Potential Fire Hazard Detection System Based on Microcontroller Using the Fuzzy Mamdani Method

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Abstract: Early fire prevention is very important. Based on statistical data from the DKI Jakarta Provincial Fire and Rescue Service. In 2016 there were 1,047 fire cases, while in 2017 it almost doubled to 2,055 cases. The danger of a room is also influenced by the level of a gas (based on LEL and UEL values). Therefore, it is necessary to have a tool to prevent or warn of potential fire hazards early. This final project research makes potential fire hazard detection system. The sensors used include MQ-9, MQ-5, MQ-2, and thermal sensor AMG8833. The working system of this tool is AMG8833 connect raspberry to detects fire, output from AMG8833 will be sent to Arduino as input for Fuzzy Mamdani along with the values from the sensors MQ-9, MQ-5, MQ- 2 (there are 4 inputs). The result or decision of Fuzzy is the level of potential fire hazard that occurs. The results of the research are expected to be able to provide early warning or prevention of fire. In addition, it is hoped that this research module can be used as a teaching module for fire hazard detection systems to support a better vocational education system. From 10 trials, 90% of the system success was found for detecting potential fire hazards, for detecting fires using AMG8833 also success and for the success of sending information via LED-RBG by 90%, and via telegram 100%.

1 INTRODUCTION

Fire is an element that is very useful for humans if you can control it, but fire can also be dangerous to humans like fire. Fire is one of the disasters that often occurs both in big cities and in rural areas that can cause huge losses (Irawati, 2017). Fires can occur at any time without anyone being able to predict them. Many factors can affect the occurrence of fires, including electrical short circuits, temperature increases from mechanical processes that cause fires, and human factors or human error (Wijaya, et al., 2020).

In a company or housing, it is very important to have a means of detecting the potential level of fire hazard. This tool aims to detect the potential level of fire hazard early on so that it can be overcome quickly before a fire occurs. Many fire disasters have caused many casualties and property losses. Fires in homes often occur due to accidents in the kitchen environment, or electrical problems in the installation of electronic devices. Fires start at a small level but can endanger large houses or surrounding buildings (Irawati, 2017).

Based on statistical data from the DKI Jakarta Provincial Fire and Rescue Service, there were 1,047 fire cases in DKI Jakarta province in 2016. A total of 754 cases were caused by electricity, 35 cases due to cigarettes, 75 cases due to stoves and 183 cases due to other factors and 0 for unknown cases, but in 2017 fire cases increased almost 2 times to 2,055 cases. A total of 851 cases were caused by electricity, 33 cases were caused by cigarettes, 156 cases were caused by stoves, 1009 cases were caused by other factors, and 6 cases had no known cause. While the results of statistical data on fire incidents in Indonesia in 2007, most fire accidents occurred in residential areas, namely 65.8%, shopping centers 9.8%, industrial buildings by 8%, offices by 5.6%, markets by 4.8%, hotels by 4.6 %, and other buildings by 0.4% (Agusri, 2021).

The room can be said to be flammable if a certain volume of hazardous gas has passed the Lower Explosive Limit (LEL) or the lower limit of the

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explosion and can be said to be very dangerous or very easy to fire if it has passed the Upper Explosive Limit (UEL) or the upper limit of explosion. According to data from CHRISALIS SCIENTIFIC TECHNOLOGIES INC. the lower explosion limit (LEL) of methane gas in a room is 5% of the total volume and the upper limit (UEL) of 15% of the total volume of the room, the lower limit of the explosion (LEL) of carbon monoxide gas is 12.5% of the total volume and above (UEL) 74% of the total volume of the room. Therefore, a fire hazard detection system is needed that works properly to prevent fires (Amanda, 2021).

In this study, a system that can detect the potential level of fire hazard from an early age will be made using 3 types of parameters using the Fuzzy Mamdani method (Batubara, 2017). Information on the potential level of fire hazard will be sent via telegram. It is hoped that this system can reduce or prevent fires so that they can reduce the number of fatalities and minimize losses.

The formulation of the problem in this study include:

How to detect potential fire hazard level with Fuzzy Mamdani using AMG8833, MQ-9, MQ-5, MQ-2, and DHT22 sensors?

