Computer Engineering and Applications Vol. 8, No. 3, October 2019

Peat Land Fire Monitoring System Using Fuzzy Logic Algorithm

Masayu Annisah, Nyayu Latifah Husni*, Tresna Dewi, RM Aprillia Rachmawati

Electrical Engineering, State Polytechnic of Sriwijaya, Indonesia
**nyayu_latifah@polsri.ac.id*

ABSTRACT

In this research, a fuzzy logic algorithm is implemented in a monitoring system for detecting the potential fires in peat land. The monitoring system in this research employs two sensors as the fuzzy inputs, i.e. TGS 2600 gas sensor and DHT11 temperature sensor. The outputs of the fuzzy logic are the specified conditions of motor activation (PWM) with 360^0 rotations. The system is monitored through camera, which sends the monitoring result to android via web server. The result is sent when TGS 2600 and DHT11 sensors detect the determined gas concentration and surrounding temperature. Before sending the result, the rotating motor stops every five minutes to take the photograph of peat land location. The result shows that the algorithm used in this research has been successful in determining the condition of the peat lands correctly and therefore can be used as the early prevention of fires.

Keywords: DHT11, Fuzzy Logic, Monitoring System, Peat Land, TGS 2600

1. INTRODUCTION

Indonesia is one of the countries in the world that has a lot of forest or peat lands. The utilization and protection of forest or peat lands in Indonesia are arranged in some rules, such as in: i) the 1945 Indonesian constitution; ii) law of number 5 in 1990; iii) law of number 23 in 1997; iv) law of number 41 in 1999; v) law of number 32 in 2004; vi) government regulation number 6 in 2007; and vii) Decision of the Minister of Forestry as well as Decision of Directorate General of Forest Entrepreneur and Directorate General of Forest Protection and Nature Conservation (PHKA). However, although the rules about utilization and protection of forest or peat lands are already available, the disruption to them is still increased.

In Indonesia, one of the most frequent disasters happened is forest or peat lands fires. They have become main problems that happened almost every years [1]. In 1997/1998 peat swamp forest with area 2,124,000 hectares have been burned [2]. According to Lanpanporo [3] and Ruchiat [4], up to now, the main cause of forest or peat lands fires could not be known certainly, however, some expert argued that forest or peat lands fires occured due to 2 causes, i.e. i) some small-scale activities in agricultural; ii) large-scale activities plantation and agricultural; that were managed by the Forest Concessionaire or Industrial Plantation Forest [2].

Forest or peat lands fires can occur in 2 ways, i.e. intentionally or unintentionally. Basically, the intentional fires is due to the opening of new land in large scale. It is certainly very useful in order to clear the land quickly and to save costs [3]. For the second way, the unintentional factor, it occurs because of the situation caused by nature, for example, during the dry season, the sun heat can cause the peat lands become drier than before which can increase the chance of occuring a spark that can lead to widespread of fire [4].

Each year, the large peat lands fires caused the land degradation that lead to the disruption of environment [5] and the degradation of the air quality. According to Wiggins [6] and Bacciu [7], the gas concentration detected from the burning of peat and forest in open space has many substances, such as Carbon Monoxide, Carbon Dioxide, carbonaceous aerosol, nitrogen oxides, and CH4. These gasses sometimes could be dangerous for the human being.

This research focused on monitoring system that functions to establish solution for preventing the occurrence of fires on forest or peat lands. This device was designed in the form of a monitored system, where it could monitor the condition of the forest or peat lands area. It worked by using a fuzzy logic algorithm in which the inputs of the TGS 2600 sensors and the DHT11 sensors had function to identify the gas and the temperature that could reflect the presence of the fire occurrence. The device built in this research could give detail and actual information about the peat land condition that can be monitored in the android.

2. FUZZY LOGIC ALGORITHM

The fuzzy system was introduced by Prof. Lotfi Zadeh in the mid of 1960s at the University of California. The fuzzy system was created because of boolean logic could not achieve high accuracy, in which it only had logic 0 and 1. The Fuzzy method often used because it was famous with the knowledge rules base in the form of inputs and outputs. Therefore, based on these rules, the system would have the ability to take decisions for doing to action that should be done [8].

In this research, a sugeno fuzzy logic was used. Basically, using of fuzzy logic requires three basic stages, namely: i) Fuzzification; ii) rule based and inference; and iii) Defuzzification [9]. The Fuzzification is the process of converting crips input into linguistic variable form using membership function. Inference system is an input-fuzzy conversion process with the "If-Then" rule to Output-Fuzzy. Defuzzification is the process of converting Output-Fuzzy from inference system into output crips using membership function into a value.

