Register   Login

HOME   REGISTER   LOGIN   ISSUES ▾   PEOPLE ▾   ABOUT ▾   JOURNAL POLICIES ▾   PUBLICATION ETHICS   CITED IN SCOPUS   CONTACT   🔍 SEARCH

HOME / ARCHIVES / Vol 16 No 3 (2022): BAREKENG: Jurnal Ilmu Matematika dan Terapan
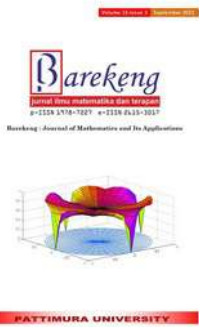
BAREKENG : Journal of Mathematics and Its Applications, volume 16 issue 3 (September 2022) was officially published in English (also journal name officialy in english).
BAREKENG : Journal of Mathematics and Its Applications, has been published four (4) times a year in March, June, September, and December (4 issues). This issue contain 40 articles available online and consists of authors from 3 countries (Indonesia, Malaysia and Nigeria).

DOI: https://doi.org/10.30598/barekengvol16iss3year2022

PUBLISHED: 2022-09-01

Articles

ANALYSIS OF THE VACCINATION'S IMPACT ON THE INCREASE IN COVID-19'S DAILY NEW AND RECOVERED CASES USING THE VECTOR AUTOREGRESSIVE (VAR) MODEL (CASE STUDY: WEST KALIMANTAN)
Yundari Yundari, Nur'ainul Miftahul Huda
761-770

📄 pdf download

📊 Abstract views 44 | 📄 PDF Download downloads 46 | DOI https://doi.org/10.30598/barekengvol16iss3pp761-770

CLASSIFICATION OF STUNTING IN CHILDREN UNDER FIVE YEARS IN PADANG CITY USING SUPPORT VECTOR MACHINE
Izzati Rahmi, Mega Susanti, Hazmira Yozza, Frilianda Wulandari
771-778

📄 pdf download

📊 Abstract views 51 | 📄 PDF Download downloads 44 | DOI https://doi.org/10.30598/barekengvol16iss3pp771-778

RIDGE LEAST ABSOLUTE DEVIATION PERFORMANCE IN ADDRESSING MULTICOLLINEARITY AND DIFFERENT LEVELS OF OUTLIER SIMULTANEOUSLY
Netti Herawati, Subian Saidi, Dorrah Azis
779-786

📄 pdf download

📊 Abstract views 29 | 📄 PDF Download downloads 32 | DOI https://doi.org/10.30598/barekengvol16iss3pp779-786

CALCULATION OF CREDITED INTEREST RATE WITH INVESTMENT YEAR METHOD AND PORTFOLIO METHOD
Jevilia Aryento, Felivia Kusnadi, Dharma Lesmono
787-796

📄 pdf download

📊 Abstract views 47 | 📄 PDF Download downloads 34 | DOI https://doi.org/10.30598/barekengvol16iss3pp787-796

OUTLIER DETECTION ON HIGH DIMENSIONAL DATA USING MINIMUM VECTOR VARIANCE (MVV)
Andi Harismahyanti A., Indahwati Indahwati, Anwar Fitrianto, Erfiani Erfiani
797-804

📄 pdf download

📊 Abstract views 44 | 📄 PDF Download downloads 34 | DOI https://doi.org/10.30598/barekengvol16iss3pp797-804

ONE-DIMENSIONAL CUTTING STOCK PROBLEM THAT MINIMIZES THE NUMBER OF DIFFERENT PATTERNS
Bib Paruhum Silalahi, Farida Hanum, Fajar Setyawan, Prapto Tri Supriyo
805-814

📄 pdf download

📊 Abstract views 55 | 📄 PDF Download downloads 33 | DOI https://doi.org/10.30598/barekengvol16iss3pp805-814

THE BAYESIAN SEM APPROACH ON RELIGIOUS TOURISM AND SME'S ENTREPRENEURIAL OPPORTUNITY INTERRELATION IN RURAL AREA

Frilianda Wulandari, Dodi Devianto, Ferra Yanuar

815-828

[pdf download]

AN EXISTENCE AND UNIQUENESS OF THE WEAK SOLUTION OF THE DIRICHLET PROBLEM WITH THE DATA IN MORREY SPACES

Nicky Kurnia Tumalun

829-834

[pdf download]

OPTIMAL CONTROL OF INFLUENZA A DYNAMICS IN THE EMERGENCE OF A TWO STRAIN

Jonner Nainggolan

835-844

[pdf download]

TAGUCHI METHOD APPLIED FOR THE INVESTIGATION OF CORROSION LEVEL ON METAL INERT GAS WELDING OF MILD STEEL

Nanang Fatchurrohman, Low Tze Chin, Jufriadif Na'am

845-852

[pdf download]

AN ORDINAL LOGISTIC REGRESSION MODEL FOR ANALYZING RISK ZONE STATUS OF COVID-19 SPREAD

Tessya Mutiara Dewi, Rosita Kusumawati

853-860

[pdf download]

MULTILEVEL NON-LINIER REGRESSION FOR REPEATED MEASURMENT DATA AS STUDY OF PEANUT GROWTH

Arie Purwanto, Umul Aiman

861-868

[pdf download]

ON THE IRREGULARITY STRENGTH AND MODULAR IRREGULARITY STRENGTH OF FRIENDSHIP GRAPHS AND ITS DISJOINT UNION

Fredrylo Alberth Noel Joddy Apituley, Mozart W. Talakua, Yopi Andry Lesnussa

869-876

[pdf download]

FUZZY LOGIC APPLICATION ON EMPLOYEE ACHIEVEMENT ASSESSMENT (CASE STUDY: EDUCATION QUALITY ASSURANCE INSTITUTE OF MALUKU PROVINCE)

Nurhidayah Nurhidayah, Yopi Andry Lesnussa, Zeth Arthur Leleury

877-886

[pdf download]

