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CLASSIFICATION OF GUARANTEE FRUIT MURABILITY BASED ON HSV IMAGE WITH K-NEAREST NEIGHBOR

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ABSTRACT
Guava bol is one of the fruits from Indonesia that is favored by many Indonesian people. The guava itself has a soft and dense flesh texture compared to water guava. The guava itself has a pink color if it is raw but if the guava is ripe it will be dark red. From a human perspective, it is very easy to tell the difference, but most people find it difficult to tell which guava is ripe, half-ripe and unripe guava because of differences in opinion from one human eye to another. Based on these problems, researchers created a system that was able to detect the level of ripeness of the fruit by utilizing the Hue Saturation Value (HSV) feature extraction with K-Nearest Neighbor (KNN). In this study to facilitate the manufacture of a classification system for the level of maturity of guava fruit using the Matlab program. The data used in this study were 465 datasets which were divided into 324 training data and 141 test data. The data had class data, namely ripe, half-cooked, and raw. The data is then classified using the K-Nearest Neighbor method by calculating the closest distance with a value of K = 3. From this research, the accuracy value is 97.16%.
Keywords : *Guava bol, Hue Saturation Value, K-Nearest Neighbor, Matlab*

1. Introduction

Guava bol or what can also be called red guava is one of the fruits from Indonesia that is favored by most Indonesian people. Guava bol itself has a soft meat texture and is also denser than water guava. The guava itself has many health benefits, namely in relieving fever, treating canker sores because the guava itself is rich in vitamin C.

The origin of this fruit tree is not known with certainty, but guava itself has long been planted in Semanjuntak, Malaya, Sumatra and Java. Because of the rich benefits of this fruit, now this fruit is planted in many countries with tropical climates, for example in Caribbean countries such as Trinidad, Tobago and Jamaica. In Indonesia, the spread of guava is widely planted on the island of Java.

Each fruit has special characteristics in determining a level of maturity, one of which is the color of the skin, for example in the Jambu Bol fruit, at the stage of classifying the level of maturity in the Jambu Bol fruit it is still classified as manual in the stages of classification of maturity by humans. In this case, of course, it has a drawback which requires quite a lot of energy in the accuracy of the maturity level which becomes inaccurate because it depends on human vision which is based on each human being. Therefore, in identifying the level of maturity of the guava fruit, a system is needed that can help properly and efficiently. That is, one way that is quite accurate is image processing that can help to identify the level of maturity with the help of the classification process of fruit maturity levels based on HSV and K-Nearest Neighbor images.

Digital Image Processing or what is often called digital image processing is a field of science that studies how an image is formed, processed, and analyzed so as to produce information that can be understood by humans. This study aims to utilize the field of digital image processing in helping humans in everyday life to produce information that is easy to understand.(Rifki Kosasih, 2021)

Several studies have been conducted to prove the accuracy of the Hue Saturation Value (HSV) feature using the K-Nearest Neighbor method. In a study conducted by (Nafiah, 2019) in "Classification of Maturity of Mangoes Based on HSV Image with KNN" on the accuracy results generated from testing the testing data obtained in the manga test has an average accuracy value of 55% with a distance between K=1- 10. By using 129 training data and 40 testing data.

Based on the results of the tests that have been carried out (Lestari et al., 2019), it can be concluded that the application of the K-Nearest Neighbor method on the classification of banana

species based on HSV color can be applied very well. By using 100 training data and 50 testing data, the results obtained are 82% in the green banana class and the value of K = 3.

Subsequent research conducted by (Wijaya & Ridwan, 2019) under the title "Classification of Types of Apples Using the K-Nearest Neigbor Method" in the classification of types of apples using the K-Nearest Neigbor method as a classifier and feature extraction of HSV and LBP. The examiner uses 800 image data, consisting of 200 test data and 600 training data. In the test results, the average value of the resulting Precision is 94%, Recall is 100% and the Accuracy value is 94%.

