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CLASSIFICATION OF DURIAN TYPES USING FEATURES EXTRACTION GRAY LEVEL CO-OCCURRENCE MATRIX (GLCM) AND K-NEAREST NEIGHBORS (KNN)

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ABSTRACT
Durian is one of the most popular fruits because it has a delicious taste and distinctive aroma. It has different shapes and types, especially from thorns and different colors and has fruit parts that are also not the same as other parts. In terms of fruit selection, care must be taken because consumers generally still find it difficult to distinguish physically identified types of Durian fruit due to limited knowledge of the types of Durian fruit and require a relatively long time and accuracy in sorting. Therefore, there is a need for a method to sort the types of Durian fruit effectively and efficiently. Namely image segmentation based on the classification of the types of Durian fruit to help consumers. The method used is Gray Level Co-Occurrence Matrices for feature extraction, while to determine the proximity between the test image and the training image using the K-Nearest Neighbor method based on texture based on the color of the Durian fruit obtained. Extraction features using the GLCM method based on angles of 0°, 45°, 90° and 135°. Then the KNN method is used for the classification of characteristic results using K = 3. In this study, 1281 data training was used and 321 data testing was used, resulting in an accuracy of 93%.
Keywords : *Classification, Gray Level Co-occurrence Matrix, K-Nearest Neighbors, Durian fruit*

1. Introduction

Durian (Durio zibethinus murr) is very popular with the public because it has a delicious taste and distinctive aroma. Durian fruit has a high economic value in Indonesia with a wide and diverse market range. Durian is one type of fruit that is highly nutritious and has a great opportunity to be developed. It has various shapes of thorns and different fruit colors and has fruit parts that are also not the same as other fruit parts. With the enjoyment of a delicious taste and also a lot of durian fruit fans, the durian fruit is dubbed the king of all fruits (Cortaga, et al., 2022; Hashim, et al., 2022).

In this case the selection of fruit must really be done so that consumers are right in choosing the type of durian fruit based on size, weight, shape, ripeness and color. Unfortunately, in this case, consumers are still difficult to distinguish the type of Durian fruit that is physically identified due to limited knowledge about the types of durian fruit, it takes a relatively long time and the level of accuracy of sorting is low. Therefore we need a method for sorting effectively and efficiently. That is one of them with image processing that can help a sorting process so that it can be obtained with uniform results and in accordance with the price. As research material, researchers used the types of durian fruit using a technology that can help the process of segmenting the level of durian fruit types based on color similarity using GLCM and K-Nearest Neighbor Extraction(Sinaga, et al., 2021; Kamdar, et al., 2022; Larasati, 2021; Syahrorini, et al., 2021).

Feature Extraction is a process to retrieve or view the feature values contained in an image. K-Nearest Neighbor (K-NN) is a method that uses a supervised algorithm where the results of the new test sample are classified based on the majority of the categories in K-NN. The purpose of this algorithm is to classify new objects based on attributes and training samples. The classifier does not use any model to match and is only based on memory(Yustika Manik et al., 2020; Anraeni, et al., 2021; Himeur, et al., 2021).

Several studies have been conducted to prove the accuracy of the Gray Level Co-Occurrence Matrix algorithm. In a study conducted by (Ratri Enggar Pawening, 2020) "Quality

classification of local oranges based on texture and shape using the K-Nearest Neighbor (K-NN) method" with energy, Correlation, Contrast, Homogeneity features for texture feature extraction(Mulyono et al., 2020). Texture features are searched based on angles of 0°, 45°, 90°, 135°, resulting in the highest accuracy rate on the k1 test of 93.33% and the lowest accuracy of 86.20% on the k7 and k8 tests.

Subsequent research conducted by (Rachmawanto & Hadi, 2021) examined "Optimization of Feature Extraction in K-NN in Corn Leaf Disease Classification" to calculate the value of color extraction features and feature extraction, using a GLCM method in training data and classification test data for the K algorithm(Syahrorini et al., 2021). -NN. The best accuracy results are obtained, namely 85% by using the k value is 3 and the pixel distance is 1 and the lowest accuracy with the k value is 3 and the pixel distance 3 is 70%.

Based on this background, the author proposes a study where durian fruit classification will be carried out with GLCM and KNN extraction, so this research is entitled "Classification of Durian Types Using Gray Level Co-Occurrence Matrix (GLCM) and K-Nearest Neighbors (KNN) Extraction Features" and is expected to produce a model that can predict the classification of durian fruit types with good accuracy results(Widiyanto & Purwanto, 2019).