QUOTIENT SEMINEAR-RINGS OF THE ENDOMORPHISM OF SEMINEAR-RINGS

Meryta Febrilian Fatimah, Fitriana Hasnani, Nikken Prima Puspita

887-896

[pdf download]

SURVIVAL ANALYSIS OF DENGUE HEMORRHAGIC FEVER PATIENTS (DHF)

Firza Khairunnisa, Fazrina Saumi, Amelia Amelia

897-908

[pdf download]

ON COMPUTATIONAL BAYESIAN ORDINAL LOGISTIC REGRESSION LINK FUNCTION IN CASES OF CERVICAL CANCER IN TUBAN

Nur Mahmudah, Fetrika Anggraini

909-918

[pdf download]

Department, Faculty of Mathematics and Natural Sciences, University of Pattimura. This journal publish article related to Pure Mathematics, Applied Mathematics, Statistics, Actuarial Science, Mathematic Computation and Mathematics Education.

The meaning word of **Barekeng** is a local term of Moluccas language which means **Counting** or **Calculating**. Counting is a main and fundamental activities in the field of Mathematics. Therefore we tried to promote **"Barekeng"** as the name of our scientific journal.

Read more...

Journal Statistics

Visitors   See more ▶

98,502		12		4	
3,307		12		4	
296		12		3	
268		11		3	
241		11		3	
226		10		2	
115		10		2	
102		10		2	
85		10		2	
81		9		2	
74		9		2	
74		8		2	
73		8		2	
63		8		2	
53		7		2	
49		7		2	
48		7		1	
43		7		1	
39		6		1	
34		6		1	
32		6		1	
28		6		1	
21		6		1	
19		5		1	
19		5		1	
18		5		1	
18		5		1	
18		4		1	
17		4		1	
17		4		1	
17		4		1	
16		4		1	
15		4		1	

Pageviews: 212,491

FLAG counter

Stat Counter

View My Stats

Updates Information

Good News!!!

Since 2020, BAREKENG: Journal of Mathematics and Its Applications, published four times a year, in March, June, September, and December.
The articles for Volume 16 issue 3, September 2022 had been published with authors from 3 countries (Indonesia, Malaysia & Nigeria), while for Volume 16 issue 4 December 2022 are in process. Now, BAREKENG: Journal of Mathematics and Its Applications, call for papers to Volume 17 issue 1, March 2023.

Google Scholar Citation

Analysis Citation

COMPARISON OF ARIMA AND GARMA'S PERFORMANCE ON DATA ON POSITIVE COVID-19 CASES IN INDONESIA
A'yunin Sofro, Khusnia Nurul Khikmah

919-926

🗎 pdf download

📊 Abstract views 49 | 📄 Pdf Download downloads 38 | DOI https://doi.org/10.30598/barekengvol16iss3pp919-926

PERFORMANCE COMPARISON OF GRADIENT-BASED CONVOLUTIONAL NEURAL NETWORK OPTIMIZERS FOR FACIAL EXPRESSION RECOGNITION
Sri Nurdiati, Mohamad Khoirun Najib, Fahren Bukhari, Refi Revina, Fitra Nuvus Salsabila

927-938

🗎 pdf download

📊 Abstract views 46 | 📄 Pdf Download downloads 70 | DOI https://doi.org/10.30598/barekengvol16iss3pp927-938

TEXT CLUSTERING ONLINE LEARNING OPINION DURING COVID-19 PANDEMIC IN INDONESIA USING TWEETS
Maulida Fajrining Tyas, Anang Kurnia, Agus Mohamad Soleh

939-948

🗎 pdf download

📊 Abstract views 39 | 📄 Pdf Download downloads 29 | DOI https://doi.org/10.30598/barekengvol16iss3pp939-948

MULTI-RESPONSE OPTIMIZATION OF DIELECTRIC FLUID MIXTURE IN EDM USING GREY RELATIONAL ANALYSIS (GRA) IN TAGUCHI METHOD
Veniola Forestryani, Niam Rosyadi, Muhammad Ahsan

949-960

🗎 pdf download

📊 Abstract views 39 | 📄 Pdf Download downloads 26 | DOI https://doi.org/10.30598/barekengvol16iss3pp949-960

THE HARMONIC INDEX AND THE GUTMAN INDEX OF COPRIME GRAPH OF INTEGER GROUP MODULO WITH ORDER OF PRIME POWER
Muhammad Naoval Husni, Hanna Syafitri, Ayes Malona Siboro, Abdul Gazir Syarifudin, Qurratul Aini, I Gede Adhitya Wisnu Wardhana

961-966

🗎 pdf download

📊 Abstract views 85 | 📄 Pdf Download downloads 35 | DOI https://doi.org/10.30598/barekengvol16iss3pp961-966

ANALYSIS OF THE SPRUCE BUDWORM MODEL USING THE HEUN METHOD AND THIRD-ORDER RUNGE-KUTTA
Irwan Irwan, Muh Irwan, Rosmaniar Rosmaniar, Wahidah Alwi, Risnawati Ibnas

967-974

🗎 pdf download

📊 Abstract views 27 | 📄 Pdf Download downloads 24 | DOI https://doi.org/10.30598/barekengvol16iss3pp967-974

AN ITERATIVE PROCEDURE FOR OUTLIER DETECTION IN GSTAR(1;1) MODEL
Nur'ainul Miftahul Huda, Utriweni Mukhaiyar, Nurfitri Imro'ah

975-984

🗎 pdf download

📊 Abstract views 37 | 📄 Pdf Download downloads 22 | DOI https://doi.org/10.30598/barekengvol16iss3pp975-984

BINARY LOGISTICS REGRESSION MODEL TO IDENTIFY FACTORS ASSOCIATED WITH LOW BIRTH WEIGHT (LBW) (CASE STUDY: BABY DATA AT DR. M. HAULUSSY HOSPITAL AMBON)
Yunita Puspita Sari, Marlon S. Noya Van Delsen, Yopi Andry Lesnussa