In a study conducted by (Suban et al., 2020) on the research title "Identification of the Maturity Level of Carica Papaya Using K-Nearest Neighbor" In the study of the maturity level of papaya using K-Nearest Neighbor, in this study aims to assist papaya farmers in recognizing the level of ripeness of papaya fruit so that it can effectively determine the level of ripeness of papaya fruit. The test was carried out using 12 datasets consisting of 6 test data and 6 training data. The test results get a 100% success rate.

In this study, in identifying the level of maturity of the guava fruit, the author will examine how to classify the level of maturity of the guava fruit using HSV imagery using the KNN method. Based on the description above, it is proposed the title "Classification of the Maturity Level of Guava Bol Fruit Based on HSV Image with KNN" which can be expected to produce a model that can predict the maturity level of Guava Bol fruit with accurate final results.

2. Literature Review

According to research conducted by (Wibowo et al., 2021) in the study "Detection of Ripeness of Crystal Guava Fruit Based on Color Features Using Hsv (Hue Saturation Value) and K-Nearest Neighbor Color Space Transformation Methods in this study generally in measuring a maturity still uses the manual method which has an inconsistent level of accuracy and tends to experience errors. Researchers use digital images in classifying the level of maturity in crystal guava fruit. With the digital image, it is possible to determine guava fruit based on color, by applying it to digital image processing using the hsv color space method. From the results of the detection of ripeness in the study, it produced a percentage value of 91.67% in the category of ripe guava fruit and in the unripe fruit it produced a percentage of 90%. So it can be said that using the hsv color space transformation method can be done in the detection of crystal guava fruit

According to research conducted by (Salsabila et al., 2021) in the study "Identification of Flower Type Image Using the KNN Algorithm with HSV Color Extraction and GLCM Texture" in the variety of flower types and from each species having similarities in each variety it is difficult to distinguish in determining the type of flower. Applying the K-Nearest Neighbor algorithm as well as feature extraction for color and texture is very helpful in this study to identify flowers more easily and save time. In this study, the level of accuracy in identifying the largest type of interest was 71% using the K-7.

In a study conducted by (Liantoni & Annisa, 2018) under the title "Classification of watermelon using the k-nearest neighbor based on first order statistical extraction." Watermelon ripeness can be distinguished based on the texture of the watermelon rind. The similarity of watermelon rind texture makes it difficult for people to identify ripe and unripe watermelons. In identifying the maturity level of watermelon using the K-Nearest Neighbor method using 100 datasets, consisting of 70 training data and 30 test data. In this study, in identifying watermelons using the k-nearest neighbor method based on the color of the fruit skin, it obtained an accuracy of 86.66%.

In a study conducted by (Media & Budidarma, 2022) with the title "Classification of Ambon Banana Fruit Ripeness Using KNN and PCA Methods Based on RGB and HSV Imagery" The quality of bananas is very influential at harvest. Previously, farmers used manual methods in determining the maturity level of Ambon bananas, causing several factors that could make the classification less accurate. From that problem, the researcher developed a system that can help classify the ripeness level of Ambon bananas by utilizing the RGB and HSV color features using

the K-Nearest Neighbor (KNN) method. In this study, it produced an accuracy rate of 90.9% with 10 test data getting accurate classification results and 1 data getting inaccurate results.

According to research conducted by (Ulshqhvv et al., 2016) entitled "Classification for Determining the Maturity Level of Sunpride Bananas" Color is one of the important components in recognizing an object. Of the many types of colors that can be distinguished by the naked eye, the various types of colors can be classified making it easier for us to identify colors. In classifying the level of ripeness on sunpride bananas just by looking at the color of the bananas. But the human eye is often not accurate in seeing the level of ripeness of bananas. KNN method is an algorithm that can be used in classifying an object.