3. EXPERIMENTAL SETUP

3.1. HARDWARE DESIGN

In this research, two sensors, i.e. TGS 2600 gas sensors and DHT11 temperature sensors were used as the inputs of the fuzzy logic. In addition, the monitoring devices in this research were also equipped with a camera that has function to determine the location point that showed the occurrence of a fire sign. To transmit the data information, a web server was used on this system. Arduino Mega controller was used to control all the components in the system. This fire monitoring system used fuzzy logic method in the form of C/C++ language.

This device was designed in two parts of the boxes. Each box had different size. The first bigger box was mounted with the Arduino Mega controller, LCD, and other small components. The other box with smaller size was designed for the microchips of the raspberry Pi, Pi camera, and the two input sensors. Both boxes

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

were connected with two servomotors. The servomotors were designed to be able to rotate at 360^0 angles clockwise (CW) and rotate 360^0 counterclockwise (CCW). Beside the servomotors, the monitoring device in this research was also equipped with buzzers and LCDs that function as voice and text indicators that can indicate the dangers condition of fire. Figure 1 represents the diagram block of the system, while Figure 2 shows the hardware of the proposed monitoring device.

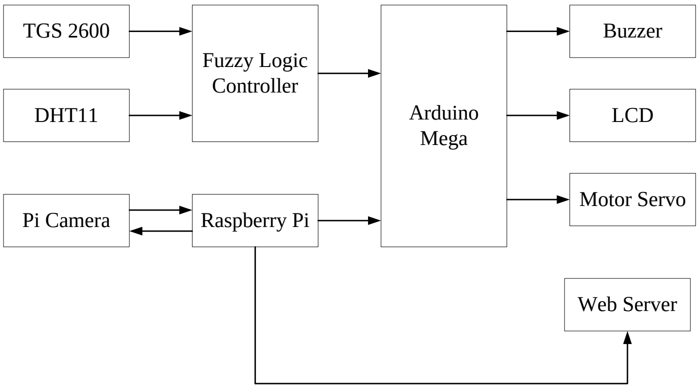

FIGURE 1. Diagram Block of Monitoring System

FIGURE 2. Monitoring System Hardware

3.2. SOFTWARE DESIGN

Two inputs obtained from gas sensor (TGS 2600) and temperature sensor (DHT11) were inputted to the fuzzy logic. These inputs were processed and the fuzzy logic would decide what should be done by the system based on the rules of the fuzzy. Figure 3 shows the flowchart of the monitoring system.

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

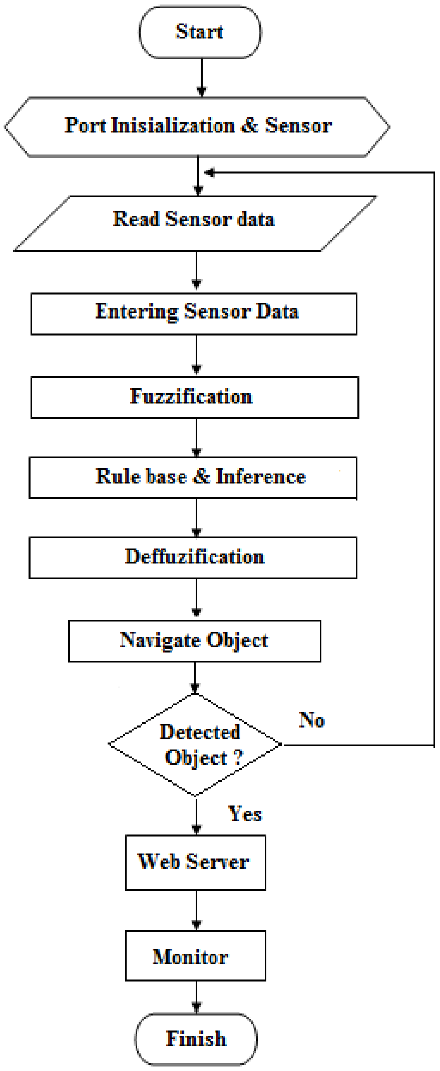

FIGURE 3. Flowchart of Monitoring System

3.2.1. FUZZIFICATION

The fuzzification process is the first step that changes the input of crisp into fuzzy variables. In this research, 2 variables, i.e. gas concentration (ppm) and temperature (°C), were used. Three conditions for each sensors were established, as can be seen in the Table 1. The crisps inputs used for the fuzzification process of both inputs in this research are presented in Equation (1) - (6), in which Equation (1) – (3) were used for the gas sensor membership functions, and the equation (4) – (6) were used for the temperature sensor.