985-994

🗎 pdf download

📊 Abstract views 28 | 📄 Pdf Download downloads 24 | DOI https://doi.org/10.30598/barekengvol16iss3pp985-994

CONTROL CHART AS VERIFICATION TOOLS IN TIME SERIES MODEL
Nurfitri Imro'ah, Nur'ainul Miftahul Huda

995-1002

🗎 pdf download

📊 Abstract views 26 | 📄 Pdf Download downloads 23 | DOI https://doi.org/10.30598/barekengvol16iss3pp995-1002

SPATIO-TEMPORAL ANALYSIS OF RUPIAH LOANS PROVIDED BY COMMERCIAL BANKS AND RURAL BANKS
Muktar Redy Susila

1003-1012

🗎 pdf download

📊 Abstract views 27 | 📄 Pdf Download downloads 25 | DOI https://doi.org/10.30598/barekengvol16iss3pp1003-1012

THE INTERSECTION GRAPH REPRESENTATION OF A DIHEDRAL GROUP WITH PRIME ORDER AND ITS NUMERICAL INVARIANTS
Dewi Santri Ramdani, I Gede Adhitya Wisnu Wardhana, Zatta Yumni Awanis

1013-1020

🗎 pdf download

📊 Abstract views 75 | 📄 Pdf Download downloads 28 | DOI https://doi.org/10.30598/barekengvol16iss3pp1013-1020

DESIGN OF ROV STRAIGHT MOTION CONTROL USING PROPORTIONAL SLIDING MODE CONTROL METHOD

Firman Yudianto, Teguh Herlambang, Fajar Annas Susanto, Andy Suryowinoto, Berny Pebo Tomasouw

1051-1058

📄 pdf download

MULTIPLE STRATEGIES AS OPTIMAL CONTROL OF A COVID-19 DISEASE WITH QUARANTINE AND USING HEALTH MASKS

Lukman Hakim

1059-1068

📄 pdf download

THE PROPERTIES OF ROUGH V-COEXACT SEQUENCE IN ROUGH GROUP

Desfan Hafifullah, Fitriani Fitriani, Ahmad Faisol

1069-1078

📄 pdf download

ESTIMATION OF THIRD FINGER MOTION USING ENSEMBLE KALMAN FILTER

Teguh Herlambang, Hendro Nurhadi, Abdul Muhith, Dinita Rahmalia, Berny Pebo Tomasouw

1079-1086

📄 pdf download

APPLICATION FUZZY MAMDANI TO DETERMINE THE RIPENESS LEVEL OF CRYSTAL GUAVA FRUIT

Ahmad Kamsyakawuni, Abduh Riski, Anisa Binti Khumairoh

1087-1096

📄 pdf download

CENTRALITY MEASURES ON BRINKMANN GRAPH: BEFORE AND AFTER NODE DELETION

Masrurotullaily Masrurotullaily

1097-1104

📄 pdf download

FINANCIAL DISTRESS PREDICTION OF FINANCIAL SECTOR SERVICE COMPANIES ON INDONESIAN STOCK EXCHANGE USING COX PROPORTIONAL HAZARD

Candra Yanuar Dwi Putra, Mohamat Fatekurohman, Dian Anggraeni

1105-1114

📄 5006

ANALYTICAL HIERARCHY PROCESS IN DETERMINING LEVEL THE FEASIBILITY OF THE AUTOMATED TELLER MACHINE LOCATION (CASE STUDY BANK SYARIAH INDONESIA JEMBER)

Agustina Pradjaningsih, Dyan Mei Anggraeni, Kiswara Agung Santoso

1115-1122

📄 pdf download

NUMERICAL SOLUTION OF VOLTERRA INTEGRO-DIFFERENTIAL EQUATIONS BY AKBARI-GANJI'S METHOD

O. A. Uwaheren, A. F. Adebisi, C. Y. Ishola, M. T. Raji, A. O. Yekeem, O. J. Peter

1123-1130

📄 pdf download

APPLICATION FUZZY MAMDANI TO DETERMINE THE RIPENESS LEVEL OF CRYSTAL GUAVA FRUIT

Ahmad Kamsyakawuni [1*]**, Abduh Riski**[2]**, Anisa Binti Khumairoh**[3]

[1,2,3]*Department of Mathematics, Faculty of Mathematics and Natural Science, Jember University*
[1,2]*MOCo Research Group, Faculty of Mathematics and Natural Science, Jember University*
Kalimantan St., No.37, Kampus Tegalboto, Jember, 68121, Indonesia

Corresponding author's e-mail: [1] kamsyakawuni.fmipa@unej.ac.id*

Abstract. *Crystal guava is one of Indonesia's flora diversities. The rind of the unripe crystal guava fruit is green, and the rind of the ripe crystal guava fruit is yellowish green. However, it is difficult to determine the ripeness of crystal guava due to the similar color of the fruit skin. Determining fruit ripeness is uncertain and therefore requires a way to deal with this uncertainty. One of the methods you can use is fuzzy Mamdani. In this study, the ripeness level of crystal guava is determined using fuzzy Mamdani. Crystal guava fruits fall into four ripeness categories: raw, half ripe, ripe, and very ripe. The data used is in the form of an RGB image separated from the background so that only crystal guava fruit objects are captured. The image of the fruit object was then extracted by looking for the median red, green, and blue at each pixel of the image. This value is used as input for the fuzzy Mamdani process. The fuzzy set and fuzzy rules that have been formed can be applied to determine the maturity level of crystal guava fruit by validating the results of 140 image data with an accuracy of 83,5%.*

Keywords: *Crystal Guava Fruit, Fuzzy Mamdani, RGB Image, Ripeness Level*

https://ojs3.unpatti.ac.id/index.php/barekeng/   barekeng.math@yahoo.com

1. INTRODUCTION

Indonesia is a country with a tropical climate that has a diversity of flora. Crystal guava is one of the diversities of flora in Indonesia. This type of guava has advantages such as the relatively small number of seeds ranging from 3% of the fruit size [1]. This fruit also has a crunchy flesh texture and a fresh sweet taste [2]. Farmers prefer this variety of guava because it is simple to grow and can produce fruit all year long [3]. This fruit has a high selling value compared to other varieties of guava [4]. People used to use crystal guava fruit from raw to ripe.