According to research conducted by (Ciputra et al., 2018) entitled "Classification of the Maturity Level of Manalagi Apples With Naïve Bayes Algorithm and Extraction of Digital Image Features" That apple is a fairly popular fruit that is often consumed and has various kinds of shapes and colors. Apples themselves have various skin colors, such as red, green, and yellowish. One of the uniqueness of manalagi apples is that the color of the apple when it is raw or ripe is difficult to distinguish because the difference is not too significant. Unripe apples are green, while ripe apples are yellowish green. This is what makes it quite difficult for ordinary people to distinguish between them. Based on the results of trials that have been carried out by researchers, it is evident that the proposed method can be used to classify manalagi apples. However, the level of accuracy is still not satisfactory, which is 63%. So for the next research the method can be developed again. Maybe it can be maximized again in the preprocessing process and image feature extraction.

According to research conducted by (Miftahus Sholihin, 2018) entitled "Classification of Egg Quality Based on Color Features Using the K-Nearest Neighbor Method", the purpose of writing in an effort to make it easier to determine the quality of eggs using the K-Nearest Neighbor method (K-NN) to implement a digital image processing so that it can be used in everyday life so that it can help humans as the goal is to produce information that can be understood by humans.

According to research conducted by (Areni et al., 2019) entitled "Classification of Strawberry Ripeness Based on Color Segmentation Using the HSV Method". So the purpose of writing is to develop a system that can classify ripeness in strawberries automatically using the SVM method for solving classification problems by finding the optimal hyperplane separator between classes. Basically SVM is a linear classifier, which was developed to work on non-linear problems, by incorporating the concept of the kernel trick in high-dimensional workspaces.

a) Guava bol
   Guava bol (guava head and guava) is one of the fruit trees of the relatives of guava which is an annual fruit plant originating from the Indo-China region, Malaysia, the Philippines, Indonesia. Other literature concludes that this guava fruit comes from Malaysia. The guava fruit has a softer and denser texture and flesh than the water guava (Syarifah et al., 2022). Guava fruit is a type of shrubs that are able to live in the tropics, for example, such as Indonesia.(Roring et al., 2022)
b) Image Processing
   Image processing is a science that studies how an image is formed, processed and analyzed so that it can produce information that can be understood by humans. Image is also a function of light intensity which is represented in a two-dimensional plane. The technique used in manipulating or processing an image in two-dimensional form is also called image processing (Hanafi et al., 2019).
c) Feature extraction
   Feature extraction is a process of taking a feature of an object that is able to describe the characteristics of an object. A feature is an object that has characteristics or properties. Feature extraction is the process of taking feature values or features from an image (Paramita et al., 2019). Feature extraction is a feature or feature extraction a form in which the value obtained will be analyzed for further processing (Shandy et al., 2019).
d) Hue Saturation Value

Hue Saturation Value (HSV) is one component that can represent the color of visible light wavelengths (red, orange, yellow, green, blue, purple). Therefore, this component can be used as a reference that can recognize the color of an object in a digital image (Raysyah et al., 2021).

e) K-Nearest Neighbor

The KNN algorithm finds an algorithm that is supervised by the learning outcomes of a new instance that will be classified based on the classification of the closest k categories. The K-Nearest Neighbor (KNN) algorithm is a classification method that determines a label (class) of a new object based on a class from the closest distance k in the training data group. The value of k used in using the K-NN. method (Barkah, 2020).

3. Research Methods

a. System Design Flow

At this stage the researcher will implement the methodology that will be used. The following is a flowchart of the implementation of system design which can be seen in Figure 1:

