy Logic is very helpful in guiding computer to find the right thing to measure and count [7]. There are several studies related to weather prediction including, fuzzy logic to predict rain to estimate water levels to avoid flooding [8], fuzzy logic system to predict the weather for general farming [9], and Weather Prediction Application Based on ANFIS (Adaptive Neural Fuzzy Inference System) Method in West Jakarta Region [1],

In this paper, we will make the simulation from the weather prediction system. In the paper A. Daniadi et al, (2016), using a fuzzy logic system to investigate the influence of weather on electrical

loads [10], simulations are carried out with Simulink MATLAB using input from the constant in Simulink MATLAB which is then processed by fuzzy, in this study will use inputs in real terms. The simulation will take the real sensor data from temperature sensor, humidity sensor, and light sensor that can produce reliable rule conditions using a fuzzy system to predict the weather system. The system can be applied to protect hydroponic plants from weather conditions such as rain, cloudy or heat.

2. Methodology

As shown in Figure 1, the concept of a weather prediction system is to take sensor data from Arduino to be processed into a fuzzy system in MATLAB which is then used to determine weather conditions.
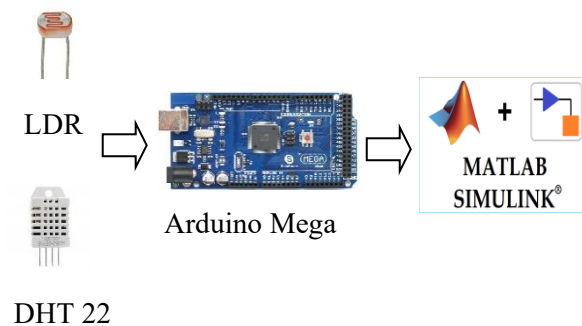

Figure 1. System Design

2.1. Sensor system

There are two sensors in this weather prediction system. In the picture. 2 is DHT 22, this sensor is used to read the temperature and humidity in the surrounding environment. Next in Figure 3 is the LDR (Light Dependent Resistor), a sensor that is used to read the value of light intensity in the surrounding environment.

Figure 2. DHT 22

Figure 3. LDR

2.2. Fuzzy System

The Fuzzy Logic algorithm is used to determine whether predictions. On picture. 4 is shown in the diagram process fuzzy logic algorithm. In this study using the Mamdani fuzzy system and using 3 variable inputs, namely temperature, humidity, and light intensity. Temperature input variables have 2 linguistic variables namely low and high. The humidity input variable has 2 linguistic variables namely low and high. While the light intensity has 3 linguistic variables, namely dark, dim and bright. This study also has a weather output varibales with a cloudy and bright linguistic variable. Fuzzy logic algorithm linguistic values are determined from each variable. Fuzzification the module will map numeric values to fuzzy sets. Input value will be converted into fuzzy input as a linguistic value.
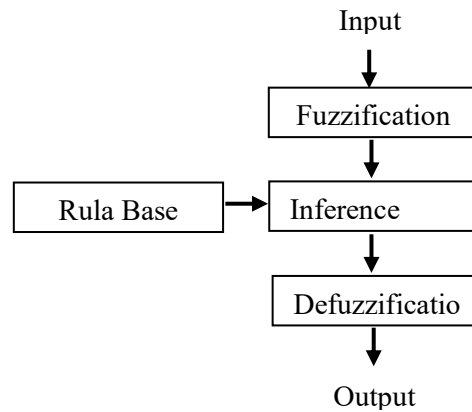
Input

Fuzzification

Rula Base → Inference

Defuzzificatio

Output

Figure 4. The Diagram Process Fuzzy Logic Algorithm

Figure 5 shows the fuzzy input membership function of the temperature parameter.
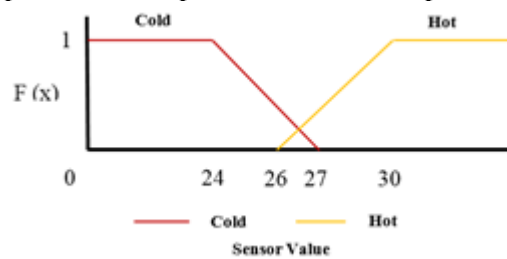