How to detect fire using AMG8833 sensor?

How to convey information that there has been a potential fire hazard?

2 METHOD

The stages carried out in this study are depicted in the flow chart in Figure 1 below

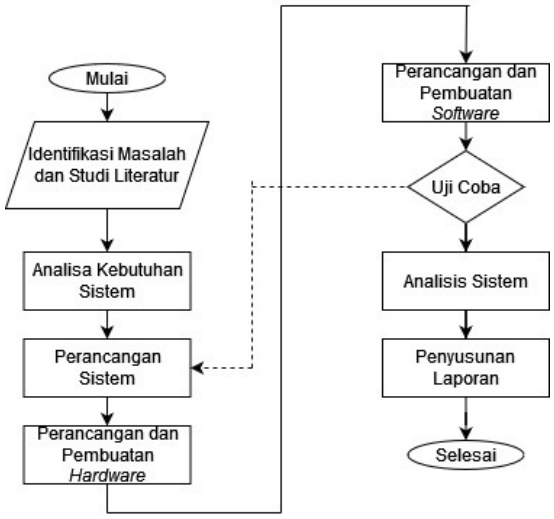

Figure 1: Research Flowchart.

Based on the flow chart above, the detailed flow of research activities will be described in the following sub-chapters

2.1 System Analysis

The following are the hardware and software requirements used to build the overall system.

Hardware	Software
Sensor MQ-9	Arduino IDE
Sensor MQ-5	Python
Sensor MQ-2	MATLAB
Sensor AMG8833	Eagle
Raspberry Pi 4B	Telegram
Arduino Uno	
Buzzer SFM27	
LED RGB	
Water Pump	
Smartphone	

This system has four input parameters. In the input or input section there are 4 sensors, namely the MQ-9, MQ-5, MQ-2 sensors to detect dangerous gases and the AMG8833 sensor to detect fire, the four sensors are integrated using the Fuzzy Mamdani method on the Arduino Uno to detect whether there is a potential danger fire or not. (Febriany, 2016). The results of the system will determine the potential fire hazard level between levels 0 to 4, if the system states a fire hazard potential level 0 then nothing happens, while if the system states a fire hazard potential level 1 or 2 or 3 or 4 the LED will light up (green for level 1, yellow for level 2, orange/orange for level 3 and red for level 4), the water pump will pour water (if fire is detected) and the raspberry will send a message/notification to the smartphone (telegram) . Then when the level of one or more harmful gases or exceeds the safe limit, the system will sound a buzzer. The concept of the system is illustrated in the block diagram in Figure 2 (Mahendra, 2021).

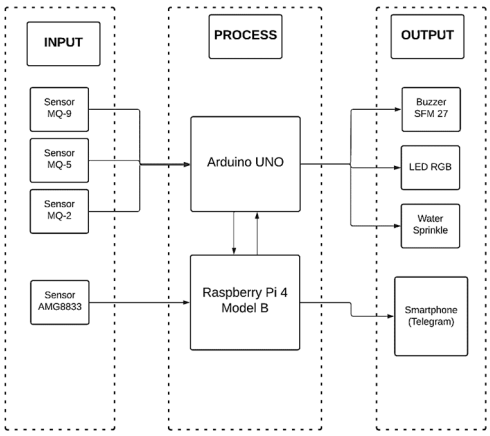

Figure 2: System Concept.

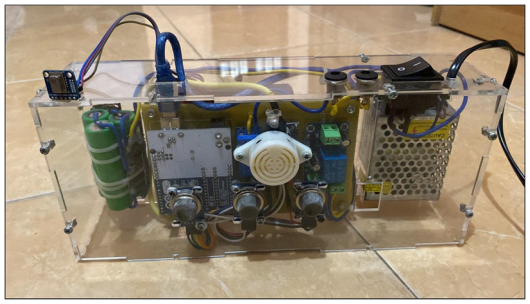

Figure 3: Mechanical Design Results.