The process of determining the ripeness of crystal guava fruit is usually done manually by paying attention to the color of the fruit's skin. Crystal guava fruit that is still raw has green skin, while ripe fruit has yellowish green skin [5]. However, determining the ripeness of crystal guava fruit is difficult because of the similarity of color on the skin of the crystal guava fruit from raw to ripe. Determination of the ripeness of crystal guava fruit is uncertain because of the similarity of color on the skin of the fruit. This is why we need a method that can handle the uncertainty of determining the ripeness of crystal guava fruit. Fuzzy logic can solve problems that contain uncertainty [6].

A fuzzy Inference System is a rule system based on fuzzy logic. One method of fuzzy inference system is the Mamdani method. The Mamdani method or commonly known as the Min-Max method was first introduced by H. Mamdani in 1975. The Mamdani method is a method that uses the MIN implication function and the composition of the MAX rule. Fuzzy Mamdani is a fuzzy inference that is simple and easy to understand [7].

Many previous studies regarding the determination of fruit ripeness have been carried out, Mulato [8] conducted a study on the classification of red guava fruit ripeness using fuzzy Mamdani. The results obtained show a fuzzy accuracy of 83.3%. Lustini et al [9] also researched the classification of pineapple ripeness using fuzzy logic. The results obtained indicate an accuracy rate of 86.67%. Another study was conducted by Muthiati et al [10], who conducted a study on the detection of tomato ripeness. The ripeness level of the fruit is classified using fuzzy logic. Arief [11] conducted a study on the classification of citrus fruit ripeness. The fruits were classified based on color features using the SVM method. This research will determine the ripeness level of crystal guava fruit using fuzzy Mamdani. Crystal guava is categorized into four categories, namely raw, half ripe, ripe, and very ripe. It is hoped that by determining the ripeness of crystal guava fruit using fuzzy, the ripeness of the fruit can be more easily determined and more accurate.

2. RESEARCH METHODS

2.1 Data Collection

The first stage in this research is data collection. The image data used is 140 data consisting of 35 image data of crystal guava fruit in each category of ripeness level. Image data was taken with the Vivo Y30 smartphone camera with a white background.

2.2 Pre-Processing Data

In this step, the object and background are separated so that only the crystal guava fruit object is taken.

2.3 Feature Extraction

Image is one of the multimedia components that play an important role as a form of visual information. Image has characteristics that are rich in information. A digital image is a collection of pixels arranged in a matrix form. Each element in a digital image (element matrix) is referred to as a pixel (pixel) [12]. A color image or RGB image is an image in which each pixel has three color components, namely red (red), green (green), and blue (blue) components. Each color component has a pixel intensity value starting from 0 to 255. For example, a pixel that has a color intensity value of 255 in the red layer, 255 in the green layer, and 0 in the blue layer will produce a yellow color [13]. An illustration of an RGB image can be seen in Figure 1.

In this step, the crystal guava object image obtained from the previous stage is extracted by finding the average Red (R) value, Green (G) average value, and Blue (B) average value for each image pixel. These

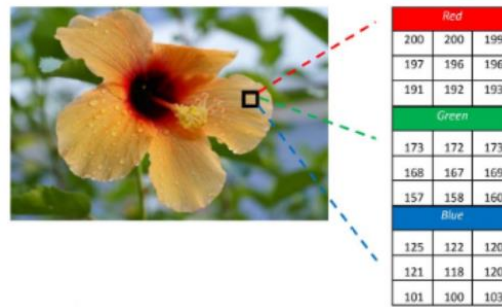values are used as inputs in the Mamdani fuzzy process.

Figure 1. RGB Image Illustration

2.4 Application of Fuzzy Mamdani

Fuzzy logic was first introduced by Prof. Lotfi Zadeh in 1965. Fuzzy logic is generally used to solve problems that contain an element of uncertainty. The level of true or false in fuzzy logic depends on the weight of the membership [14]. A fuzzy Inference System is a rule system based on fuzzy logic. One method of fuzzy inference system is fuzzy Mamdani. Fuzzy Mamdani or commonly known as the Min-Max method was first introduced by H. Mamdani in 1975. This method works based on linguistic rules.

In this step, fuzzy sets are formed and fuzzy rules are drawn up based on data training. The inputs used are Average Red, Average Green, and Average Blue variables, while the output used is ripeness level. There are four stages in the Mamdani fuzzy calculation, including:

a. Fuzzification

At this stage, the process of converting firm values (crisp) into fuzzy sets is carried out. The fuzzy set is grouped into a fuzzy variable based on its linguistic level. For each fuzzy set, the domain and membership function are determined which are then used to determine the membership value of each fuzzy set based on the input variables.

b. Application of The Implication Function

At this stage, the preparation of rules that state the relationship between input variables and output variables is carried out. The general form used to construct fuzzy rules can be written as follows [14],

$$\text{IF } (x_1 \text{ is } A_1) \text{ AND } (x_2 \text{ is } A_2) \text{ AND } \dots \text{ AND } (x_n \text{ is } A_n) \text{ THEN } y \text{ is } B \tag{1}$$

After forming the fuzzy rules, then determining the membership value based on the fuzzy rules that have been formed using the MIN implication function. By using AND operator, the results are obtained by taking the smallest membership value between elements in the set in question.