Figure 5. Member Function Graphic of Temperature

From the graph, the function member of temperature parameter (Fig. 5), the formula for determining linguistic values the temperature is cold and hot can be seen as follows

$$Cold = \begin{cases} 0, & x \leq 0 \\ 1, & 0 \leq x \leq 24 \\ \frac{27-x}{27-24}, & 24 \leq x \leq 27 \end{cases} \quad (1)$$

$$Hot = \begin{cases} 0, & x \leq 26, x \geq 50 \\ \frac{x-26}{30-26}, & 26 \leq x \leq 30 \\ 1, & 26 \leq x \leq 30 \end{cases} \quad (2)$$

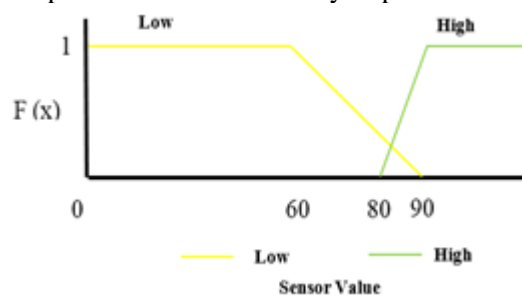In Figure 6 is a membership function of the fuzzy input from humidity parameter.

Figure 6. Member function Graphic of Humidity Parameter

From the graph, members of the function of humidity parameters (Fig. 6), the formula for determining linguistic values of low and high temperatures can be seen as follows.

$$Low = \begin{cases} 0, & x \leq 0 \\ 1, & 0 \leq x \leq 60 \\ \frac{90-x}{90-60}, & 60 \leq x \leq 90 \end{cases} \quad (3)$$

$$High = \begin{cases} 0, & x \leq 80, x \geq 100 \\ \frac{x-80}{90-80}, & 80 \leq x \leq 90 \\ 1, & 90 \leq x \leq 100 \end{cases} \qquad (4)$$

In Figure 7 is a membership function of the fuzzy input from light intensity parameter.
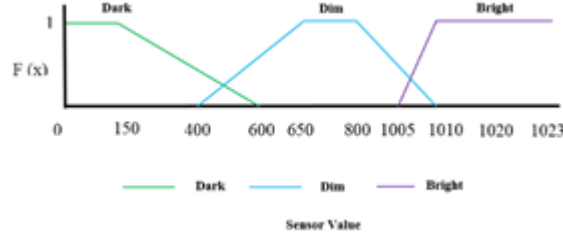

Figure 7. Member function Graphic of Light Intensity Parameter

From the graph, members of the function of light intensity parameters (Fig. 7), the formula for determining linguistic values of dark, dim and bright light intensity can be seen as follows.

$$Dark = \begin{cases} 0, & x \leq 0 \\ 1, & 0 \leq x \leq 150 \\ \frac{600-x}{600-150}, & 150 \leq x \leq 600 \end{cases} \qquad (5)$$

$$Dim = \begin{cases} 0, & x \leq 400, x \geq 1010 \\ \frac{x-400}{650-100}, & 400 \leq x \leq 450 \\ 1, & 650 \leq x \leq 800 \\ \frac{1010-400}{1010-800}, & 800 \leq x \leq 1010 \end{cases} \qquad (6)$$

$$Bright = \begin{cases} 0, & x \leq 1005, x \geq 1023 \\ \frac{x-1005}{1020-1005}, & 1005 \leq x \leq 1020 \\ 1, & 1020 \leq x \leq 1023 \end{cases} \qquad (7)$$

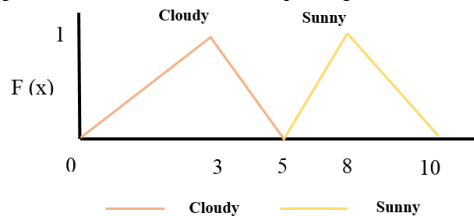In Figure 8 is a membership function of the fuzzy output from defuzzification.

