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Determination of Quality Seed Coffee Use Method of Fuzzy Logic

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Abstract. Coffee is one of Indonesian plantation yields whose selling value is quite high. Particularly in Gayo highland, this plant is the main incomes for the farmers. There are two kinds of coffee plant raised on namely Arabica and Robusta. This study aims to explain application of fuzzy logic method using tsukamoto method. The result of this study shows that accuracy level can reach up to 30%. The accuracy for each coffee beans quality can be explained as: 80%Arabica grade 1, 0% Arabica grade 2, 0% Arabica grade 3, 100% robusta grade 1, 0% robusta grade 2, and 0% robusta grade 3.

1. Introduction

Coffee is one of plantation products of Indonesian that has very high selling value. In Gayo highlands, this plant is the main income of farmers. There are two types of coffee namely Arabica and Robusta, but the most widely cultivated coffee is Arabica. This coffee is not only sold domestically but also sold globally.

In trading process, high quality coffee beans are required because the quality is an important factor in trading world. The better the quality of the coffee beans, the higher number of demand. Determination of coffee bean quality among Gayo highlander is still manual, visible determination. The determination requires longer time and more labors and leads to delay in import distribution process of coffee beans. It is a bad impact for Gayo coffee farmers.

Determination of image quality. This application is expected to assist Gayo coffee farmers in determining quality of coffee beans. Based on the background, question of this research is how the method of *fuzzy logic* determining quality of coffee beans. This study aims to discuss application of *fuzzy logic* in determining quality of the coffee beans.

Limitations of problems in this study are as follows:

1. Types of coffee used in this research are arabica and robusta.
2. Method used is Tsukamoto *fuzzy logic*.
3. Determination of quality is divided into 3 classes: grade 1, grade 2, and grade 3.
4. This application was created by using *Visual Studio 2012*.

Quality criteria of coffee beans is based on color and shape.

The benefits of this study are as follows:

1. Results of this study can ease performance of farmers for determining process of coffee bean quality of coffee beans in a relatively shorter time.

Results of this study are also expected to be basis for further studies.

Previous researches have been conducted by several researchers such as applying Sample Additive Weighting method (SAW) on Export Quality Coffee Beans. Red Guava Fruit Maturity (*Psidium Guajava*) is ensured by using Fuzzy Model with 83.3% testing data results and 16.7% error. Sweet Corn Seed Quality Classification color-based using *Fuzzy Logic* receive 68% broken corn grain, 68% damaged corn grains, and 68% whole seeds corn. Determination of cocoa quality used mamdani method producing an expert system that is capable of determining quality of cocoa based on criteria affecting quality of cocoa. Result of Fuzzy Tsukamoto Logic Method in Decision Making System is applied to ease weighting and decision making of fuzzy logic [1] [2] [3] [4] [5].

2. Research methodology

According to [6], fuzzy logic was introduced by Prof. Lotfi Zadeh in 1962. Fuzzy logic is a problem-solving control systems methodology, which is suitable to implement on: simple systems, small systems, embedded systems, PC networks, multi-channel or data acquisition-based workstations, and control systems. In classical logic, it is stated that everything is binary (has only two possibilities: "Yes or No", "True or False", "Good or Bad", and so on). Therefore, all of these may have value of 0 or 1, but the value depends on their weight of membership. Fuzzy Tsukamoto is if (X is A) and (Y is B) then (Z is C), where A, B, and C is a fuzzy set. Inference stages of the tsukamoto method are as follows:

- 2.1 *Fuzzyfication is process to transform input value system that has firm value to linguistic variables using membership functions and stored in the fuzzy base.*

$$\mu_{R_{low}}[110] = (141-110) / 44 = 31 / 44 = 0.7045$$

$$\mu_{R_{high}}[110] = (110-97) / 44 = 13 / 44 = 0.2954$$

$$\mu_{G_{low}}[106] = (139-106) / 45 = 33 / 45 = 0.7333$$

$$\mu_{G_{high}}[106] = (106-94) / 45 = 12 / 45 = 0.2666$$

$$\mu_{B_{low}}[101] = (131-101) / 36 = 30 / 36 = 0.8333$$

$$\mu_{B_{high}}[101] = (101-95) / 36 = 6 / 36 = 0.1666$$

$$\mu_{Sobel_{low}}[39] = (60-39) / 24 = 21 / 24 = 0.875$$

$$\mu_{Sobel_{high}}[39] = (39-36) / 24 = 3 / 24 = 0.125$$

- 2.2 *Fuzzy formation of a knowledge base (rule in form of IF ... THEN) [R1] G_high, r_high IF and THEN AND b_tinggi AND sobel_tinggi Grade1 [R2] IF AND b_high, g_high, r_high AND THEN AND sobel_high Grade1.*