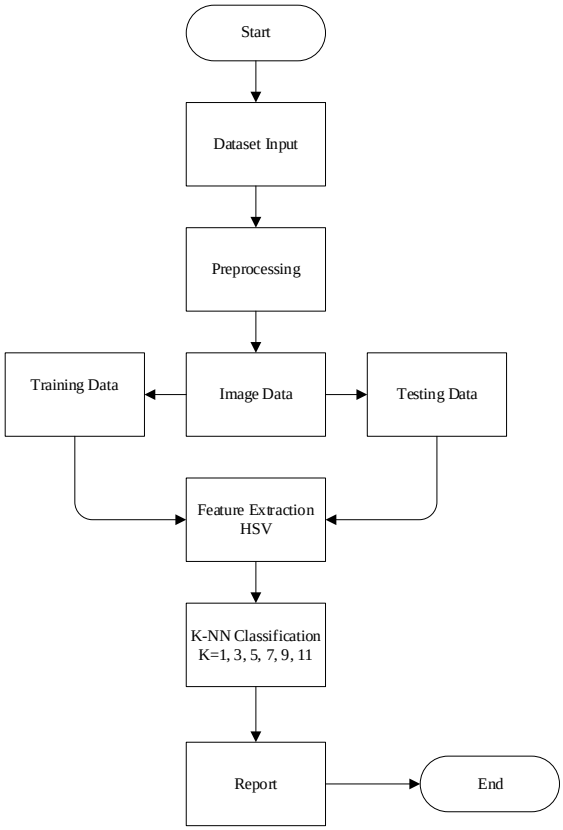

Fig 1. System Design Flow

b. Preporcessing

The pre-processing process is used to obtain images that will be continued and utilized so that they are ready to be used in the designed system. At this stage, preprocessing the image, which in this process consists of the process of changing a size in the image and separating the background from the fruit object. At this stage using a third-party application with an image size of 500 x 500 pixels in jpg format (Salsabila et al., 2021).

c. Data Sharing

The distribution of data in this study is to divide 2 image data consisting of training data and test data. The training data aims to train the algorithm in finding the appropriate model, while the test data aims to test and find out the results of the model obtained by

the training data. In this study, the distribution of data was 70% training data and 30% test data.

d. HSV Feature Extraction
Feature extraction is the stage of extracting information contained in an object in a digital image. In this stage of research using feature extraction using HSV which is used as feature extraction with color selection based on hue, saturation, and value values.(Akhir, 2020)

e. K-Nearest Neighbor ClassificationAt this stage is the stage of identifying the guava fruit image data using the K-Nearest Neighbor algorithm. Data from the feature extraction stages that have been standardized. After that it will compare the accuracy value based on the k value used (Muhammad et al., 2021). The value of the distance in the K-NN method can be calculated by using the Euclidian Distance formula (Shidiq, 2021).

4. Results and Discussions

In this study, we will develop a system that is able to classify the level of maturity in guava fruit. As for in this study, we will apply HSV color feature extraction and in the classification stage using the K-Nearest Neighbor algorithm. In this study, to facilitate the manufacture of a classification system for the level of maturity of guava fruit, the MATLAB program will be used. The level of maturity of the guava fruit used is Ripe, Half Ripe, and Raw. The following is an example of the level of maturity of the guava fruit used in this study :

No	Class	Definition	Picture
1	Mature	The image of a ripe guava fruit	
2	half-baked	Image of half-ripe guava fruit	
3	raw	Image of raw guava fruit	

Fig 2. Maturity Grade Class

A. Testing
In the early stages of testing, namely Image Pre-Processing is carried out. At this stage it is used to simplify the process of identifying the image. This stage consists of resizing the image, separating the background from the object, segmenting the image and removing noise in the image. At the stage of resizing and separating the image background, it is done using a third party application with a size of 500 x 500 pixels and a white background.

Fig 3. Original Image

Fig 4. Image After Pre Processing

After the image is obtained, then image segmentation is carried out by testing using Matlab Software. By testing using 93 training data with different maturity levels, by converting from RGB images to Greyscale images.

Fig 5. Image Greyscale

In the next stage, after the image has been converted from an RGB image to a Greyscale image, then morphological segmentation is carried out which is useful for eliminating noise in the image.

Fig 6. Binary Image

After the image is segmented, then the image will be applied by feature extraction using the HSV (Hue Saturation Value) component, in this feature extraction stage the aim is to obtain features or information from the image object.

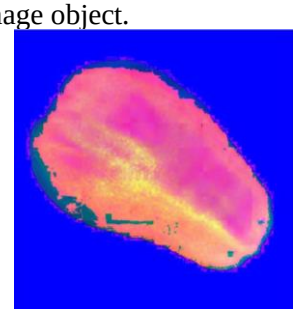

Fig 7. Image HSV

The following is the result of calculating the value of the training data feature extraction obtained from feature extraction using HSV. Figure 7 shows 15 data from a total of 324 training data images.

