

# The Coffee Roasting Process using Fuzzy Mamdani

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**Abstract.** The purpose of this research is to analyze whether fuzzy mamdani method can be used to determine roasting time in roasting coffee process. Coffee roasting process is one of the important stages in coffee processing, because in the roasting process will determine the aroma of coffee taste. In the roasting process there is often an error in determining the duration of roasting. Improper roasting process will cause the taste of coffee is not as expected. The variables used in the roasting process include temperature, density, water content of coffee, number of copies, size of fire, and time. Since the value of each variable is unclear or uncertain, a fuzzy logic method is needed to solve this problem. Every variable used in the fuzzy method will be determined its fuzzy set. Observation was done by using temperature data 1100C density 700 gram, water content 13%, quantity 1300 gram, and fire size 500C, from observation data got roasting time 10,19 minute, where time data have match with set fuzzy made. The results show that the proposed fuzzy mamdani method can be used as a decision system in determining coffee roasting time.

## 1. Introduction

Flavor and sense in coffee drinks one of which is formed through the process of roasting coffee [1, 2]. To get a taste of quality coffee required the right variable as a determinant in the roasting process [3, 4]. During the roasting process sometimes unexpected things happen like baking time. The values of the predefined variable are ambiguous or uncertain. For that we need fuzzy logic method to solve this problem [5, 6]. In this research, fuzzy mamdani method is used to determine the timing of pemangangan. Fuzzy logic mamdani is one method that is very flexible and has tolerance to existing data. Fuzzy mamdani has more intuitive advantages, accepted by many parties [7]. The use of fuzzy mamdani is similar to the use of forecasting methods in the field of statistics. Determination of analysis based on fuzzy approach is more efficient in approach using numbers than with forecasting methods [8, 9]. The input functions used in coffee roasting process include temperature, density, coffee water content, coffee quantity, fire size, and time.

Based on previous research, there are some research which is used as reference by writer that is research conducted by Schenker, S., et al, "Impact of roasting conditions on the formation of aroma compounds in coffee beans", this research is done to know the influence of temperature and long roasting. To achieve a specific flavor profile, proper time-control and temperature roasting is required [2]. Research conducted by Roza Susanti et al., "Temperature Monitoring for Coffee Seed Roasting", in this study more emphasis on making coffee roasting process appliance by using temperature sensor [10]. And another research is Eko Joni et al, "Heater Coffee Roaster Controller System Using Fuzzy Logic",



in this study designed heater coffee control system with fuzzy logic. The variables included in fuzzy logic are coffee color and baker room temperature, while the output variable is the heating temperature for roasting [11].

Based on the research that has been done, there are researches that have not used fuzzy mamdani method for roasting coffee process, also the research that has used fuzzy logic is only time parameter which is not taken into account for roasting process. Therefore, applied fuzzy mamdani method for roasting process with the aim to provide accurate information in determining the time of roasting

The purpose of this research is to analyze whether fuzzy mamdani method can be used to determine roasting time in roasting coffee process.

## 2. Methods

The method used to set the coffee roasting time is fuzzy mamdani method. The first stage is the stage of data collection or variables used for the process of roasting coffee. The input variables for the fuzzy mamdani method in roasting coffee are temperature, density, water content of coffee, quantity of coffee, fire size, and time. After the variables are obtained, the next step is to process those variables by creating a fuzzy set of each variable used, making the function implications (rules) use the minimum function, making the composition rule using the maximum method, and defuzzication using the centroid method.