The workflow of the system in this study can be seen in Figure 4 below

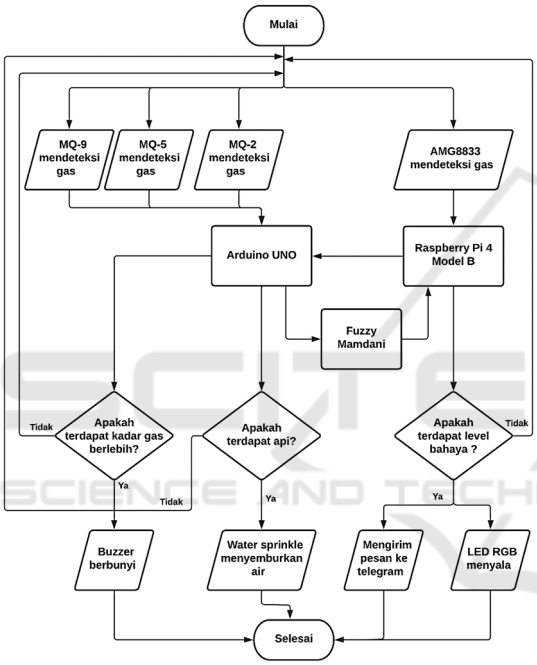

Figure 4: System Workflow Diagram.

2.2 Fuzzy Logic

The application of fuzzy logic to the system is used to identify the potential level of fire hazard. In this study, the fuzzy mamdani method was used with 4 inputs and 1 output in the form of identification. Fuzzy in this system will be processed by a microcontroller with input in the form of carbon monoxide gas from the MQ-9 sensor reading, methane gas from the MQ-5 sensor reading, propane gas reading from the MQ-2 sensor and the fire temperature reading from the AMG8833 sensor. While the output is in the form of identifying the level of potential fire hazard from level 0 to level 4 (Muhathir, 2021).

3 RESULTS AND DISCUSSION

In this design, there are inputs in the form of carbon monoxide gas from the MQ-9 sensor readings, methane gas from the MQ-5 sensor readings, propane gas readings from the MQ-2 sensor and fire temperature readings from the AMG8833 sensor. Then the output is in the form of identification of the potential level of fire hazard from level 0 to level 4. Here is the membership function of Fuzzy logic input and its output.

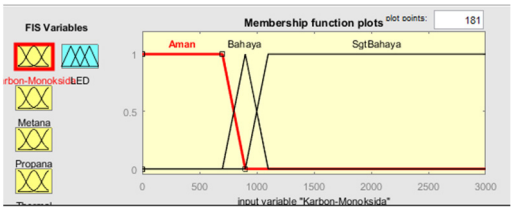

Figure 5: Membership Function Gas CO.

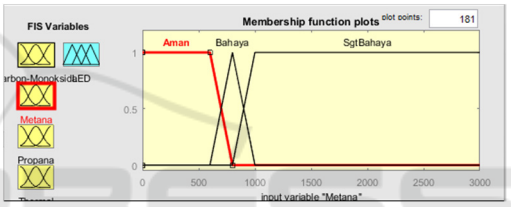

Figure 6: Membership Function Gas CH4.

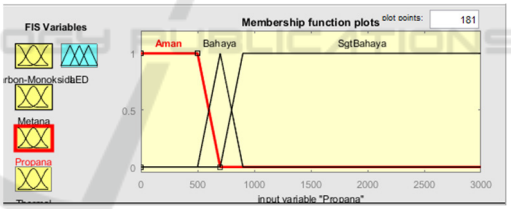

Figure 7: Membership Function Gas C3H8.

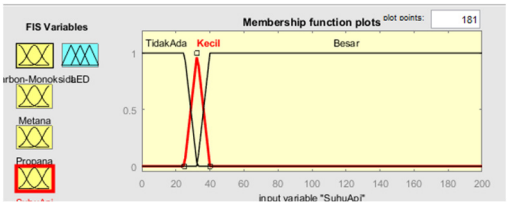

Figure 8: Membership Function Fire Temperature.