Table 1 - Extraction of Train Data Features

Extraction of Train Data Features			
H	S	V	Lable

0.858914789376453	0.447790820700768	0.569655877171535	ripe guava'
0.761487334952204	0.399970903413537	0.330544267096094	'ripe guava'
0.746486494176734	0.393303941600565	0.406086811638294	'ripe guava'
0.856435818003799	0.447861417800717	0.569193077883543	'ripe guava'
0.857530837952772	0.448144363198090	0.569236405982389	'ripe guava'
0.856878624614507	0.448101315479503	0.569301134590781	'ripe guava'
0.748853331325994	0.393113358030175	0.406200068875168	'ripe guava'
0.858344638296856	0.448150887041525	0.568967599027371	'ripe guava'
0.858877569653578	0.448238308513892	0.569150657339190	'ripe guava'
0.856976566363179	0.448305527085602	0.569278100932888	'ripe guava'
0.845331989861416	0.806858109779093	0.728918560129941	half ripe guava'
0.813905336526575	0.728252749676079	0.792736574908568	half ripe guava'
0.854403745608884	0.781266209550236	0.638700301793834	half ripe guava'
0.551895411000629	0.721418972206852	0.683437642977284	half ripe guava'
0.854575648608521	0.781311991475823	0.638779431099671	half ripe guava'
0.771242367885911	0.612185928114706	0.792962280802732	half ripe guava'
0.944522582563979	0.813746332056402	0.656451941378866	half ripe guava'
0.556065104059182	0.721421852835196	0.683349671693613	half ripe guava'
0.552496254949604	0.721287296988324	0.683455613869026	half ripe guava'
0.553576802588112	0.721262353445010	0.683378526498730	half ripe guava'
0.725772462425981	0.256930996524210	0.827657811774479	raw guava'
0.656859687863818	0.491408698740814	0.592972134245536	raw guava'
0.520347953423636	0.320547959483361	0.641549622097152	raw guava'
0.632210905627517	0.482715382950257	0.668561647021611	raw guava'
0.469821802285845	0.412283459500353	0.593451326574686	raw guava'
0.766866648994234	0.510044976205937	0.844354362248417	raw guava'
0.805766481568985	0.620874241563755	0.796881304397185	raw guava'
0.796754235913636	0.693702680757039	0.677285705199937	raw guava'
0.619991948588803	0.510658731030648	0.634882473878647	raw guava'
0.616352734561619	0.510675401419006	0.634925127593092	raw guava'

After obtaining feature extraction from the training data, the next step is the application of feature extraction to the test data. The following is the result of HSV feature extraction that is generated on the test data, for example, 15 data are displayed from the total training data of 141 images.

Table 2 – Testing Data Feature Extract

Testing Data Feature Extract		
H	S	V
0.858920815346271	0.568921732652925	0.288970208751252
0.769341156174716	0.388785992335580	0.415076784635717
0.745939196110354	0.393396343304167	0.404871187363835
0.130272300996550	0.896701858793214	0.444262596908549
0.862038150021587	0.448507734653959	0.567213143001390
0.501056443908730	0.825300668575589	0.692318267548344
0.0469374146295465	0.731094341867903	0.698525133490020
0.958771415822603	0.838065525766108	0.660869867390383
0.317295516230515	0.760210778811161	0.799808748616650

0.532675251841110	0.605040449802019	0.762542673248639
0.516831917783230	0.319379307611885	0.639378025568002
0.617894485440264	0.511263553305300	0.634853666504467
0.515192794007375	0.319052775803206	0.639535581920201
0.222778781134637	0.361072983367088	0.648316960979222
0.646262139420974	0.490665326431990	0.662364716613663

After the characteristics of the training data and test data are obtained, the next stage is classification using KNN by calculating the closest distance K. At this stage, classification is carried out with a value of k = 3 with a total of 141 test data so that the following results are obtained. For example, 15 data from each class of 5 test data are displayed.

