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FUZZY LOGIC FOR CONTROLLING SMOKE LEVEL ON SMART SMOKING ROOM

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Abstract

Public space is one of the facilities that need in public areas. One of the public space facilities is a special smoking room. The existing smoking room is still conventional, meaning that there is without controlling system to maintain the air condition in the rooms. This study discusses a smart system to control air levels in smoking rooms based on fuzzy logic. Fuzzy analysis is carried out with input parameters, namely temperature, air humidity, CO levels, smoke levels and output parameters are supply fans, exhaust fans, and air ionizers. Based on the results of smart smoking model test compared wit the Matlab analysis, the Mean Squared Error (MSE) value on the supply fan = 0.0640, MSE on the exhaust fan = 0.0502 and MSE on the ionizer = 0.0604. The results for the MSE value are closed to zero, its means smart smoking rooms models is works properly.

Keywords: *Fuzzy logic, Smart smoking models.*

1. Introduction

Global Youth Tobacco Survey in 2019, 19.2% of students in Indonesia aged 13-15 years are smokers[1]. Smoking indoors will leave nicotine[2], smoke[3] and carbon monoxide[4] on the wall of the room[5]. More than 4800 chemicals[6] The carcinogens in cigarettes will be more dangerous when the cigarette smoke is trapped in a confined space[7]. Smoking can cause various diseases such as heart disease[8], stroke, lung cancer[9], oral cavity cancer[10], diabetes, hypertension and others[11]. Passive smoking is one of the victims, as a result of many smokers who smoke indiscriminately[12].

Many research on smoking rooms include: prototype cleaners and cigarette smoke monitoring to detect smoke and CO[13], smoke and exhaust gases NOx[14]. Smoking room design with smoke decomposer[15], room temperature control and pay attention to health thresholds[16]. The TGS 2442 sensor is the CO sensor and the AF-30 sensor is the smoke sensor. Smoking room control system with two input parameters was developed using fuzzy tsukamoto[17], mamdani[18], decision tree, wireless sensor network and PID[18].

The solution to this problem is that it is necessary to conduct a study on the optimization of smoking rooms. Monitor smoke levels and CO levels indoors to find out the clean air threshold[19]. Regulate the circulation of clean air into the room with the input fan and remove dirty air with the exhaust fan and decompose it with an ionizer[20]. In this smart smoking rooms study, four combinations of input parameters were used, namely the value of smoke levels, CO levels, temperature, humidity, and ouput parameter is supply fan, exhaust fan, ionizer. With the combination of these four parameters generated a lot of input data to be processed with Fuzzy Logic.

2. Research Method

2.1. Smart Smoking Models

Figure 1 is a smart smoking rooms block diagrams, divided into input, process and output. On the input side there are sensors MQ-2 and MQ-7 as detectors of smoke and CO levels. DHT 22 as sensors for temperature and humidity levels. Input data is processed with Fuzzy on ArduinoMega. The output is supply fan, exhaust fan and air ionizer. This smart smoking design model is equipped with IoT as a monitoring system on the Thingspeak and an LCD Oled display text containing information about the air conditions in the smoking room.

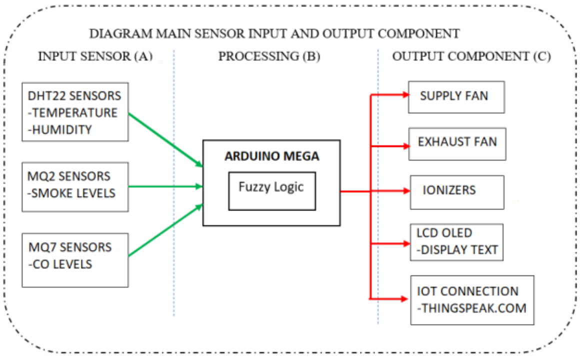

Figure 1. Smart Smoking Models Block Diagram

Figure 2 is flow chart for smart smoking system. The process is starts from the input data of smoke level, CO level, Oled LCD output connected to I2C serial communication. Input data from temperature, humidity, smoke and CO levels are obtained in crisp form. And then fuzzy control makes fuzzification, fuzzy rules and defuzzification to get crisp output values for the duration time for supply fan, exhaust fan and ionizer runs. Crisp input and output data are displayed on the OLED LCD and the Thingspeak, the data is processed and compared with Fuzzy Matlab to get the Mean Squared Error (MSE) value.