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

TABLE 1.
Linguistic Variable for Gas Concentration and Temperature Inputs

Inputs		Linguistic Variable	Symbol
Gas Concentration (ppm)	0 – 85	Low Concentration	LC
	75 – 115	Normal	N
	100 - 150	High Concentration	HC
Temperature (ºC)	20 – 28	Cold	C
	25 – 38	Normal	N
	32 - 45	Warm	W

$$\mu_{low}(x_i) = \begin{cases} 1 \text{ for } 0 < x \leq 75 \\ \frac{x-85}{75-85} \text{ for } 75 < x \leq 85 \\ 0 \text{ for } x \geq 85 \end{cases} \quad (1)$$

$$\mu_{normal}(x_i) = \begin{cases} 0 \text{ for } x < 75 \text{ and } x > 115 \\ \frac{x-85}{85-75} \text{ for } 75 \leq x \leq 85 \text{ and } x > 115 \\ \frac{x-115}{100-115} \text{ for } 100 < x \leq 115 \\ 1 \text{ for } 85 < x < 115 \end{cases} \quad (2)$$

$$\mu_{high}(x_i) = \begin{cases} 1 \text{ for } x > 115 \\ \frac{x-85}{85-75} \text{ for } 100 < x \leq 115 \\ 0 \text{ for } x \leq 100 \end{cases} \quad (3)$$

$$\mu_{cold}(x_i) = \begin{cases} 1 \text{ for } x < 25 \\ \frac{x-28}{25-28} \text{ for } 25 \leq x < 28 \\ 0 \text{ for } x \geq 28 \end{cases} \quad (4)$$

$$\mu_{normal}(x_i) = \begin{cases} 0 \text{ for } x < 25 \text{ and } x > 38 \\ \frac{x-28}{28-25} \text{ for } 25 < x \leq 28 \\ \frac{x-38}{32-38} \text{ for } 32 < x \leq 38 \\ 1 \text{ for } 25 < x < 32 \end{cases} \quad (5)$$

$$\mu_{warm}(x_i) = \begin{cases} 1 \text{ for } x > 38 \\ \frac{x-32}{38-32} \text{ for } 32 < x \leq 38 \\ 0 \text{ for } x < 32 \end{cases} \quad (6)$$

3.2.2. RULE BASED AND INFERENCE

This step is the process of determining Rule based for the monitoring system. The system would follow the command that has been determined by the rule based. Table 2 shows the 9 rules based of the proposed monitoring system.

TABLE 2.
Monitoring System inputs-output

TGS 2600	DHT11	Condition
High Concentration	Warm	Dangerous
High Concentration	Normal	Dangerous
High Concentration	Cold	Alert
Normal	Warm	Alert
Normal	Normal	Safe
Normal	Cold	Safe
Low Concentration	Warm	Dangerous
Low Concentration	Normal	Alert
Low Concentration	Cold	Safe

3.2.3. DEFUZZIFICATION

Defuzzification is the next step after determining the rule based, this process will display the output in the form of graphic membership function. Figure 4 and 5 illustrate the form of fuzzy input from monitoring peat land fire detection system, while Figure 6 represents the 3-dimensional graphic form of monitoring system,