Figure 8. Member function Graphic of Defuzzyfication

From the graph, members of the function of defuzzyfication (Fig. 8), the formula for determining linguistic values of cloudy and sunny from fuzzification can be seen as follows.

$$Cloudy = \begin{cases} 0, & x \leq 0 \\ \frac{x}{3}, & 0 \leq x \leq 3 \\ \frac{5-x}{5-3}, & 3 \leq x \leq 5 \end{cases} \qquad (8)$$

$$Sunny = \begin{cases} 0, & x \leq 0 \\ \frac{x-5}{8-5}, & 5 \leq x \leq 8 \\ \frac{10-x}{10-8}, & 8 \leq x \leq 10 \end{cases} \qquad (9)$$

After the fuzzification process, then continue the inference process. In the inference module simulated decision making based on fuzzy concepts using rules of knowledge. The rule can be determined by combining all linguistics of all variables. The output of the inference process is the feasibility value. We have 12 fuzzy rules based on a combination of linguistic variables and weather prediction system knowledge. The rule base fuzzy in the can be seen in Figure 9.
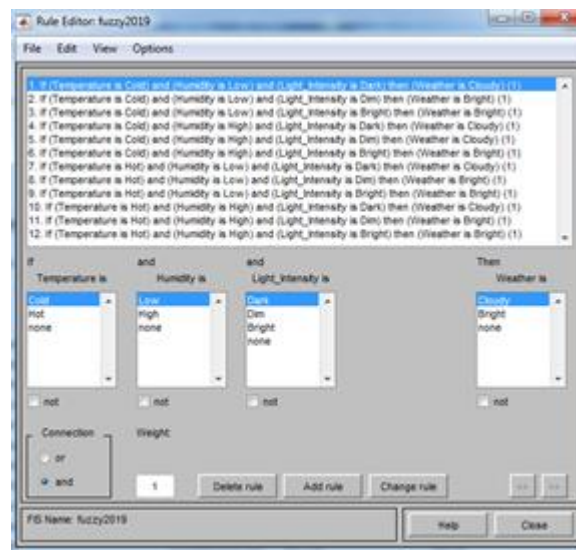
Figure 9. Rulebases System

After the inference process, the next is the defuzzification process. The defuzzification process use the Centroid Method (Center of Gravity). Formula from The Centroid method is:

$$z^* = \frac{\int ux\,(z)z\,dz}{\int ux\,z\,dz} \tag{10}$$

A set of sample points needs to be taken to use the equation. The more samples are taken, the more accurate the results will be.

3. Results and Analysis

Simulations carried out in this study use data from Arduino that has been connected with DHT22 and LDR sensors. Simulink in MATLAB reads data in real time from Arduino then processes it using a fuzzy system then produces defuzzification value which is then used to control output. Matlab Simulink simulation can be seen in Figure 10.
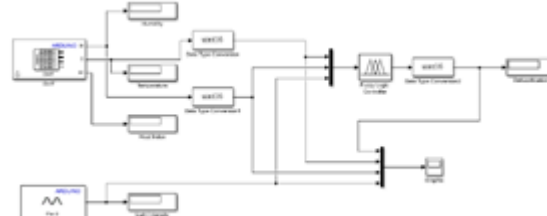

Figure 10. Simulink MATLAB System

Simulation is done to determine the results calculation algorithm using fuzzy logic. In this case, the temperature value is 25, the humidity value is 70, and the value of light intensity is 700. First, fuzzification module maps numeric values into fuzzy sets or fuzzy input (Figure 11-15).
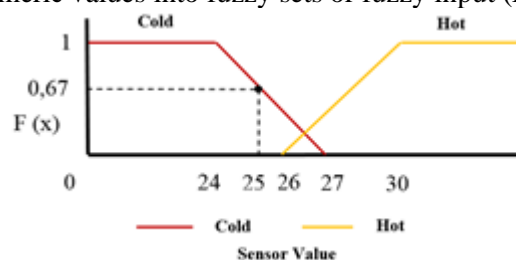