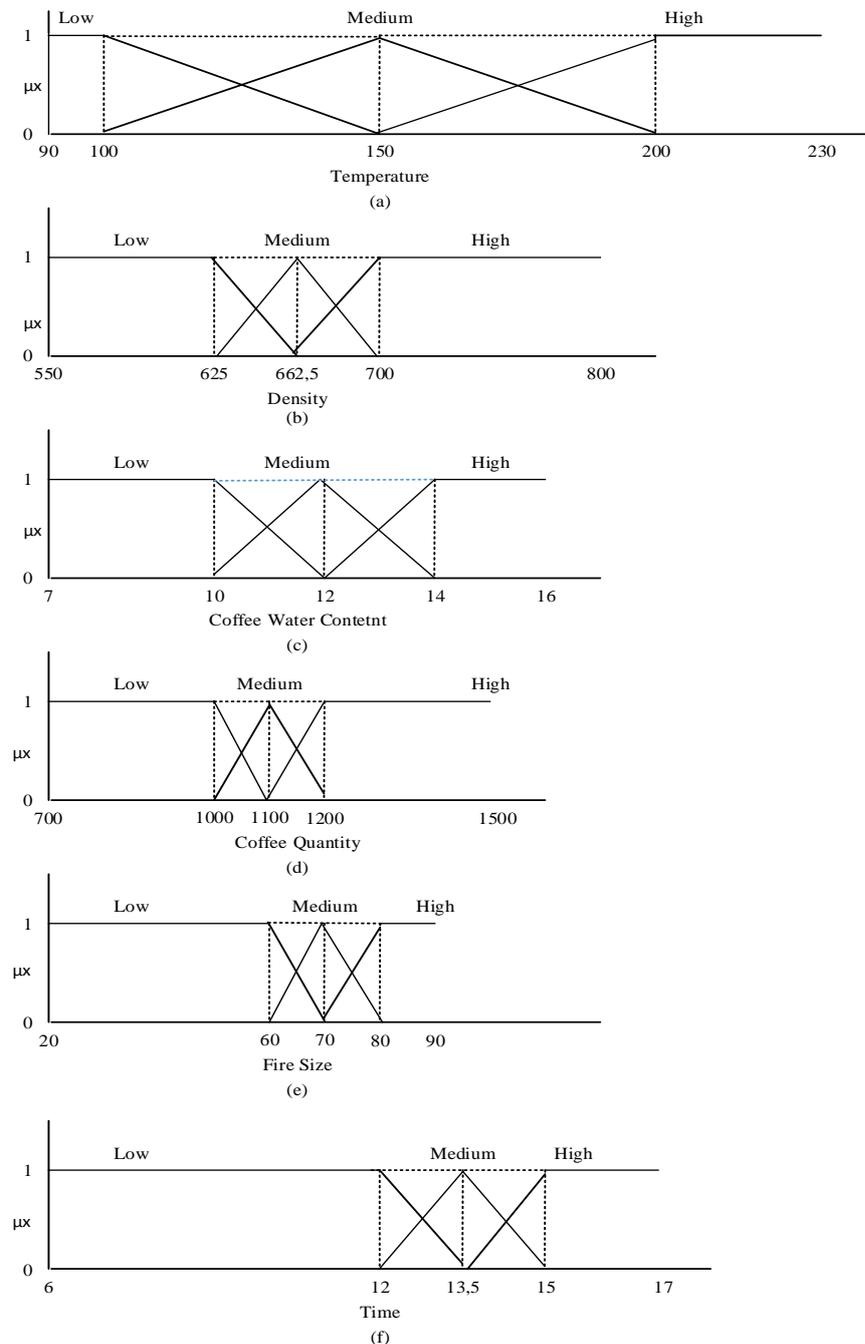
## 3. Results and discussion

The fuzzy set used in the roasting process is shown in Table 1.

**Table 1.** The fuzzy set.

Function	Variable	The Fuzzy Set	Domain
Input	Temperature	Low	[90, 100]
		Medium	[100, 200]
		High	[200, 230]
	Density	Low	[550, 625]
		Medium	[625, 700]
		High	[700, 800]
	Coffee water content	Low	[7, 10]
		Medium	[10, 14]
		High	[14, 16]
	Coffee Quantity	Low	[700, 1000]
		Medium	[1000, 1200]
		High	[1200, 1500]
	Fire size	Low	[20, 60]
		Medium	[60, 80]
		High	[80, 90]
Output	Time	Low	[6, 12]
		Medium	[12, 15]
		High	[15, 17]

Variable representation for roasting process is used curve shaped shoulder (for low and high fuzzy set) and triangle curve (for medium set fuzzy), fuzzy set curve can be seen in figure 1. Roasting process uses 5 input variables with fuzzy set of 3 (low, medium, and high) so that rules are made as many as 243 rules.



**Figure 1.** The fuzzy set for roasting process.

The sample data used to determine the time in the roasting process is temperature 110 °C density 700 grams, water content 13%, quantity 1300 grams, and fire size 50 °C. The rule used is:

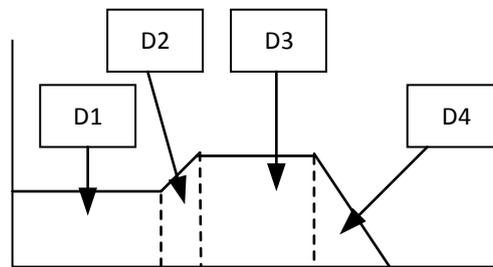
- If temperature low and high density and water content medium and high quantity and fire size low then time high,  $a_1 = \min(0,8; 1, 0,5, 1, 1) = 0,5$
- If temperature low and high density and water content high and high quantity and fire size low then time high,  $a_2 = \min(0,8; 1, 0,5, 1, 1) = 0,5$
- If temperature medium and high density and water content medium and high quantity and fire size low then time medium,  $a_3 = \min(0,25; 1, 0,5, 1, 1) = 0,25$

- If temperature medium and high density and water content high and high quantity and fire size low then time medium,  $a_4 = \min (0,25; 1, 0,5, 1, 1) = 0,25$

Application of each rule function in the roasting process is used maximum method to compose between all rules, so the membership function for the result of this composition is:

$$\mu_{Time} = \begin{cases} 0,25 ; 6 \leq x \leq 12,35 \\ \frac{x-12}{1,5} ; 12,35 \leq x \leq 12,75 \\ 0,5 ; 12,75 \leq x \leq 14,3 \\ \frac{15-x}{1,5} ; 14,3 \leq x \leq 15 \\ 0 ; x \geq 15 \end{cases} \quad (1)$$

The output of fuzzy system can be seen in Figure 2.



**Figure 2.** The solution of area fuzzy.

In figure 2, the result area is divided into two parts, namely D1, D2, D3, and D5. And the last stage is done defuzzification process by using method of centroid. Figure 2 shown is the solution of fuzzy area.

$$z = \frac{14,57 + 1,43 + 10,48 + 3,38}{1,5 + 0,28 + 0,98 + 2,73} = 10,19$$

Based on the calculation, the roasting time used is 10,19 minute.

#### 4. Conclusion

From the discussion that has been done, fuzzy mamdani can be used as a decision maker on the roasting process. Decision-making is determined from the input variable data consisting of, temperature, density, coffee water content, coffee quantity, fire size, and generating the output variable is the processing time.

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