c. Composition of rules

At this stage, the process of merging the membership function from the applicable rules of the implication function is carried out. This merging process uses the MAX method. The fuzzy set solution is obtained by taking the maximum value of the rule, then using it to modify the fuzzy region and apply it to the output. If all the rules have been evaluated, then the output will contain a fuzzy set that describes the entire rule.

d. Defuzzification

Defuzzification is a process of converting fuzzy sets into crisp values. The input in the defuzzification stage is a fuzzy set obtained from the composition of the rules, while the output obtained is a number in the domain of the output variable fuzzy set. The method commonly used in the defuzzification stage is the centroid method (center point). In general, the centroid method can be written as Equation (2).

$$z^* = \frac{\int z \cdot \mu_A(z) dz}{\int \mu_A(z) dz} \tag{2}$$

2.5 Result Analysis

In this step, the results are validated by comparing the results of determining the level of fruit ripeness by farmers and the fuzzy program. The level of fuzzy accuracy used can be calculated by validating the results using the following Equation (3).

$$\text{Accuracy} = \frac{appropriate\ data}{overall\ data} \times 100 \tag{3}$$

3. RESULTS AND DISCUSSION

3.1. Pre-Processing Data

The data that has been collected, then separated the image of the fruit from the background, so that only the image of the crystal guava fruit object is taken. An example crystal guava fruit of the results of pre-processing data before the background separation can be seen in Figure 2 (a) and after the background, separation can be seen in Figure 2 (b).

(a)   (b)
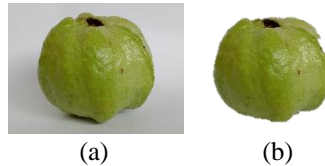
(a) Before the background separation; (b) After the background separation
Figure 2. The Results of Pre-Processing Data

3.2 Feature Extraction

Feature extraction is done to obtain the characteristics or information contained in an image or image. The image of the crystal guava fruit object that has been separated from the background is then extracted so that 3 information is obtained in the form of an average value of Red, an average of Green, and an average of Blue. This information is used as input to the fuzzy process. The value of the Red average, Green average, and Blue average are obtained from the calculation of the average Red value for each image pixel, the average Green value for each image pixel, and the average Blue value for each image pixel. Example of feature extraction results in Figure 2 (b) the value of Red Average = 121.1564, Green Average = 129.1392, and Blue Average = 45.1977.

3.3 Application of Mamdani Fuzzy

3.3.1 Fuzzy Set Formation

In this study, three inputs were used in determining the ripeness level of crystal guava fruit which included Red Average, Green Average, Blue Average, and one output in the form of fruit Ripeness Level. The formation of fuzzy sets is carried out on each variable. The Red Average variable is grouped based on its linguistic level into several fuzzy sets, namely low, medium, and high. Likewise for the Green and Blue variable average. Meanwhile, the Ripeness Level output variable is grouped into several fuzzy sets, namely raw, half ripe, ripe, and very ripe.

The fuzzy set that has been formed is then searched for the domain value in each fuzzy set. This domain contains values in the universe of speech, but can also be operated in fuzzy sets. Domains are determined based on training on the data used. In the data training process, the domain can be changed by shifting the domain value so that the correct domain is obtained for each fuzzy set used. Table 1 is a table for the formation of fuzzy sets and domains on the input variables. Table 2 is a table for the formation of fuzzy sets and domains on the output variables.

Table 1. Fuzzy Sets on the Input Variables

Variable	Fuzzy Set	Domain
Red Average (w)	Low	[0; 120]
	Medium	[62; 145]
	High	[120; 255]
Green Average (x)	Low	[0; 123]
	Medium	[75; 146]
	High	[123; 255]
Blue Average (y)	Low	[0; 55]
	Medium	[23; 73]
	High	[55; 255]

Table 2. Fuzzy Sets on the Output Variables

| Variable	Fuzzy Set	Domain
Ripeness Level (z)	Raw	[0; 40]
	Half Ripe	[20; 60]
	Ripe	[40; 80]
	Very Ripe	[60; 100]

For each variable, its membership function is determined. The membership function is a curve that shows the mapping of input points into membership values with an interval of 0 to 1 [15]. The determination of the membership function in a fuzzy set can be different for each person. This is due to individual differences in expressing abstract concepts. However, the determination of the membership function must still reflect the issues discussed.

In this study, the membership function of the shoulder curve and the triangular curve were used to represent it. This form is suitable for representing fuzzy sets based on training on more accurate data. The Red Average variable consists of three low, medium, and high fuzzy sets. In the low and high Red Average variables, the left shoulder and right shoulder curve representations are used. The Red Average variable is being used as a triangular curve representation. The membership function for the Red Average variable is shown in Equations (4), (5), and (6). The membership function of the Red Average variable can be seen in Figure 2.

$$\mu_{R\,rendah}(w) = \begin{cases} 1 & ; w \leq 62 \\ \frac{120-w}{58} & ; 62 < w < 120 \\ 0 & ; w \geq 120 \end{cases} \tag{4}$$

$$\mu_{R\,sedang}(w) = \begin{cases} 0 & ; w \leq 62 \ atau \ w \geq 145 \\ \frac{w-62}{58} & ; 62 < w < 120 \\ \frac{145-w}{25} & ; 120 \leq w < 145 \end{cases} \tag{5}$$

$$\mu_{R\,tinggi}(w) = \begin{cases} 0 & ; w \leq 120 \\ \frac{w-120}{25} & ; 120 < w < 145 \\ 1 & ; w \geq 145 \end{cases} \tag{6}$$
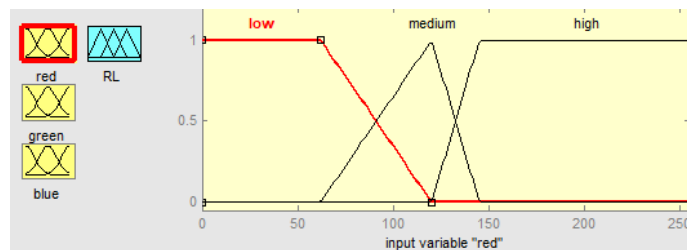
Figure 2. The Membership Function of the Red Average Variable