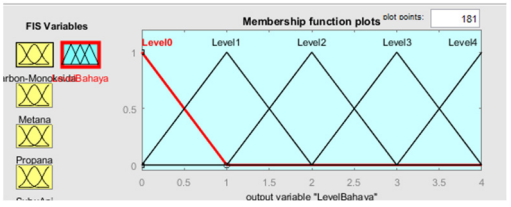

Figure 9: Fuzzy Logic Output.

3.1 Fuzzy Logic Test

In modeling the Fuzzy logic method that will be used for the control process of the system in this final project, a simulation is needed to determine the input, output, or rules that will be used. Matlab software is used for fuzzy logic simulations either with toolbox, m-file, or simulink (Suyono, 2017).

Fuzzy testing is done by comparing the fuzzy output with the results of matlab and the results of manual calculations (Sutrisno, 2014).

Table 1: Fuzzy Logic Inference.

CO	CH4	C3H8	Fire	Danger Level
A	A	A	None	0
A	A	A	Small	1
A	A	A	Big	2
A	A	B	None	1
A	A	B	Small	2
A	A	B	Big	3
A	A	SB	None	2
A	A	SB	Small	4
A	A	SB	Big	4
A	B	A	None	1
A	B	A	Small	2
A	B	A	Big	3
A	B	B	None	1
A	B	B	Small	2
A	B	B	Big	3
A	B	SB	None	2
A	B	SB	Small	4
A	B	SB	Big	4
A	SB	A	None	2
A	SB	A	Small	4
A	SB	A	Big	4
A	SB	B	None	2
A	SB	B	Small	4
A	SB	B	Big	4
A	SB	SB	None	3
A	SB	SB	Small	4
A	SB	SB	Big	1
B	A	A	None	2
B	A	A	Small	3
B	A	A	Big	1
B	A	B	None	2
B	A	B	Small	3
B	A	B	Big	2
B	A	SB	None	4
B	A	SB	Small	4
B	A	SB	Big	1
B	B	A	None	2
B	B	A	Small	3
B	B	A	Big	1
B	B	B	None	2
B	B	B	Small	3
B	B	B	Big	4
B	B	SB	None	3
B	B	SB	Small	4
B	B	SB	Big	4
B	SB	A	None	2
B	SB	A	Small	4
B	SB	A	Big	4
B	SB	B	None	3
B	SB	B	Small	4
B	SB	B	Big	4
B	SB	SB	None	3
B	SB	SB	Small	4

Table 1: Fuzzy Logic Inference (cont.).

CO	CH4	C3H8	Fire	Danger Level
B	SB	SB	Big	4
SB	A	A	None	2
SB	A	A	Small	4
SB	A	A	Big	4
SB	A	B	None	2
SB	A	B	Small	4
SB	A	B	Big	4
SB	A	SB	None	3
SB	A	SB	Small	4
SB	A	SB	Big	4
SB	B	A	None	2
SB	B	A	Small	4
SB	B	A	Big	4
SB	B	B	None	3
SB	B	B	Small	4
SB	B	B	Big	4
SB	B	SB	None	3
SB	B	SB	Small	4
SB	B	SB	Big	4
SB	SB	A	None	3
SB	SB	A	Small	4
SB	SB	A	Big	4
SB	SB	B	None	3
SB	SB	B	Small	4
SB	SB	B	Big	4
SB	SB	SB	None	4
SB	SB	SB	Small	2
SB	SB	SB	Big	4

3.2 Telegram Test

In this test, to find out whether the telegram message that was sent was successfully sent by the system.

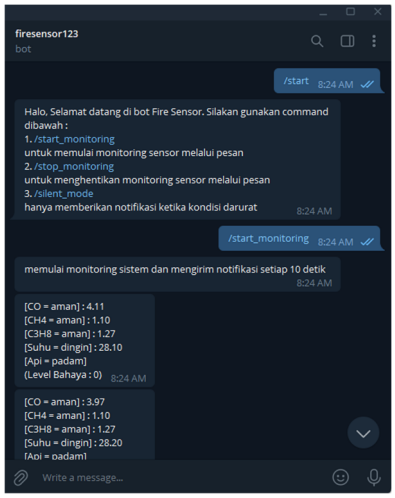

Figure 10: Telegram Test.

3.3 Water Pump Test

Table 2: Testing Water Pump.