- 2.3 *M inference engine uses MIN implications function to gain value of α -predicate for each rule ($\alpha_1, \alpha_2, \alpha_3, \dots \alpha_n$). Then each α -predicate value is used to calculate output of result inference explicitly (crisp) for each rule ($z_1, z_2, z_3, \dots z_n$).*

$$[R1] G_{high} r_{high} \text{ IF AND THEN AND } b_{high} \text{ AND } sobel_{high} \text{ Grade1}$$

$$\alpha\text{-predicate}_1 = \min(0.2954; 0.2666; 0.1666; 0.125)$$

$$= 0.125$$

$$Z_1 = 106 + (0.125 \times (143 - 106))$$

$$= 106 + (0.125 \times 37)$$

$$= 106 + 4.625$$

$$= 110.625$$

$$[R2] \text{ IF } b_{high} g_{high} r_{high} \text{ AND } sobel_{high} \text{ Grade1}$$

$$\alpha\text{-predicate}_2 = \min(0.2954; 0.2666; 0.1666; 0.875)$$

$$= 0.1666$$

$$Z_2 = 106 + (0.1666 \times (149 - 100))$$

$$\begin{aligned}
 &= 106 + (0.1666 \times 37) \\
 &= 106 + 6.1642 \\
 &= 112.1642
 \end{aligned}$$

2.4 Defuzzification is the last output (z) obtained by using average weighted as follows:

$$Z = \frac{\alpha_1 Z_1 + \alpha_2 Z_2}{\alpha_1 + \alpha_2}$$

Description:

Z = Defuzzification

α_1 = Value of the smallest on rules to 1

α_2 = The smallest value in rule to 2

z_1 = Value firmly on rules to 1

z_2 = Value firmly on rule to 2

$$Z = \frac{\alpha_{pred1} * z_1 + \alpha_{pred2} * z_2}{\alpha_1 + \alpha_2}$$

$$Z = \frac{0.125 * 110.625 + 0.1666 * 112.1642}{0.125 + 0.1666}$$

$$Z = \frac{13.828125 + 18.68655572}{0.2916}$$

$$Z = 111.5044$$

Data collection techniques are gathered from the internet journals and books related to the study as references. Used material in this research is sample of arabica coffee beans and robusta coffee bean directed with retrieval technique. Coffee beans used are coffee beans that have different colors and shapes. The sampling process coffee beans are taken 3 cm from the surface whose background is white with even lighting conditions. Data processing technique is original image process to gain information. In making application of determining coffee quality by image processing by inputting RGB image input and then converting to gray scale, processing Sobel edge detection method, taking the average value R, G, B and average pixel edge detection pixels. After receiving value of color and shape, the next process is determining image of coffee beans into: Grade1 quality, Grade 2 and Grade 3 using Tsukamoto.

Flowchart image test process is a flowchart describing process of system testing. Display flowchart of image test can be seen in Figure 1 below.

Figure 1 shows that the test process is begun with inputting image of coffee beans, then taking the average value of pixels R, G, and B to define colors. Subsequently, converting the RGB image into *grayscale* image and the *grayscale* image will be processed using Sobel edge detection method, then taking the average value of Sobel edge detection pixels to define shape of the image. Next, selecting type of coffee to save to database. Then, performing process of determining quality of coffee beans by using Tsukamoto *fuzzy logic* with obtained final grade results: grade 1, grade 2, or grade 3.

Range of values for quality of each class is as follows:

- Range values for grade 1 is from 106.1 to 143
- Range values for grade 2 is from 69.1 to 106
- Range values for Grade 3 is from 33 to 6