The Green Average variable consists of three low, medium, and high fuzzy sets. The membership function for the Green Average variable is shown in Equations (7), (8), and (9). The membership function of the Green Average variable can be seen in Figure 3.

$$\mu_{G\,rendah}(x) = \begin{cases} 1 & ; x \leq 75 \\ \frac{123-x}{48} & ; 75 < x < 123 \\ 0 & ; x \geq 123 \end{cases} \tag{7}$$

$$\mu_{G\,sedang}(x) = \begin{cases} 0 & ; x \leq 75 \ atau \ x \geq 146 \\ \frac{x-75}{48} & ; 75 < x < 123 \\ \frac{146-x}{23} & ; 123 \leq x < 146 \end{cases} \tag{8}$$

$$\mu_{G\,tinggi}(x) = \begin{cases} 0 & ; x \leq 123 \\ \frac{x-123}{23} & ; 123 < x < 146 \\ 1 & ; x \geq 146 \end{cases} \tag{9}$$
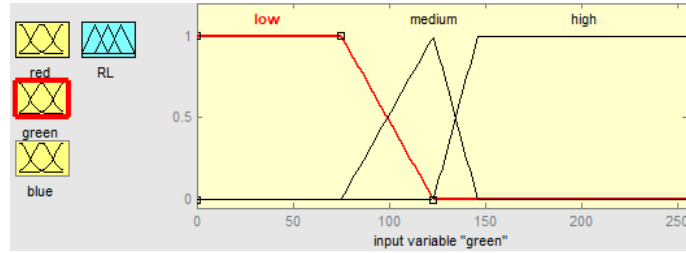
Figure 3. The Membership Function of the Green Average Variable

The Blue Average variable consists of three low, medium, and high fuzzy sets. The membership function for the Blue Average variable is shown in Equations (10), (11), and (12). The membership function of the Blue Average variable can be seen in Figure 4.

$$\mu_{B_{rendah}}(x) = \begin{cases} 1 & ; y \leq 23 \\ \frac{55-y}{32} & ; 23 < y < 55 \\ 0 & ; y \geq 55 \end{cases} \tag{10}$$

$$\mu_{B_{sedang}}(x) = \begin{cases} 0 & ; y \leq 23 \ atau \ y \geq 73 \\ \frac{y-23}{32} & ; 23 < y < 55 \\ \frac{73-y}{18} & ; 55 \leq y < 73 \end{cases} \tag{11}$$

$$\mu_{B_{tinggi}}(x) = \begin{cases} 0 & ; y \leq 55 \\ \frac{y-55}{18} & ; 55 < y < 73 \\ 1 & ; y \geq 73 \end{cases} \tag{12}$$
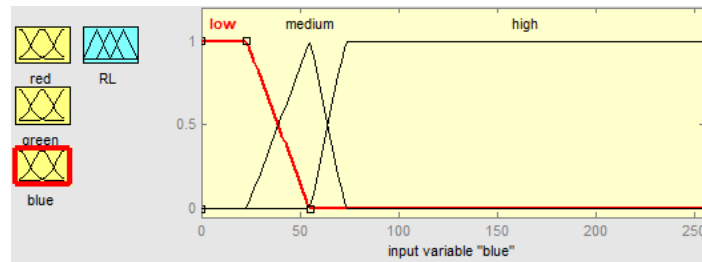

Figure 4. The Membership Function of the Blue Average Variable

The Ripeness Level variable consists of four fuzzy sets: raw, half ripe, ripe, and very ripe. Raw and very mature Ripeness Level variables were used to represent the left and right shoulder curves. In the half-ripe and ripe Ripeness Level variables, a triangular curve representation is used. The membership function for the Ripeness Level variable is shown in equations (13), (14), (15), and (16). The membership function of the Ripeness Level variable can be seen in Figure 5.

$$\mu_{RL_{mentah}}(z) = \begin{cases} 1 & ; z \leq 20 \\ \frac{40-z}{20} & ; 20 < z < 40 \\ 0 & ; z \geq 40 \end{cases} \tag{13}$$

$$\mu_{RL_{setengahmatang}}(z) = \begin{cases} 0 & ; z \leq 20 \ atau \ z \geq 60 \\ \frac{z-20}{20} & ; 20 < z < 40 \\ \frac{60-z}{20} & ; 40 \leq z < 60 \end{cases} \tag{14}$$

$$\mu_{RL_{matang}}(z) = \begin{cases} 0 & ; z \leq 40 \ atau \ z \geq 80 \\ \frac{z-40}{20} & ; 40 < z < 60 \\ \frac{80-z}{20} & ; 60 \leq z < 80 \end{cases} \tag{15}$$

$$\mu_{RL_{sangatmatang}}(z) = \begin{cases} 0 & ; z \leq 60 \\ \frac{z-60}{20} & ; 60 < z < 80 \\ 1 & ; z \geq 80 \end{cases} \tag{16}$$
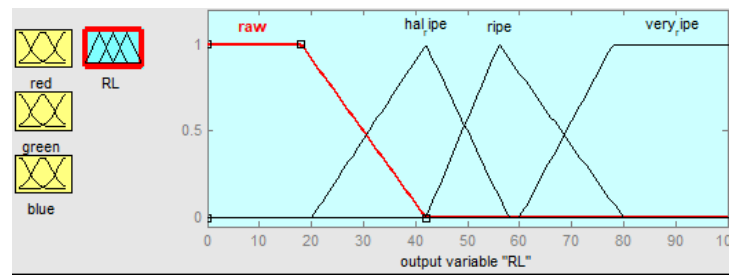
Figure 5. The Membership Function of the Ripeness Level Variable

3.3.2 Fuzzy Rules

After forming a fuzzy set, then determine the fuzzy rules. Fuzzy rules are indicated by the presence of a set of linguistic statements. The formation of fuzzy rules is based on the relationship between one set and another [16]. Based on Equation (1) and the data training that has been carried out, there are 27 fuzzy rules used in this study. Determination of fuzzy rules can be written as follows:

[R1] IF (Red Average is Low) AND (Green Average is Low) AND (Blue Average is Low) THEN (Ripeness Level is Raw),

[R2] JIKA (Red Average is Low) AND (Green Average is Low) AND (Blue Average is Medium) THEN (Ripeness Level is Raw),

etc. The overall rules used can be seen in Table 3.