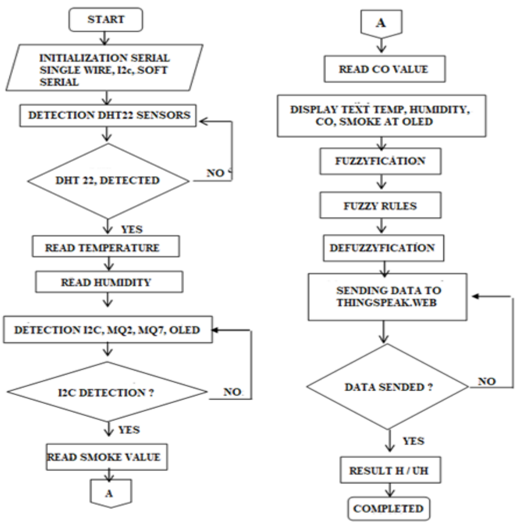

Figure 2. Flow Chart Smart Smoking Models

2.2. Fuzzy Logic Operation System

a. Fuzzyfication

Fuzzification of input parameters is values of temperature, humidity, CO level, smoke levels, and output parameters are the supply fan, exhaust fan and air ionizer according to Table 1.

Table 1. Fuzzyfication Input and Output Parameters

No	Parameter Input	Range
1	Temperature	Value a= 18ºC, and value b= 28ºC
2	Humidity	Value a= 40% and value b= 60%

3	CO levels	Value a= 10 ppm, and value b= 20 ppm
4	Smoke levels	Value a= 100 ppm, and value b= 400 ppm
	Parameter Output	**Range**
5	Supply fans	Value a= 4 sec, and value b= 10 sec
6	Supply fans	Value a= 4 sec, and value b= 10 sec
7	Ionizer	Value a= 3 sec, and value b= 11 sec

b. Fuzzy Rules
Fuzzy Rule base contains fuzzy logic statements with an IF-THEN statement on Table 2

Table 2. Fuzzy Rule Smart Healthy Smoking Room

	INPUT PARAMETER				**OUTPUT PARAMETER**		
RULE	**Temperature (IF)**	**Humidity (AND)**	**CO level (AND)**	**Smoke level (AND)**	**Supply fan (THEN)**	**Exhaust fan (AND)**	**Ionizer (AND)**
1	Cold	Dry	Light	Light	Short	Short	Short
2	Cold	Dry	Light	Heavy	Short	Long	Long
3	Cold	Dry	Heavy	Light	Short	Long	Long
4	Cold	Dry	Heavy	Heavy	Long	Long	Long
5	Cold	Wet	Light	Light	Short	Short	Short
6	Cold	Wet	Light	Heavy	Short	Long	Long
7	Cold	Wet	Heavy	Light	Short	Long	Long
8	Cold	Wet	Heavy	Heavy	Long	Long	Long
9	Hot	Dry	Light	Light	Long	Short	Short
10	Hot	Dry	Light	Heavy	Long	Long	Long
11	Hot	Dry	Heavy	Light	Long	Long	Long
12	Hot	Dry	Heavy	Heavy	Long	Long	Long
13	Hot	Wet	Light	Light	Long	Short	Short
14	Hot	Wet	Light	Heavy	Long	Long	Long
15	Hot	Wet	Heavy	Light	Long	Long	Long
16	Hot	Wet	Heavy	Heavy	Long	Long	Long

c. Inferance Engine and Defuzzyfication.
Defuzzification is the processing fuzzy values obtained from the Fuzzy Inference Engine be a firm value. The first step is to form a fuzzy set, calculate the degree of membership, the value of alpha predicate (α) with the MIN function. The final step is to find the crisp(z) value which is called defuzzification. Center of Area defuzzification method in equation (1)[21]