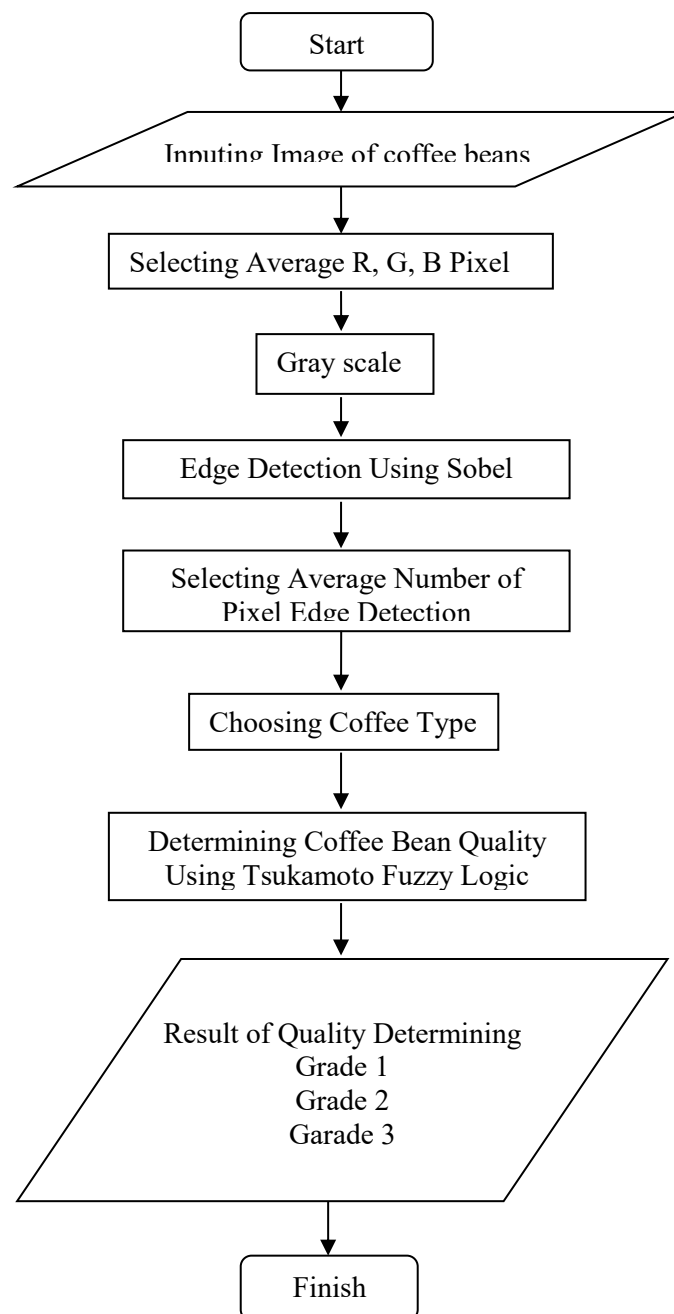


Figure 1. Flow chart image test process

3. Results and discussions

Determination form of quality is a page to process image quality of coffee beans with Tsukamoto *fuzzy logic* method. Determining quality is shown in Figure 2 below:

System testing is a process undertaken to determine application success rate of coffee beans quality determination by using *fuzzy logic*. Inputs used in membership function is *fuzzy logic* method with average value of pixels R, G, B, and edge image detection. After getting the average value of the pixel, the next step is selecting type of input coffee to perform process of *fuzzy logic*, by clicking the button rule, then clicking the button count Z to obtain a weighted average of Tsukamoto fuzzy, then clicking the button quality to figure out results quality of coffee beans.

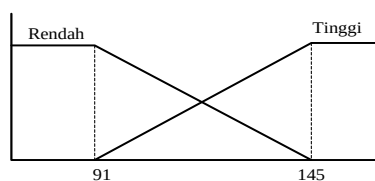
No	Jenis Kopi	Grade	R	G	B	Sobel	Ztotal
1	Arabika	Grade 1	114	110	100	36	108.83037814
2	Arabika	Grade 1	110	105	97	39	110.48150381
3	Arabika	Grade 1	111	109	105	42	111.90393039
4	Arabika	Grade 1	106	105	102	38	110.50254402
5	Arabika	Grade 1	122	121	117	47	116.31093256
6	Arabika	Grade 1	117	114	109	37	109.80387506

Figure 2. Determination form of quality

Quality determination form the of a page used by *users* to perform determining process of coffee beans quality on tested data to obtain information about the data. The form displayed image of coffee beans by clicking on the button to download *all* tested images to be tested. After selecting the images, the *users* select type of coffee to make process of fuzzy. Then clicking the button rule, then clicking the z calculate button and clicking quality determination button to gather quality of coffee beans.

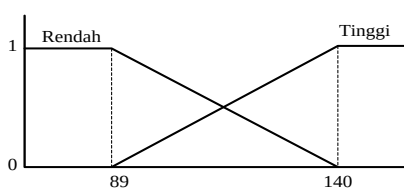
There are 4 variable memberships of curves fuzzy which are used as fuzzy input is as follows:

1. Membership function of R pixel variable
Value of Rpixel value range is 91-145



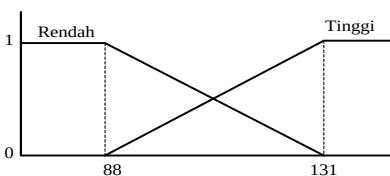
Values range used in Rpixel variable curve is 91 (minimum) to 145 (maximum).