Table 3 – KNN Test Result

Test Data	Original Class	KNN results	Information
1	'ripe guava'	'ripe guava'	Accurate
2	'ripe guava'	'ripe guava'	Accurate
3	'ripe guava'	'ripe guava'	Accurate
4	'ripe guava'	'ripe guava'	Accurate
5	'ripe guava'	'ripe guava'	Accurate
76	half ripe guava'	half ripe guava'	Accurate
77	half ripe guava'	raw guava'	Not Accurate
78	half ripe guava'	raw guava'	Not Accurate
79	half ripe guava'	half ripe guava'	Accurate
80	half ripe guava'	'ripe guava'	Not Accurate
137	raw guava'	half ripe guava'	Not Accurate
138	raw guava'	raw guava'	Accurate
139	raw guava'	raw guava'	Accurate
140	raw guava'	raw guava'	Accurate
141	raw guava'	raw guava'	Accurate

B. Final Test Results

From the testing process 141 test data tested using the KNN method obtained as many as 137 image data with accurate results and 4 images with inaccurate classification results and the test results can be seen as follows :

$$Accuracy = \frac{TP\ (True\ Positive)}{\text{Amuount Of Data}}\ X\ 100\%$$

$$Accuracy = \frac{137}{4}\ X\ 100\% = 97{,}16\%$$

From the level of accuracy obtained by the system in the classification of the maturity level of guava fruit based on HSV images with K-Nearest Neighbor is 97.16% of 141 test data with a test value of k = 3 The following is a diagram of the resulting accuracy :

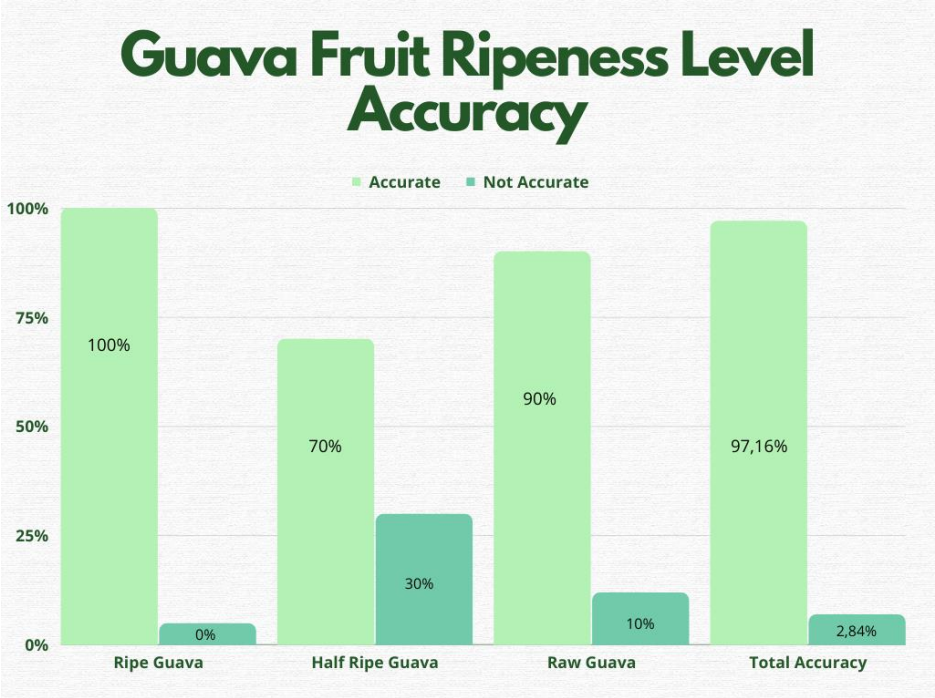

Fig 8. Accuracy Chart

5. Conclusion

From the results of this study, the results are in the form of a classification system for the maturity level of guava fruit HSV images using K-Nearest Neighbor which was developed using Matlab software, which in the system produces a classification of the maturity level of guava fruit by utilizing the HSV image feature of skin color. guava fruit. The level of maturity of guava fruit using the K-Nearest Neighbor method and also utilizing this HSV image feature uses 324 training data and 141 test data by dividing 3 classes of fruit maturity, namely ripe, half-ripe, and unripe. From the results of making the system the quality of accuracy of the classification of the level of maturity on guava fruit is 97.16% with the closest value of K = 3 which is image data with accurate results and 4 images with inaccurate results.