`

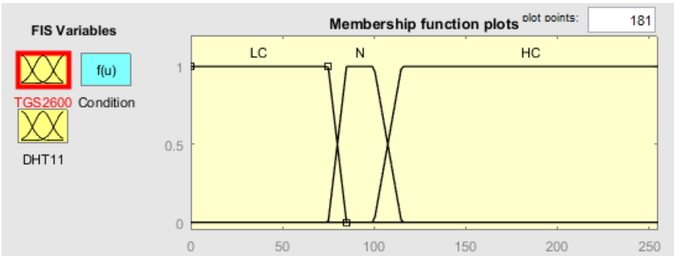

FIGURE 4. Gas Concentration Inputs Membership Functions

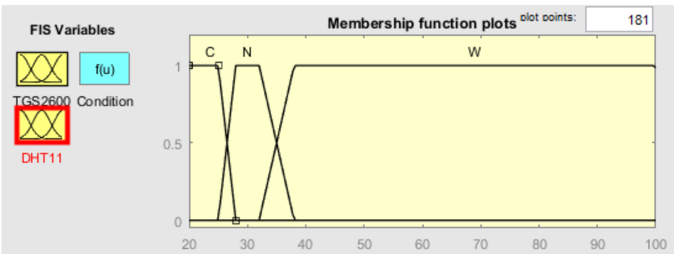

FIGURE 5. Temperature Inputs Membership Functions

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

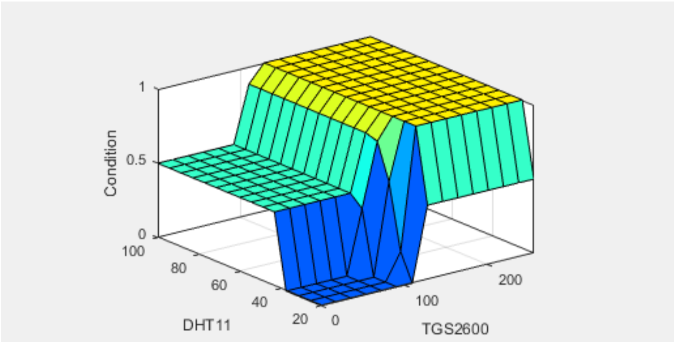

FIGURE 6. Monitoring System Outputs

4. RESULT

The experiment was conducted in an open space of 200 cm x 150 cm peatland. An artificial combustion was performed to the peat land. The data obtained is shown in Figure 7. Those data can be monitored in the android. In Figure 7 (a), the gas concentration was only 80 ppm with the temperature 26 ^{O}C; the fuzzy output stated that the condition was in the safe condition. It means that the fire has no chance to be occurred. Figure 7 (b) the gas concentration was 211 ppm with the temperature 30 ^{O}C; the fuzzy output stated that the condition was in the alert condition. It means that the fire has a chance to be occurred. Figure 7 (c) the gas concentration was 313 ppm with the temperature 41 ^{O}C; the fuzzy output stated that the condition was in the dangerous condition. It means that the fire has a big chance to be occurred.

(a) (b) (c)

FIGURE 7. Experimental Data from Android Display

5. CONCLUSION

From this research, it can be concluded that this monitoring system worked well. The result showed that the algorithm used in this research has been successful to determine the condition of the peat lands correctly. Therefore, the proposed monitoring system in this research can be used as the early prevention of fires. The device in this research can be applied not only at the peat land but also in the forest.

ACKNOWLEDGEMENTS

Authors thank to the State Polytechnic of Sriwijaya and all researchers in Signal Processing and Control Laboratory, Electrical Engineering, State Polytechnic of Sriwijaya who provided companionship and sharing of their knowledge.

REFERENCES

[1] Putra, "Determining critical groundwater level to prevent degraded peatland from severe peat fire Determining critical groundwater level to prevent degraded peatland from severe peat fire," *IOP Conf. Ser. Earth Environ. Sci1e2n3c4e*, vol. 149, 2018.

[2] N. L. Husni, A. Silvia, and S. Nurmaini, "New Challenges in Air Quality Sensing using Robotic Sensor Network," *Enviromental Sci.*, 2013.

[3] H. Purnomo, B. Shantiko, S. Sitorus, H. Gunawan, R. Achdiawan, H. Kartodihardjo, and A. Ayu, "Forest Policy and Economics Fire economy and actor network of forest and land fi res in Indonesia," *For. Policy Econ.*, vol. 78, pp. 21–31, 2017.

[4] B. T. Siti Nurmaini, Reza Firsandaya Malik, Deris Stiawan, Firdaus, Saparudin, "Information Framework of Pervasive Real Time Monitoring System: Case of Peat Land Forest Fires and Air Quality in South Sumatera, Indonesia," *OP Conf. Ser. Mater. Sci. Eng.*, vol. 190, 2017.

[5] J. Miettinen, "Fire Distribution in Peninsular Malaysia , Sumatra and Borneo in 2015 with Special Emphasis on Peatland Fires," *Environ. Manage.*, pp. 747–757, 2017.

[6] E. B. Wiggins, C. I. Czimczik, G. M. Santos, Y. Chen, X. Xu, S. R. Holden, J. T. Randerson, C. F. Harvey, F. Ming, and L. E. Yu, "Smoke radiocarbon measurements from Indonesian fires provide evidence for burning of millennia- aged peat," vol. 115, no. 49, pp. 12419–12424, 2018.

[7] V. Bacciu, D. Spano, and M. Salis, "Emissions from Forest Fires : Methods of Estimation and National Results," *Environ. Sci. Eng.*, pp. 87–102, 2015.

[8] S. Nurmaini, S. Zaiton, and R. Firnando, "Cooperative Avoidance Control-based Interval Fuzzy Kohonen Networks Algorithm in Simple Swarm Robots," vol. 12, no. 4, 2014.

[9] A. S. Handayani, "Target Tracking in Mobile Robot under Uncertain Environment using Fuzzy Logic Controller."

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)