$$z^* = \frac{\sum \mu_i z_i}{\sum \mu_i} \quad \ldots\ldots (1)$$

2.3. Mean Squared Error *(MSE)*

Mean Squared Error (MSE) according equation (2)[22]

$$MSE = \frac{\sum_{t=1}^{n}(At - Ft)^2}{n} \quad \text{....... (2)}$$

3. Results and Discussions

3.1. FuzzyLogic with Mathematic Calculation

Test for all paramters with input value of temperature (24°C), Humidity (48%) CO level (16 ppm), Smoke level (215 ppm)

a. Test fuzzification member with temperature (24°C) humidity (48) CO levels (16) smoke levels (215)

1)	Temperature	µ Cold	= (28-24)/(28-18)	= 0.4
		µ Hot	= (24-18)/(28-18)	= 0.6
2)	Humidity	µ Dry	= (60-48)/60-40)	= 0.6
		µ Wet	= (48-40)/(60-40)	= 0.4
3)	CO Level	µ Light	= (20-16)/(20-10)	= 0.4
		µ Heavy	= (16-10)/(20-10)	= 0.6
4)	Smoke level	µ Light	= (400-215)/(400-100)	= 0.63
		µ Heavy	= (215-100)/(400-100)	= 0.37

b**.** Fuzzy inference engine using the Min function is applied to each rule to get the value of Min α predicate.

αpredicate R1 = MIN [µTemp Cold ∩ µHum Dry ∩ µCO Light ∩ µSmoke Light]
= MIN (0.4 ; 0.6 ; 0.4 ; 0.6) = 0.4

Table 3. Result α predikat Min According Fuzzy Rules (Table 2).

RULE	***INPUT***				***RESULT INFERENCE ENGINE***				
	Temp (IF)	***Hum (AND)***	***CO (AND)***	***Smoke (AND)***	***Temp***	***Hum***	***CO***	***Smoke***	***RESULT α (MIN)***
1	*Cold*	*Dry*	*Light*	*Light*	*0,4*	*0,6*	*0,4*	*0,62*	***0,4***
2	*Cold*	*Dry*	*Light*	*Heavy*	*0,4*	*0,6*	*0,4*	*0,37*	***0,37***
3	*Cold*	*Dry*	*Heavy*	*Light*	*0,4*	*0,6*	*0,6*	*0,62*	***0,4***
4	*Cold*	*Dry*	*Heavy*	*Heavy*	*0,4*	*0,6*	*0,6*	*0,37*	***0,37***
5	*Cold*	*Wet*	*Light*	*Light*	*0,4*	*0,4*	*0,4*	*0,62*	***0,4***
6	*Cold*	*Wet*	*Light*	*Heavy*	*0,4*	*0,4*	*0,4*	*0,37*	***0,37***
7	*Cold*	*Wet*	*Heavy*	*Light*	*0,4*	*0,4*	*0,6*	*0,62*	***0,4***
8	*Cold*	*Wet*	*Heavy*	*Heavy*	*0,4*	*0,4*	*0,6*	*0,37*	***0,37***
9	*Hot*	*Dry*	*Light*	*Light*	*0,6*	*0,6*	*0,4*	*0,62*	***0,4***
10	*Hot*	*Dry*	*Light*	*Heavy*	*0,6*	*0,6*	*0,4*	*0,37*	***0,37***
11	*Hot*	*Dry*	*Heavy*	*Light*	*0,6*	*0,6*	*0,6*	*0,62*	***0,6***
12	*Hot*	*Dry*	*Heavy*	*Heavy*	*0,6*	*0,6*	*0,6*	*0,37*	***0,37***
13	*Hot*	*Wet*	*Light*	*Light*	*0,6*	*0,4*	*0,4*	*0,62*	***0,4***
14	*Hot*	*Wet*	*Light*	*Heavy*	*0,6*	*0,4*	*0,4*	*0,37*	***0,37***
15	*Hot*	*Wet*	*Heavy*	*Light*	*0,6*	*0,4*	*0,6*	*0,62*	***0,4***
16	*Hot*	*Wet*	*Heavy*	*Heavy*	*0,6*	*0,4*	*0,6*	*0,37*	***0,37***

Table 4. inference Engine for New member Output Parameter, according Table 2 and 3.