References

Akhir, T. (2020). *Klasifikasi Jenis Dan Tingkat Kematangan Buah Pepaya Berdasarkan Fitur Warna , Tekstur Dan Bentuk Berdasarkan Fitur Warna , Tekstur Dan Bentuk*.

Areni, I. S., Amirullah, I., & Arifin, N. (2019). Klasifikasi Kematangan Stroberi Berbasis Segmentasi Warna dengan Metode HSV. *Jurnal Penelitian Enjiniring*, *23*(2), 113–116. https://doi.org/10.25042/jpe.112019.03

Barkah, M. F. (2020). Klasifikasi Rasa Buah Jeruk Pontianak Berdasarkan Warna Kulit Buah Jeruk Menggunakan Metode K-Nearest Neighbor. *Coding: Jurnal Komputer Dan Aplikasi*, *08*(01), 55–66.

Ciputra, A., Setiadi, D. R. I. M., Rachmawanto, E. H., & Susanto, A. (2018). Klasifikasi Tingkat Kematangan Buah Apel Manalagi Dengan Algoritma Naive Bayes Dan Ekstraksi Fitur Citra Digital. *Simetris: Jurnal Teknik Mesin, Elektro Dan Ilmu Komputer*, *9*(1), 465–472. https://doi.org/10.24176/simet.v9i1.2000

Hanafi, M. H., Fadillah, N., & Insan, A. (2019). Optimasi Algoritma K-Nearest Neighbor untuk Klasifikasi Tingkat Kematangan Buah Alpukat Berdasarkan Warna. *It Journal Research and Development*, *4*(1), 10–18. https://doi.org/10.25299/itjrd.2019.vol4(1).2477

Lestari, Z. D., Nafi'iyah, N., & Susilo, P. H. (2019). Sistem Klasifikasi Jenis Pisang Berdasarkan Ciri Warna HSV Menggunakan Metode K-NN. *Seminar Nasional Teknologi Informasi Dan Komunikasi*, 11–15.

Liantoni, F., & Annisa, F. N. (2018). Fuzzy K-Nearest Neighbor Pada Klasifikasi Kematangan Cabai Berdasarkan Fitur Hsv Citra. *JIPI (Jurnal Ilmiah Penelitian Dan Pembelajaran*

Informatika), *3*(2), 101–108. https://doi.org/10.29100/jipi.v3i2.851

Media, J., & Budidarma, I. (2022). *Klasifikasi Kematangan Buah Pisang Ambon Menggunakan Metode KNN dan PCA Berdasarkan Citra RGB dan HSV*. *6*, 9–17. https://doi.org/10.30865/mib.v6i1.3287

Miftahus Sholihin, M. G. R. (2018). Klasifikasi Mutu Telur Berdasarkan Fitur Warna dengan Menggunakan Metode K-Nearest Neighbor. *Fakultas Teknologi Informasi UNMER Malang*, 1188–1193.

Muhammad, D. I., Ermatita, E., & Falih, N. (2021). Penggunaan K-Nearest Neighbor (KNN) untuk Mengklasifikasi Citra Belimbing Berdasarkan Fitur Warna. *Informatik : Jurnal Ilmu Komputer*, *17*(1), 9. https://doi.org/10.52958/iftk.v17i1.2132

Nafiah, N. (2019). Klasifikasi Kematangan Buah Mangga Berdasarkan Citra HSV dengan KNN. *Jurnal Elektronika Listrik Dan Teknologi Informasi Terapan*, *1*(2), 1–4. https://ojs.politeknikjambi.ac.id/elti