2. Membership function of G pixel variable
Value of G pixel range is 89-140



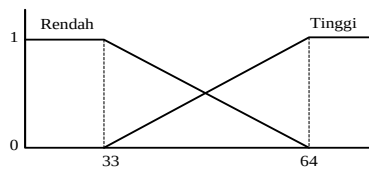
Values range used in curve of G pixel variable curve is 89 (minimum) to 140 (maximum).

3. B Pixel variable membership function
Value range of Bpixel is 88-131



Values range used in curve of B pixel variable is 88 (minimum) to 131 (maximum).

4. Membership function of the Sobel pixel variable
Sobel pixel value range is 33-64.



Values *range* used in curve of Sobel pixel is 33 (minimum) to 64 (maximum).

There is an error in process of determining coffee beans quality. Image of successful Arabica coffee beans grade 1 can be seen in Table 1 below.

Table 1. Image of successful grade 1 Arabica coffee beans

Edge Image Detection	R	G	B	Sobel	Total Z	Result
	110	106	101	36	108.23785870064	Grade 1

Success rate of applications in making determination of coffee beans quality using *fuzzy logic* method is imperfect. Display of determination results quality of every coffee bean grade can be seen in Table 2 below.

Table 2. Results of determination of quality of every grade coffee beans

Type of Coffee	Grade 1 (%)	Grade 2 (%)	Grade 3 (%)
Arabica	80	0	0
Robusta	100	0	0

The following graph is display of table 2data. The graphic displays determination result quality of each class of grain coffee.

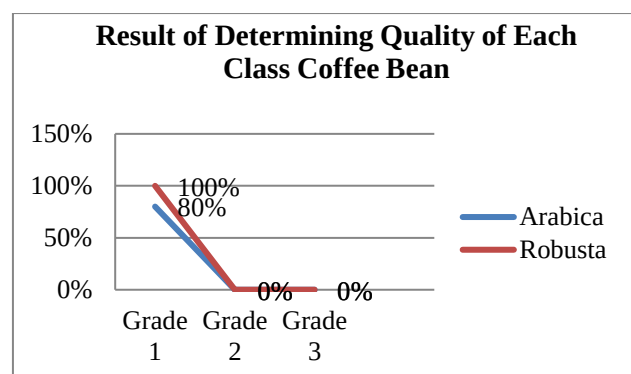


Figure 3. Determination result quality of each coffee bean class

Based on tested data, there are 18 test data which are successful; total number of test data is 60. Calculation of accuracy of the application is:

$$\text{Accuracy} = \frac{\text{Total of successful tested data}}{\text{total of tested data}} \times 100\%$$

$$\text{Accuracy} = \frac{18}{60} \times 100\% = 30\%$$

Accuracy calculations for each class are as follows:

$$1. \text{ Accuracy of arabica grade 1} = \frac{8}{10} \times 100\% = 80\%$$

2. Accuracy of arabica grade 2 = $\frac{0}{10} \times 100\% = 0\%$
3. Accuracy of arabica grade 3 = $\frac{0}{10} \times 100\% = 0\%$
4. Accuracy of robusta grade 1 = $\frac{10}{10} \times 100\% = 100\%$
5. Accuracy of robusta grade 2 = $\frac{0}{10} \times 100\% = 0\%$
6. Accuracy of robusta grade 3 = $\frac{0}{10} \times 100\% = 0\%$

From results of accuracy testing, failure in determining quality of coffee beans is 70%, where the failure is caused by poor image quality of coffee beans that spend much time thus calculation results of pixel image value do not correspond with a range of first-class determined coffee beans quality.

4. Conclusion

Based on researchers that have been done on determining applications of coffee beans quality using Tsukamoto fuzzy logic, it can be concluded that the input used in this application form (image of coffee beans), then average number of pixels R, G, B, and Sobel to be processed and calculated using fuzzy logic method. Results of coffee quality obtained by using fuzzy logic method are divided into: grade 1, grade 2 and grade 3. Process of determining quality of coffee beans using fuzzy logic is obtained by taking average value of color and edge detection coffee beans to produce data output of determination of coffee beans quality.

Accuracy of success in determining quality of coffee beans for grade 1 Arabica is 80%. Accuracy of success of determining coffee beans quality for Arabica grade 2 is 0%. Accuracy of success in determining quality of coffee beans for grade 3 Arabica is 0%. Success accuracy of determining quality of Robusta coffee beans for grade 1 is 100%. Accuracy of success of determining coffee beans quality for Robusta grade 2 is 0%. Accuracy of success of determining quality of Robusta coffee beans grade 3 is 0%. Success rate of applications in determining quality of coffee beans using fuzzy logic method is 30%.

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