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Smart Air Filter Based on Activated Charcoal and Aloe Vera Using Fuzzy Logic Algorithm

Smart Air Filter Based on Activated Charcoal and Aloe Vera Using Fuzzy Logic Algorithm

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Abstract. Smoking is one of the main risk factors of several chronic diseases such as lung cancer, upper respiratory tract cancer, heart disease, stroke, bronchitis, emphysema and others, even smoking can cause death. Cigarette smoke inhaled by passive smoking is the main cause of lung cancer in people who are not smokers. The risk of lung cancer increases by 20-30% in non-smokers but always surrounded by cigarette smoke, compared to non-smokers who are not exposed to smoke. This study aims to develop a smart device to filter cigarette smoke so that the air released from this device is free from the dangers of cigarette smoke. The materials used in this device as a cigarette smoke filter are activated charcoal and aloe vera, the pores of the charcoal open and can become adsorbents. This device uses fuzzy logic as a control method that can provide decisions that resemble human decisions. Arduino is used to adjust the fan rotation in absorb cigarette smoke and the LCD to display the level of cigarette smoke.

Keywords: cigarette smoke, smart air filter, arduino, fuzzy logic

1. Introduction

In Indonesia, smoking is a serious health problem. The impact caused by smoking is a major risk factor for several chronic diseases such as lung cancer, upper respiratory tract cancer, heart disease, stroke, bronchitis, emphysema and so on, even cases of death can be caused by smoking. People who smoke are divided into two categories, namely active smokers, and passive smokers [1]. Active smokers are people who intentionally smoke cigarettes themselves. Passive smokers are people around active smokers and also inhale cigarette smoke scattered in the air.

Active and passive smokers inhale cigarette smoke which contains gaseous and particle components. Cigarette smoke gas components consist of nitrogen and hydrocarbon compounds. Particle components consist of nicotine, tar, phenol, benzopyrene and cadmium. There are three main toxic components of cigarette smoke, including carbon monoxide, nicotine, and tar. Fifty percent of smokers cause death, almost killing six million people each year who are ex-smokers and 600,000 of them are passive smokers [2]. If not followed up, this mortality and morbidity rate will continue to increase every year.

The cigarette smoke in the air will result in clean air pollution so that the air quality becomes less good. Cigarette smoke inhaled into the lungs can causes respiratory problems [3]. In addition of air pollution caused by cigarette smoke in the room, the decline in air quality also occurs due to poor air circulation. This causes a lot of dust and germs to spread in the room [4].

Air pollution that has been exposed mainly due to cigarette smoke can be overcome by a developed device named smart air filter. The air output from this device is free from the dangers of compounds contained in cigarette smoke. This device uses Arduino UNO with an ATmega328 microcontroller which is equipped with the ability to interact with other devices through its input/output (I/O). Arduino

UNO has 14 I/O pins (0–13) which can be used to control sensors, motors and various other types of accumulators [5]. This device uses a gas sensor which it triggers a fan to absorb cigarette smoke and also uses fuzzy logic so that the fan will spin automatically according to the gas volume in the air and power efficiency will occur. This device is equipped with filters from activated charcoal and aloe vera.

Fuzzy logic was updated in 1985 by Takagi-Sugeno Kang. Sugeno corrected the weakness of the pure fuzzy system. It is in simple mathematical calculations–the THEN section was added. The fuzzy system, especially IF-THEN which has been modified, contains a weighted average value. Mathematical calculations that are not appropriate so that they cannot provide a natural framework when representing human thinking. The problem of pure fuzzy logic then has limitations in the application of different principles, so that the uncertainty of the fuzzy system cannot be processed properly [6].