Rule	***Output Rule***			***Tabel 4.4***	***New Memberships***		
	Supply	***Exhaust***	***Ionizer***	***RESULT α (MIN)***	***Supply (z)***	***Exhaust (z)***	***Ionizer (z)***
1	*Short*	*Short*	*Short*	***0,4***	*7,6*	*7,6*	*7,8*

	Output Rule			*Tabel 4.4*	*New Memberships*		
Rule	***Supply***	***Exhaust***	***Ionizer***	***RESULT α (MIN)***	***Supply (z)***	***Exhaust (z)***	***Ionizer (z)***
2	*Short*	*Long*	*Long*	***0,37***	*7,75*	*6,25*	*6*
3	*Short*	*Long*	*Long*	***0,4***	*7,6*	*6,4*	*6,2*
4	*Long*	*Long*	*Long*	***0,37***	*6,25*	*6,25*	*6*
5	*Short*	*Short*	*Short*	***0,4***	*7,6*	*7,6*	*7,8*
6	*Short*	*Long*	*Long*	***0,37***	*7,75*	*6,25*	*6*
7	*Short*	*Long*	*Long*	***0,4***	*7,6*	*6,4*	*6,2*
8	*Long*	*Long*	*Long*	***0,37***	*6,25*	*6,25*	*6*
9	*Long*	*Short*	*Short*	***0,4***	*6,4*	*7,6*	*7,8*
10	*Long*	*Long*	*Long*	***0,37***	*6,25*	*6,25*	*6*
11	*Long*	*Long*	*Long*	***0,4***	*6,4*	*6,4*	*7,8*
12	*Long*	*Long*	*Long*	***0,37***	*6,25*	*6,25*	*6*
13	*Long*	*Short*	*Short*	***0,4***	*6,4*	*7,6*	*7,8*
14	*Long*	*Long*	*Long*	***0,37***	*6,25*	*6,25*	*6*
15	*Long*	*Long*	*Long*	***0,4***	*6,4*	*6,4*	*6,2*
16	*Long*	*Long*	*Long*	***0,37***	*6,25*	*6,25*	*6*

c. Defuzzyfication
The calculation of the crips value (z) using the Center of Area method is in accordance with equation (1)[21]

1) Z for Supply Fan Running.

$$Z=\frac{0,4.7,6+0,375.7,75+0,4.7,6+0,375.6,25+0,4.7,6+0,375.7,75+0,4.7,6+0,375.6,26+0,4.6,4+0,375.6,26+0,4.6,4+0,375.6,25+0,4.6,4+0,375.6,25+0,4.6,4+0,375.6,26}{0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375}$$

Z *supply fan* = 6.818 sec

2) Z for Exhaust Fan Running

$$Z=\frac{0,4.7,6+0,375.6,25+0,4.6,4+0,375.6,25+0,4.7,6+0,375.6,25+0,4.6,4+0,375.6,25+0,4.7,6+0,375.6,25+0,4.6,4+0,375.6,25+0,4.7,6+0,375.6,25+0,4.6,4+0,375.6,26}{0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375}$$

Z *exhaust fan* = 6.637 sec

3) Z for Ionizer activated

$$Z=\frac{0,4.7,8+0,375.6+0,4.6,2+0,375.6+0,4.7,8+0,375.6+0,4.6,2+0,375.6+0,4.7,8+0,375.6+0,6.7,8+0,375.6+0,4.7,8+0,375.6+0,4.6,2+0,375.6}{0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375+0,4+0,375}$$

Z *ionizer* = 6.475 sec

3.2. Output Result Smart Smoking Model and Matlab Analysis

Table 5. the output value of the models is compared with the output value of Matlab Analysis.