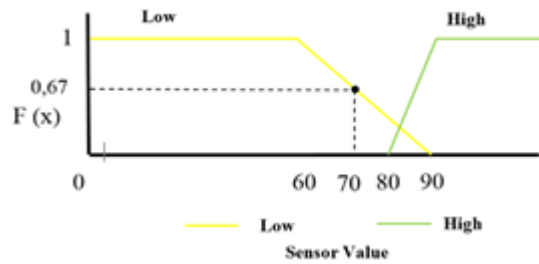
Figure 11. Graph of Temperature Value
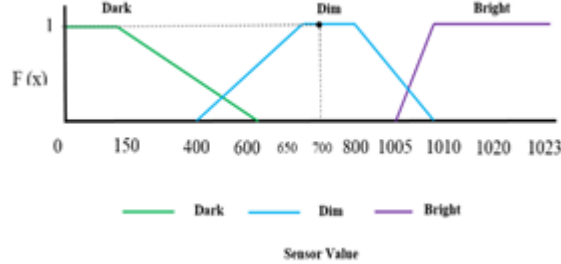
Figure 12. Graph of Humidity Value

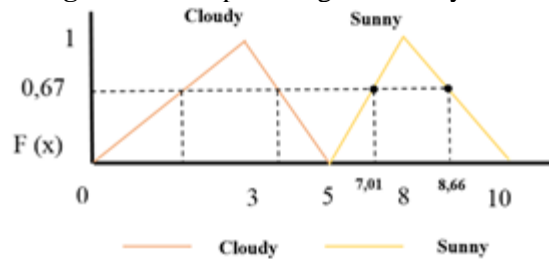**Figure 13.** Graph of Light Intensity Value

Figure 14. Graph of Output Fuzzification Output

Next is the inference process, the results of fuzzification are simulated for decision making based on fuzzy rules. The rule that can be used is the second rule:

- If temperature told (0.67) and humidity low (0.67) and light intensity dim (1) then weather prediction bright (0.67).
- So, the output of the cold inference process (0.67), and Low (0.67), Dim (1) see Fig. 12 is Bright (0.67). In The Bright (0.67), have two membership function are Bright (7.01) and Bright (8.66).
- The defuzzification process uses the centroid (center of gravity). The output of defuzzification is used as a value for predicting weather and determining weather conditions, namely 7.6393734306. In its application, this prediction system can be used to move the actuator which can move open or close according to the value of defuzzification.
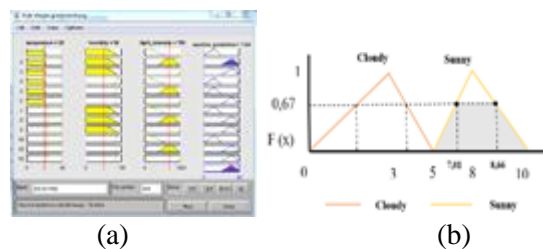

(a)   (b)

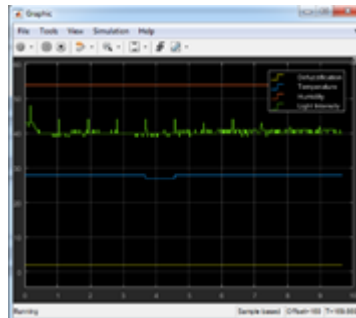**Figure 15.** – (a) MATLAB; (b) Graph of Defuzzification

Figure 16. Scope in Simulink MATLAB

4. Conclusion

From the simulations that we do show that the system we make runs in accordance with the good and right so that it can be used as one of the supporting systems in weather prediction systems. The application of fuzzy output can be used as a controller for motors, heaters, and etc. From the simulations that we do show that the system we make runs in accordance with the good and right so that it can be used as one of the supporting systems in weather prediction systems. The application of fuzzy output can be used as a controller for motors, heaters, and etc.

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