Activated charcoal and aloe vera which filter of the device have an important role in filtering cigarette smoke. Activated charcoal can be made from coconut shell with chemical activation of ZnCl2 and Na2CO3 [7]. Coconut shells go through the combustion process so that they become active. Dey [8] in a study on the benefits of activated charcoal proved that cigarette filters using activated charcoal is more effective in filtering substances from cigarettes. The type of active filter developed in the laboratory shows that the filter can protect smokers from cytotoxicity due to cigarette smoke, protein modification, apoptosis, and emphysema.

Furthermore, the aloe vera filter contained in the developed device can prevent lung disease. Aloe Vera has the potential to modulate smoke-induced changes in lung tissue that may influence the management of smoking-related diseases [9]. So, the use of aloe vera as a filter on the device is very possible to filter the air from the dangers of cigarette smoke pollution.

2. Method

This study uses Research and Development (R&D) methods, the steps in R&D as follows (1) potential and problems, potential is anything that when utilized will have added value, problems are deviations between what is expected and what is happening; (2) gather information, after the potentials and problems can be factually demonstrated and updated, then it is necessary to collect information that can be used as material for planning certain products that are expected to overcome these problems; (3) product design, products are designed to solve existing problems; (4) design validation, design validation is a product design assessment activity by experts who are competent in their fields; (5) design improvements. after the product design, assessed through discussions with experts and other experts, the weaknesses will be identified, these weaknesses are reduced by improving the design; (6) product trial, the product was tested on a limited group; (7) product revision, the product weaknesses found in the device, then corrected to obtain a more perfect product; (8) Trial usage. The product is tested on a wider group [10].

This research was conducted in the Electronic Engineering Education Class of Yogyakarta State University. This research is a continuation of the final project of the intelligent control system course.

3. Result and Discussion

The developed device aims to filter indoor air, especially from the dangers of cigarette smoke. This device uses Arduino UNO as a controller board using an ATmega processor with the ability to interact with other devices via its input/output (I/O) pins.

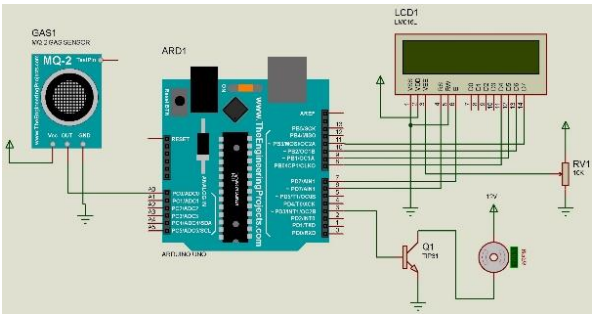

Figure 1. Electronic Circuit

Arduino board with fuzzy logic has an important role to process of determining the fan rotation speed. The fuzzification process is based on the levels of CO gas and smoke in the air. The sensor used to detect the gas content is the MQ2 gas sensor. In addition, to display the levels of gas contained in cigarette smoke uses the LCD. The electronic circuit can be seen in Figure 1.

Figure 2 is a flowchart and figure 3 is a block diagram of the device's working system include software and hardware based on figure 1. Starting from the gas sensor will detect the content of smoke. If detected, the fan will rotate to absorb the smoke according to the intensity of the amount of gas content of smoke. After the smoke is absorbed, the filtering process begins and in the end the air coming out from the device is clean from harmful compounds of cigarette smoke. The smoke level will be displayed on the LCD.