Table 3. Fuzzy Rules

Rule	Input			Output
	Red Average	Green Average	Blue Average	Ripeness Level
[R1]	Low	Low	Low	Raw
[R2]	Low	Low	Medium	Raw
[R3]	Low	Low	High	Raw
[R4]	Low	Medium	Low	Raw
[R5]	Low	Medium	Medium	Half Ripe
[R6]	Low	Medium	High	Half Ripe
[R7]	Low	High	Low	Half Ripe
[R8]	Low	High	Medium	Half Ripe
[R9]	Low	High	High	Half Ripe
[R10]	Medium	Low	Low	Raw
[R11]	Medium	Low	Medium	Half Ripe
[R12]	Medium	Low	High	Half Ripe
[R13]	Medium	Medium	Low	Half Ripe
[R14]	Medium	Medium	Medium	Half Ripe
[R15]	Medium	Medium	High	Ripe
[R16]	Medium	High	Low	Half Ripe
[R17]	Medium	High	Medium	Ripe
[R18]	Medium	High	High	Very Ripe
[R19]	High	Low	Low	Ripe
[R20]	High	Low	Medium	Ripe
[R21]	High	Low	High	Very Ripe
[R22]	High	Medium	Low	Ripe
[R23]	High	Medium	Medium	Ripe
[R24]	High	Medium	High	Very Ripe
[R25]	High	High	Low	Very Ripe
[R26]	High	High	Medium	Very Ripe
[R27]	High	High	High	Very Ripe

3.3.3 Fuzzy Mamdani Calculation

Fuzzy sets and fuzzy rules have been formed based on data training, to make it easier to use using MATLAB software. The results obtained are then presented in the MATLAB GUIDE display. The program cannot directly determine the level of ripeness of crystal guava fruit. The user must input an image of a crystal guava fruit, then perform feature extraction, so that the Red Average (R), Green Average (G), and Blue Average (B) values are obtained as input in the Mamdani fuzzy process. After passing the Mamdani fuzzy

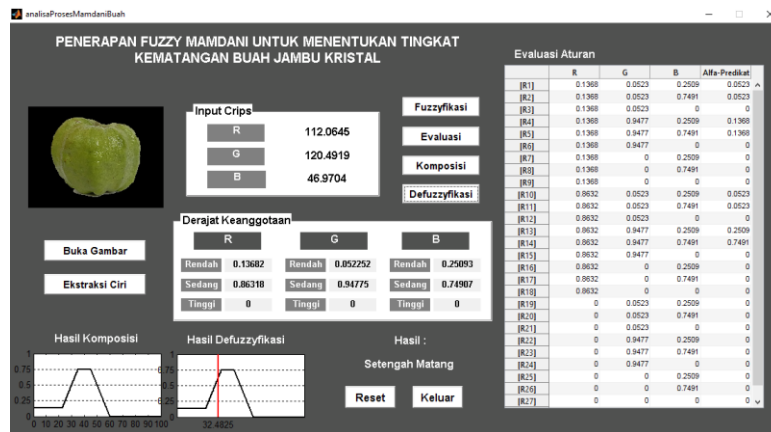process starting from fuzzification to defuzzification, the output level of crystal guava fruit ripeness will be obtained. The MATLAB GUIDE display can be seen in Figure 6.

Figure 6. MATLAB GUIDE Display

In Figure 6, for example, there is an image of a crystal guava fruit after extraction, the average value of Red = 112.0645, Green Average = 120.4919, and Blue Average = 46.9704. The fruit image will be determined by the level of ripeness with the four stages in the fuzzy Mamdani. The four stages are as follows:

1. Fuzzification, at this stage, the low, medium, and high fuzzy set membership values are sought for each variable. In the fuzzy set, the average Red is low, the membership value is 0.13682, the average Red is 0.85318, and the red average is high at 0. The same is done for the fuzzy set with the average Green variable and the average Blue.
2. Evaluation, at this stage, each rule is evaluated using the MIN implication function by finding the smallest degree of membership between elements in each rule. At this stage the rules that have fuzzy areas are [R1], [R2], [R4], [R5], [R10], [R11], [R13], and [R14].
3. In composition, at this stage, the membership function of each rule is combined at the evaluation stage using the MAX method. The MAX method is carried out by taking the maximum value of the results of the evaluation of the rules in each fuzzy set of output variables. The results of the composition of the rules can be seen in the graph in Figure 6.
4. Defuzzification, at this stage the fuzzy set resulting from the composition of the rules is converted into a crisp value using the centroid method based on Equation (2). In this image, the final defuzzification value is 32.4825. The value obtained is then adjusted to the output linguistic variable. The results showed that the fruit was in the half-ripe category.

3.4 Result Analysis

In this study, validation results were carried out on 140 image data used. Validation is done by comparing the determination of the level of fruit ripeness between farmers and whether the program is appropriate or not. The validation of the results that have been carried out can be seen in Table 4.