Paramita, C., Hari Rachmawanto, E., Atika Sari, C., & Ignatius Moses Setiadi, D. R. (2019). Klasifikasi Jeruk Nipis Terhadap Tingkat Kematangan Buah Berdasarkan Fitur Warna Menggunakan K-Nearest Neighbor. *Jurnal Informatika: Jurnal Pengembangan IT*, *4*(1), 1–6. https://doi.org/10.30591/jpit.v4i1.1267

Raysyah, S. R., Veri Arinal, & Dadang Iskandar Mulyana. (2021). Klasifikasi Tingkat Kematangan Buah Kopi Berdasarkan Deteksi Warna Menggunakan Metode Knn Dan Pca. *JSiI (Jurnal Sistem Informasi)*, *8*(2), 88–95. https://doi.org/10.30656/jsii.v8i2.3638

Rifki Kosasih. (2021). Klasifikasi Tingkat Kematangan Pisang Berdasarkan Ekstraksi Fitur Tekstur dan Algoritme KNN. *Jurnal Nasional Teknik Elektro Dan Teknologi Informasi*, *10*(4), 383–388. https://doi.org/10.22146/jnteti.v10i4.462

Roring, C. B., Mulyana, D. I., Lubis, Y. T., & Zamzami, A. R. (2022). Klasifikasi Tingkat Kematangan Buah Jambu Bol Berdasarkan Warna Kulit Menggunakkan Metode Naïve Bayes. *Jurnal Pendidikan Tambusai*, *6*(1), 2938–2948.

Salsabila, A., Yunita, R., & Rozikin, C. (2021). Identifikasi Citra Jenis Bunga menggunakan Algoritma KNN dengan Ekstrasi Warna HSV dan Tekstur GLCM. *Technomedia Journal*, *6*(1), 124–137. https://doi.org/10.33050/tmj.v6i1.1667

Shandy, Q., Panna, S. S., Malago, Y., Ilmu, F., Universitas, K., & Gorontalo, I. (2019). *Penerapan Metode Grey Level Co-Occurrence Matriks (GLCM) dan K-Nearest Neighbor (K-NN) Untuk Mendeteksi Tingkat Kematangan Buah Belimbing Bintang*. *3*(1), 31–36.

Shidiq, F. (2021). Penerapan Metode K-Nearest Neighbor (KNN) Untuk Menentukan Ikan Cupang Dengan Ekstraksi Fitur Ciri Bentuk Dan Canny. *Innovation in Research of Informatics (INNOVATICS)*, *3*(2), 39–46. https://doi.org/10.37058/innovatics.v3i2.3093

Suban, I. B., Paramartha, A., Fortwonatus, M., & Santoso, A. J. (2020). Identification the Maturity Level of Carica Papaya Using the K-Nearest Neighbor. *Journal of Physics: Conference Series*, *1577*(1). https://doi.org/10.1088/1742-6596/1577/1/012028

Syarifah, A., Riadi, A. A., & Susanto, A. (2022). Klasifikasi Tingkat Kematangan Jambu Bol Berbasis Pengolahan Citra Digital Menggunakan Metode K-Nearest Neighbor. *JIMP : Jurnal Informatika Merdeka Pasuruan*, *7*(1), 27–35. http://ejurnal.unmerpas.ac.id/index.php/informatika/article/view/417/137

Ulshqhvv, V., Fodvvl, V., Surfhvv, F., Frqvlvwv, L., Wzr, R. I., Wudlqlqj, V., & Whvwlqj, D. Q. G. (2016). *Klasifikasi untuk menentukan tingkat kematangan buah pisang sunpride*.

Wibowo, A., Hermanto, D. M. C., Lestari, K. I., & Wijoyo, H. (2021). Deteksi Kematangan Buah Jambu Kristal Berdasarkan Fitur Warna Menggunakan Metode Transformasi Ruang Warna Hsv (Hue Saturation Value) Dan K-Nearest Neighbor. *INCODING: Journal of Informatics and Computer Science Engineering*, *1*(2), 76–88. https://doi.org/10.34007/incoding.v2i1.131

Wijaya, N., & Ridwan, A. (2019). Klasifikasi Jenis Buah Apel Dengan. *Sisfokom*, *08*(1), 74–78.