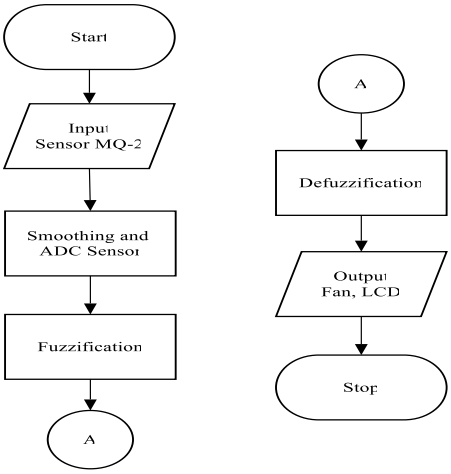

Figure 2. Flowchart of System

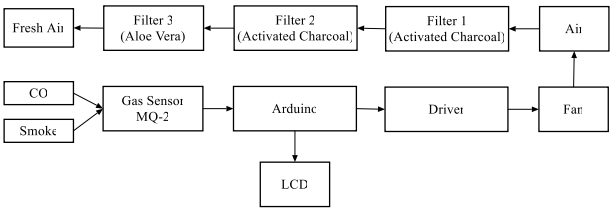

Figure 3. Block Diagram of Hardware

Based on the block diagram in Figure 3, the device model can be seen in Figure 4 and Figure 5.

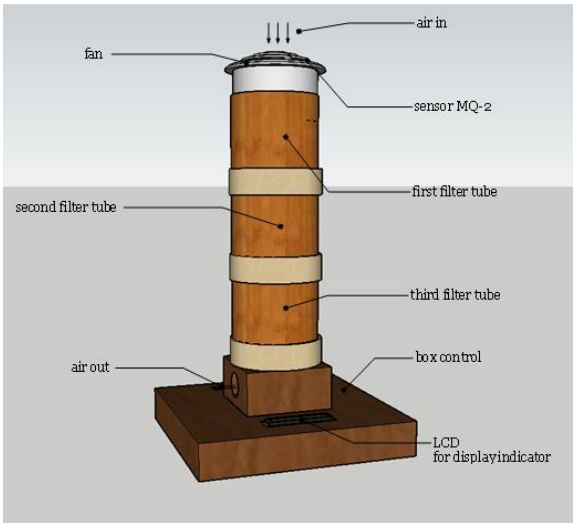

Figure 4. Device Model

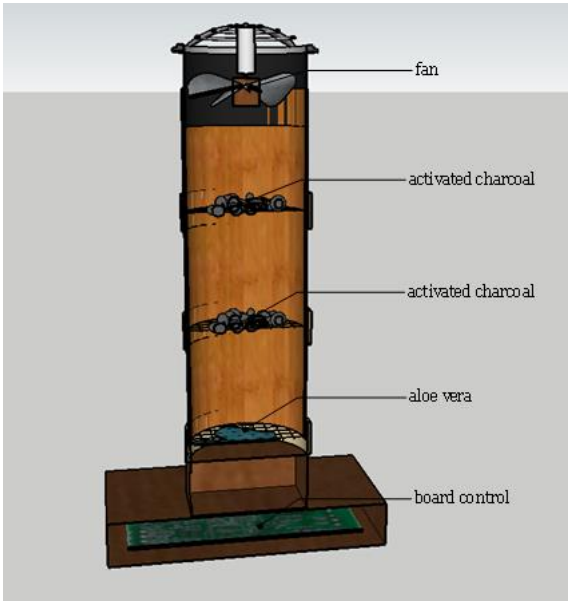

Figure 5. Cut View

This device is used to protect passive smokers from the dangers posed by active smokers. The device is placed close to an active smoker in a room. So, the cigarette smoke emitted by smokers is filtered by this device. The fuzzy logic used in processing output from the MQ2 sensor are CO and Smoke gas variables with low, medium, and high scales. Fan rotation speed settings from low, medium, fast, and very fast. There are four steps that must be done as follows:

3.1. Fuzzifications

Fuzzification is a process to convert a firm value into a fuzzy set or change a numeric variable into a linguistic variable. At this stage there are two numerical variables that will be converted into linguistic variables, namely:

3.1.1. CO Variable. CO inputs have 3 membership functions with 3 triangular membership functions.

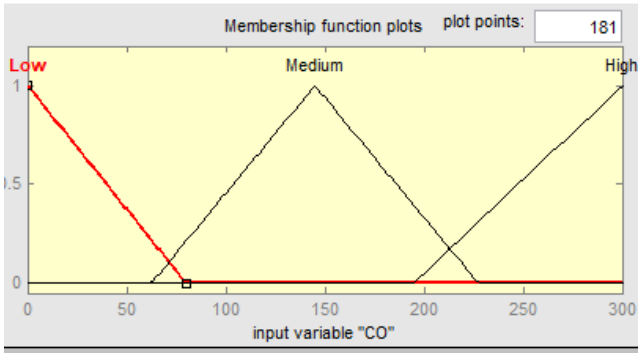

Figure 6. CO Membership Function

3.1.2. Variabel Smoke. Smoke inputs have 3 membership functions with 3 triangular membership functions.

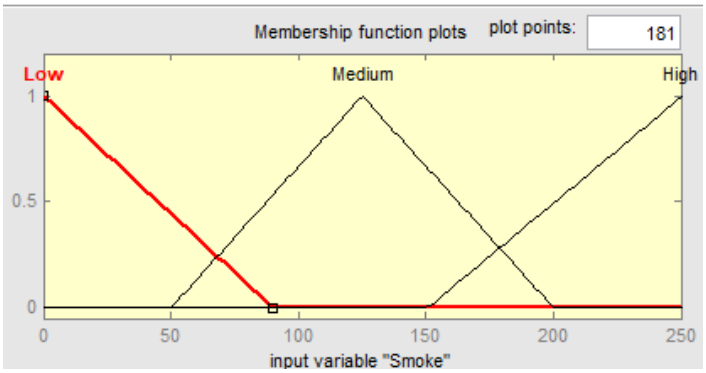

Figure 7. Smoke Membership Function

3.2. Establishment of Ground Rules

After determining membership function of the variable, then the fuzzy rules are formed. The rule is made to express the relation between fuzzy input and fuzzy output. The operator that will be used to connect the fuzzy inputs is AND and IF-THEN to describe the input-output Based on the existing fuzzy inputs, a fuzzy rule is made.

Table 1. Rule

CO↓/ SMOKE→	Low	Medium	High
Low	Low	Medium	Medium
Medium	Medium	Medium	Fast
High	Medium	Fast	Very Fast

From the two detected CO and Smoke, a rule is made as shown in table 1. Membership function of the gas content is categorized into 3, namely low, medium, and high. The input variable is connected to the fan output which has 4 membership functions, the output rotates speeds namely low, medium, fast, and very fast.

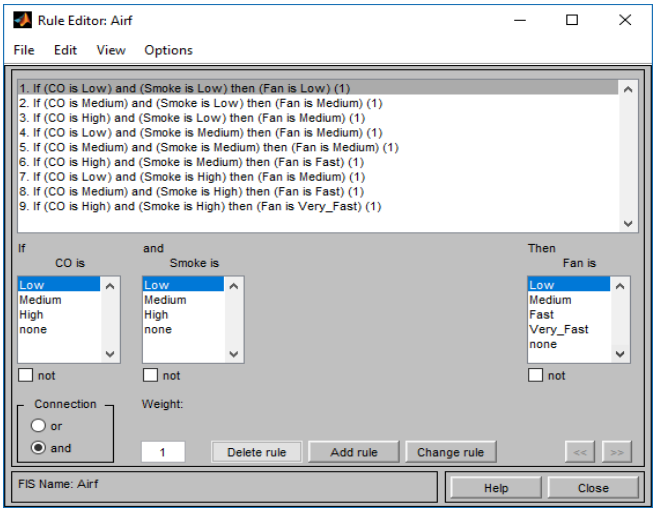

Figure 8. Rules

3.3. Interface Engine

After creating the fuzzy basic rules, the composition of the rules will be carried out to get the weights of the basic rules using the MIN implication function.

$$Wi = min\ (I1, I2, I3, ...\ Ii)$$

Explanation:

Wi : The weight of the implication to – i; i = 1, 2, 3...i
Ii : Fuzzy set input value from basic rule to –i.