Table 4. Validation Results

Data	Fruit Image	Extraction Image	Red Average	Green Average	Blue Average	Program Result	Description
001 Raw			64.0138	77.012	31.834	Raw	Correct
002 Raw			62.3598	74.9049	30.0887	Raw	Correct
003 Raw			63.7301	77.3829	31.9171	Raw	Correct
004 Raw			74.0377	82.3757	32.4553	Raw	Correct
005 Raw			65.8178	76.9513	24.5353	Raw	Correct
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
140 Very Ripe			121.1362	128.5469	60.1447	Ripe	Incorrect

Based on Table 4, the results obtained are 117 correct image data and 23 incorrect image data. The raw category of guava fruit image data that matched between farmers and the program amounted to 34 out of 35 raw category image data. The image data for the correct ripe category is 29. The image data for the ripe category is 27. The image data for the very ripe fruit category is 27. The fuzzy accuracy used can be calculated as follows:

$$Accuracy = \frac{117}{140} \times 100\% = 83.5\%$$

Determination of the level of ripeness of crystal guava fruit with four categories of ripeness levels raw, half ripe, ripe, and very ripe can be done using fuzzy Mamdani. The fuzzy set and fuzzy rules that have been formed can be applied to determine the ripeness level of crystal guava fruit with a fuzzy accuracy of 83.5%.

4 CONCLUSIONS

Determining the ripeness of crystal guava using fuzzy Mamdani is performed by extracting features on the fruit image and then forming fuzzy sets and fuzzy rules. The result of the feature extraction is in the form of a red, green, and blue average for each image pixel and is used as input for the fuzzy Mamdani process. The formed fuzzy sets are obtained through data training based on the results of feature extraction. 27 fuzzy rules are used. Verification of the results was performed with 140 test data, with 117 correct image data and 23 incorrect image data. As a result of the test, the fuzzy accuracy was 83.5%.

REFERENCES

[1] D. Kurniawan, "Mengenal Jambu Kristal," Hortikutura, 16 Juni 2015. [Online]. Available: http://hortikultura.pertanian.go.id/?p=354. [Accessed 5 Oktober 2021].

[2] S. Duryatmo, R. N. Apriyanti, S. Angkasa, A. A. Raharjo, K. Rizkika, D. S. Rahimah, A. Titisari, B. Setyawan, R. Vebriansyah, R. Fadhilah and K. R. Susilo, Jambu Kristal, Jakarta: Trubus, 2014.

[3] D. Rustani and S. Susanto, "Kualitas fisik dan kimia buah jambu keistal pada letak cabang yang berbeda," *Bul. Agrohorti,* vol. 7, no. 2, pp. 123-129, 2021.

[4] A. Wibowo, D. M. C. Hermanto, K. I. Lestari and Hadion, "Deteksi kematangan buah jambu kristal berdasarkan fiur warna menggunakan transformasi ruang warna HSV (Hue Saturation Value) dan K-Nearest Neighbour," *Journal of Informatic and Computer Science Engineering,* vol. 1, pp. 76-88, 2021.

[5] A. Apriyantono, "Deskripsi jambu varietas kristal," Varitas , 13 September 2007. [Online]. Available: http://varitas.net/dbvarietas/deskripsi/3136.pdf. [Accessed 5 Oktober 2021].

[6] S. Aly and I. Vrana, "Fuzzy expert marketing-mix model," *AGRIC,* vol. 51, no. 2, pp. 69-79, 2005.

[7]   E. F. Andriani, "Prediksi keuntungan PT. Ciesta Mandiri Sejahtera menggunakan Fuzzy Inference System Tsukamoto dan Fuzzy Inference System Mamdani," in *Fakultas Matematika dan Ilmu Pengetahuan Alam, Univeristas Jember*, Jember, 2015.

[8]   F. Y. Mulato, "Klasifikasi kematangan buah jambu biji merah (Psidium Guajava) dengan menggunakan model fuzzy," in *Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Negeri Yogyakarta*, Yogyakarta, 2014.

[9]   A. Lustini, Saparudin and A. Primanita, "Klasifikasi tingkat kematangan buah nanas menggunakan ruang warna Red-Green-Blue dan Hue-Saturation-Intensity," *Jurnal Digital Teknologi Informasi,* vol. 2, no. 1, pp. 1-8, 2019.

[10] N. N. Muthiati, Herlinawati, S. R. Sulistiyanti and S. Purwiyanti, "Deteksi tingkat kematangan buah tomat dengan metode fuzzy logic menggunakan modul kamera raspberry PI," *Jurnal Rekayasa dan Teknologi Elektro,* vol. 13, no. 2, pp. 38-42, 2019.

[11] M. Arief, "Klasifikasi kematangan buah jeruk berdasarkan fitur warna menggunakan metode SVM," *Jurnal Ilmu Komputerdan Desain Informasi Visual,* vol. 4, no. 1, pp. 9-16, 2019.

[12] R. Pratama, A. F. Assagaf and F. Tempola, "deteksi kematangan buah tomat berdasarkan fitur warna menggunakan metode transformasi ruang warna HIS," *Jurnal Informatika dan Komputer (JIKO),* vol. 2, no. 2, pp. 81-86, 2019.

[13] A. Pamungkas, "Pengolahan citra digital," Pemrogamanmatlalb, 26 Juli 2017. [Online]. Available: https://pemrogramanmatlab.com/2017/07/26/pengolahan-citra-digital/. [Accessed 23 Mei 2021].

[14] S. Kusumadewi and H. Purnomo, Aplikasi Logika Fuzzy untuk Pendukung Keputusan, Yogyakarta: Graha Ilmu, 2010.

[15] B. Setiawan, B. Yanto and K. Yasdomi, Logika Fuzzy dengan MATLAB, Bali: Jayapangus Press, 2018.

[16] L. N. Sari, "Penerapan lofika fuzzy Mamdani dan manual kapasitas jalan Indonesia pada pengaturan lampu lalu lintas," in *Fakultas Matematika dan Ilmu Pengetahuan Alam, Univeristas Jember*, Jember, 2013.