Table 5. Result of Smart smoking models and Matlab analysis

	Input Value				**Output Value Models**			**Output Value Matlab**		
NO	TempHum		CO level	Smoke level	Supply (z)	Exhaust (z)	Ionizer (z)	Supply (z)	Exhaust (z)	Ionizer (z)
1	22	85	8	76	6,54	4,15	4,34	6,74	4,13	4,37
2	22	84	9	80	6,54	4,15	4,34	6,74	4,13	4,37
3	23	82	9	83	7,34	4,03	4,18	7,5	4,26	4,54
4	23	82	11	91	7,38	4,91	5,03	7,5	5,16	5,28
5	24	80	13	98	8,18	6,17	6,11	8,24	6,23	6,24
6	25	77	14	103	8,23	6,53	6,53	8,7	6,74	6,74
7	25	76	15	108	8,11	7,13	7,13	8,39	7,5	7,5
8	26	76	15	114	8,74	7,11	7,11	8,95	7,5	7,5

9	26	74	17	121	9,06	8,76	8,74	9,44	8,96	8,95
10	26	75	19	130	9,47	10	9,87	9,64	10,1	10

3.3. Mean Squared Error (*MSE*)
The MSE value from Models value of the supply fan, exhaust fan and ionizer compared with Matlab analysis is as follows (equation 2)[22]

MSE for Supply fan:

$$MSE = \frac{(AT1-FT1)^2+(AT2-FT2)^2+(AT3-FT3)^2+(AT4-FT4)^2+(AT5-FT5)^2+(AT6-FT6)^2+(AT7-FT7)^2+(AT8-FT8)^2+(AT9-FT9)^2+(AT10-FT1)^2}{10}$$

$$MSE = \frac{(6{,}54-6{,}74)^2+(6{,}54-6{,}74)^2+(7{,}34-7{,}5)^2+(7{,}38-7{,}5)^2+(8{,}18-8{,}24)^2+(8{,}23-8{,}7)^2+(8{,}11-8{,}39)^2+(8{,}74-8{,}95)^2+(9{,}06-9{,}44)^2+(9{,}47-9{,}64)^2}{10}$$

MSE= **0.0640**

MSE for Exhaust fan:

$$MSE = \frac{(AT1-FT1)^2+(AT2-FT2)^2+(AT3-FT3)^2+(AT4-FT4)^2+(AT5-FT5)^2+(AT6-FT6)^2+(AT7-FT7)^2+(AT8-FT8)^2+(AT9-FT9)^2+(AT10-FT1)^2}{10}$$

$$MSE = \frac{(4{,}15-4{,}13)^2+(4{,}15-4{,}13)^2+(4{,}03-4{,}26)^2+(4{,}91-5{,}16)^2+(6{,}17-6{,}23)^2+(6{,}53-6{,}74)^2+(7{,}13-7{,}5)^2+(7{,}11-7{,}5)^2+(8{,}76-8{,}96)^2+(10-10{,}1)^2}{10}$$

MSE= **0.0502**

MSE for Ionizer:

$$MSE = \frac{(AT1-FT1)^2+(AT2-FT2)^2+(AT3-FT3)^2+(AT4-FT4)^2+(AT5-FT5)^2+(AT6-FT6)^2+(AT7-FT7)^2+(AT8-FT8)^2+(AT9-FT9)^2+(AT10-FT1)^2}{10}$$

$$MSE = \frac{(4{,}34-4{,}37)^2+(4{,}34-4{,}37)^2+(4{,}18-4{,}54)^2+(5{,}03-5{,}28)^2+(6{,}11-6{,}24)^2+(6{,}53-6{,}74)^2+(7{,}13-7{,}5)^2+(7{,}11-7{,}5)^2+(8{,}74-8{,}95)^2+(9{,}87-10)^2}{10}$$

MSE= **0.0604**

4. Conclusion
The results showed that the models was successfully designed by decomposing CO and indoor smoke. The value of Mean Squared Error (MSE) actual result and Matlab analysis on the supply fan is 0.0640, the MSE exhaust fan is 0.0502 and the MSE ionizer is 0.0604. The MSE value with results closed to zero, it is concluded that the prototype works properly. For the future researchs is need improvement with other methods such as artificial neural network, Genetic Algorithm or Integrated network as Big Data Analysis, and also added other sensors such as PIR sensors, Oxygen sensors to provide new input parameters.

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