3.4. Defuzzification

After doing the inference, defuzzification will be carried out to get the output in the form of a firm value. This firm value will be converted into the fan rotation speed. Defuzzification is complete using the weight average method.

$$Output = i = 1\ N\ Wi\ Zi = 1\ N\ W\ i$$

Explanation:

N = Number of rules.
Wi = The weight of the implication to -i
Zi = Behavioral output value of rule-i

The test is carried out by burning a cigarette, then the MQ2 sensor detects the levels of Smoke and CO gas in the air with units of Part Per Million (PPM). The output is detected on the Arduino IDE named clock scale that generates Pulse Width Modulation (PWM) with a maximum clock of 8 bits, range 0 – 255. The input has a maximum limit that has been calibrated according to the distance between the device and the smoker, in other words, as the range of the device. The maximum input for CO gas is 300 PPM and Smoke maximum input is 250 PPM which will be processed in a fuzzy algorithm. The delay for each reading is 3 seconds. PWM monitoring using a serial monitor on the Arduino IDE Software gives the results in Table 2.

Table 2. Test Result

NO	INPUT		OUTPUT (0 – 255)
	Gas CO (PPM)	Smoke (PPM)	
1	0	0	34,6
2	56	25	39,2
3	36	109	107
4	134	98	107

5	257	105	189
6	280	243	254
7	251	72	154
8	27	15	36,1
9	300	250	254
10	250	250	254

Arduino UNO has a 10-bit analog input and an 8-bit analog output. PWM manipulates the digital output in such a way that it produces an analog signal. The microcontroller shifts the digital output to HIGH and LOW alternately with a certain time portion for each output value. The time duration for the HIGH value is called the pulse width or pulse length. Variations in analog output values are obtained from changes in pulse length given over a period of time and repeated. Analog voltage output can be calculated by the formula:

$$\text{Vout} = \frac{clock\ \text{8bit scale}}{255} \text{ x 5 V}$$

Table 3. Convert To Analog Output

NO	Skala (0 – 255)	Analog Output (Volt)
1	34,6	0,68
2	39,2	0,77
3	107	2,10
4	107	2,10
5	189	3,71
6	254	4,98
7	154	3,02
8	36,1	0,71
9	254	4,98
10	254	4,98

The reading on the MQ2 sensor shows a fluctuate value. This refers to the levels of CO gas and smoke levels in the air that are read. Cigarette smoke that enters the device then passes through 2 times the activated charcoal filter and an aloe vera filter. After going through 3 filter processes, the air produced is free from cigarette smoke pollution. The results of the readings on the device's output are often zero.

4. Conclusion

Air pollution especially due to cigarette smoke, can be overcome with a developed filter. After making and testing smart air filter based on activated charcoal and aloe vera using fuzzy logic algorithm, the following conclusions are (a) the device developed using fuzzy logic as signal processing obtained from the gas sensor requires three stages, including fuzzification, manufacture rules, and defuzzification. (b) In making the device software, it begins with making a flowchart of the workings of the tool that will be made with a fuzzy logic algorithm which is then written using the Arduino language. (c) In making hardware, MQ2 sensor is used as input, Arduino as processor, fan as output and LCD as a display of CO2 and smoke detected. The materials used in the cigarette smoke filter tube are aloe and coconut shell charcoal. (d) The way of this device works is when the MQ2 sensor detects cigarette smoke, arduino processes and activates a fan that functions absorb and insert cigarette smoke around the device into the filter tube which has been given aloe and coconut shell charcoal. (e) Smart air filter based on fuzzy logic using activated charcoal and aloe vera works quite well with filter output as expected.

This developed device still has several shortcomings, suggestions for improvement for the perfection of this tool are: (a) The filter tube size is enlarged so that the smoke filter results are maximized (b) The tube design uses stronger materials. (c) The fan used has a stronger suction

capability so that the absorb range of the device is wider. (d) The bulkhead used to put aloe and coconut shell charcoal is strengthened and made neater.

5. References

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