Test	Water Pump
There's a fire	turn on
There's a fire	turn on
There's a fire	turn on
There's a fire	turn on
There's a fire	turn on
There's a fire	turn on
There's a fire	turn on
There's a fire	turn on
There's a fire	turn on
There's a fire	turn on

In Table 2. shows the results of the Water Pump test to pour water when a fire is detected. The results of testing the condition that there is fire, it was found that 10 attempts were made with 10 successes and 0 failures. The resulting error is 0% (Sutrisno,.2012).

3.4 Buzzer Test

Table 3: Buzzer Testing on Gas Levels.

Test	Buzzer
There is a dangerous gas level	turn on
There is a dangerous gas level	turn on
There is a dangerous gas level	turn on
There is a dangerous gas level	turn on
There is a dangerous gas level	turn on
There is a dangerous gas level	turn on
There is a dangerous gas level	turn on
There is a dangerous gas level	turn on
There is a dangerous gas level	turn on
There is a dangerous gas level	turn on

In Table 3. shows the results of the Buzzer test to give a warning when gas levels are detected that exceed the safe limit. The results of the condition test have gas levels exceeding the safe limit, 10 trials were found with 10 successes and 0 failures. The resulting error is 0% (Jami'in 2014).

3.5 LED-RGB Test

LED-RGB is used as an indicator of the output of the fuzzy mamdani method.

Table 4: LED-RGB Test.

Test	LED-RGB
Hazard Potential Level 0	No flame
Hazard Potential Level 0	No flame
Hazard Potential Level 1	Green Light
Hazard Potential Level 1	Green Light
Hazard Potential Level 1	Green Light
Hazard Potential Level 2	Yellow Light
Hazard Potential Level 2	Yellow Light
Hazard Potential Level 3	Red Light
Hazard Potential Level 4	Red Light
Hazard Potential Level 4	Red Light

In Table 4. shows the results of the Buzzer test to give a warning when gas levels are detected that exceed the safe limit. The results of the condition test showed that there was a potential fire hazard, 10 trials were found with 9 successes and 1 failure. The resulting error is 10%.

3.6 Overall System Test

In testing the overall system, a room is carried out by giving fire and gas using a gas lighter.

Table 5: Overall System Test.

CO	CH4	C3H8	Temp	Lv	LED	Pump	Buzz
19.08	1.15	6.60	28.25	0	Off	M	M
19.88	2.59	2739.7	28	2	K	M	N
1344.8	198.67	36.03	28.0	2	K	M	N
34.18	181.91	778.46	28.0	1	H	M	N
18.72	4.94	12.19	34.0	1	H	N	M
18.37	3.81	10.69	122.0	2	K	N	M
26.29	715.25	82.33	80.5	3	O	N	N
30.56	1254.5	51.58	86.0	4	Off	N	N
400.15	687.54	754.12	29.0	1	H	M	N
1694.1	50.17	954.87	28.25	3	O	M	N

In Table 5 shows the results of testing the entire system. Output on the LED, K is yellow, H is green, O is orange, M is red. Output at pump and buzzer, M is off, N is on. It was found from the results of 10 tests, there was 1 incorrect result or a 90% success rate (Sutrisno, 2014).

4 CONCLUSION

Based on the results of the tests that have been carried out in this study, it can be concluded that:

The application of Fuzzy Mamdani on a system with four input parameters including carbon monoxide gas, methane gas, propane gas and fire temperature can detect potential fire hazard levels with an accuracy of 90%.

The application of the AMG8833 sensor to detect fire, the AMG8833 sensor reads the heat value or temperature of each pixel and then takes the hottest value as the fire temperature input.

The application of delivering information on potential fire hazards via LED-RGB has an accuracy

of 90% and the delivery of information via telegram is sent once every 10 seconds with 100% accuracy. SIM800l Communication Testing to databases and websites does not occur sending data errors or without errors with a delay of 10 seconds so there is no you can say real time.

The suggestions that can be given from this research include:

The use of thermal sensors to detect fire is good enough, but it would be better if there is a camera sensor that can detect fire in real.

Testing the sensor would be better to use a gas that really matches the gas being detected.

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