2. Literature Review

Further research was conducted by (Luay Nabila El Suffa, 2021) "Identification of Formalin Chicken Meat Image Using the Gray Level Co-Occurrence Matrix (Glcm) and K-Nearest Neighbor (KNN) method" Identifying the image of fresh broiler and village chicken meat using the K method -Nearest Neighbor (K-NN) as classifier and Gray Level Co-Occurrence (GLCM) method as feature extraction(Sinaga & Agustina, 2021). The test uses a dataset of 60 and the test results get an accuracy of 85%.

a) Durian fruit
   Durian Montong or also commonly written Durian Monthong, is a type of "giant" durian originating from Thailand. This durian is actually native to Indonesia but more developed and the massive marketing is becoming more famous from Thailand. The durian montong tree has a long or perennial life, the tree is woody, cylindrical, upright, with cracked skin, rough surface, has many branches, and horizontal direction.
b) Image processing
   Image processing is this process that aims to study the processing of images where the input and output of this system are in the form of digital image files. Image processing is needed because images often experience degradation, such as noise or defects in color images that are too contrasting in the image, less sharp, blurring, and so on(Roring et al., 2022). Selecting optimal feature images for analysis purposes, carrying out information retrieval processes or object descriptions or object recognition contained in images, compressing or reducing data for data storage purposes, data transmission, and data processing time. The input of image processing is the image, while the output is the image processing result.
c) Feature Extraction
   Feature extraction is the process of taking features of an object that can describe the characteristics of the object. This stage aims to obtain information contained in an image and then serve as a reference to distinguish between one image and another(Andrian et al., 2019). The region can be defined in a global or local environment and distinguished by shape, texture, size, intensity, statistical properties, and so on.
d) Gray Level Co-Ocurence Matrix (GLCM)
   GLCM is a statistical method that can be applied in extracting features from texture analysis. GLCM was first introduced by Haralick in 1973 with 28 features to describe spatial patterns(Matrix et al., 2020). GLCM is used because this algorithm is strong if there is a rotation process, so the image can be captured in the same resolution.

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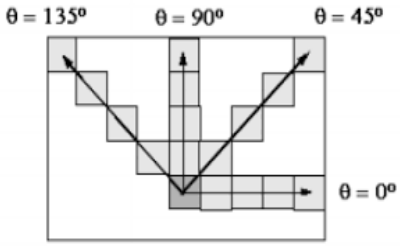


Fig 1. GLCM with angles 0^o , 45^o , 90^o , and 135^o

Neighboring pixels can be selected towards the east (right). One way to represent this relationship is in the form of (1,0), which expresses the relationship between two pixels that are lined up horizontally with a pixel with a value of 1 followed by a pixel with a value of 0. Based on this composition, the number of pixel groups that satisfy the relationship is calculated(Abidin & Fredyatama, 2021).

e) K-Nearest Neighbors (KNN)

K-Nearest Neighbor (KNN) is a method that uses a supervised algorithm where the results of the new query instance are classified based on the majority of the categories in the KNN. KNN is based on the idea that each new instance can be classified by a majority vote of k neighbors, where k is a positive integer, and usually by a small number. The KNN classification algorithm predicts the sample test category according to the k training sample which is the closest neighbor to the test sample, and puts it into the category that has the largest probability category(Rachmawanto & Hadi, 2021).

3. Research Methods

In this study, to achieve the objectives of a research, it is necessary to have a systematic process or procedure used. There are several stages of research which are described in Figure 2 below:

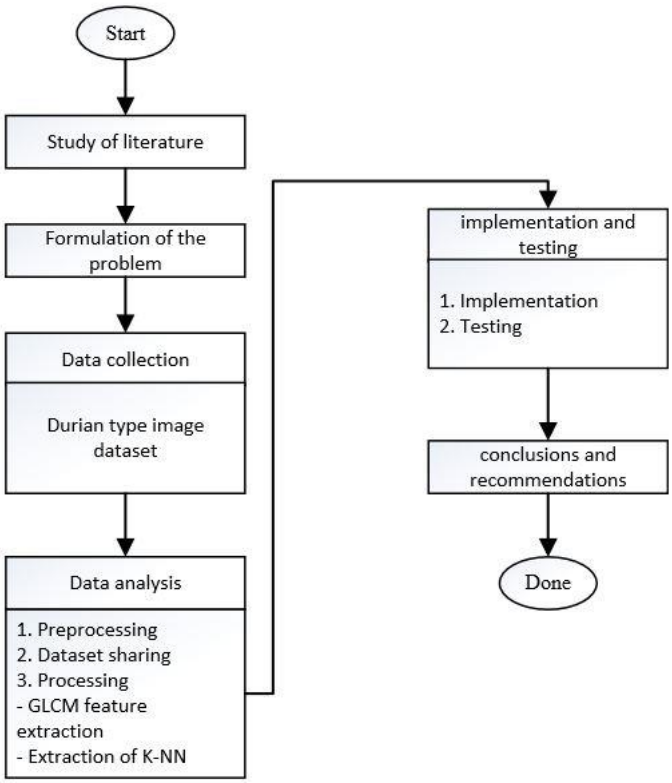


Fig 2. Stages of Methodology Application

a. Study of literature
This stage is the stage of collecting knowledge from sources to obtain information in the form of data. These sources of information serve as a theoretical basis for designing research related to digital image processing, feature extraction of Gray-Level Co-occurrence matrix (GLCM), K-Nearest Neighbor (KNN) classification and types of Durian fruit.

b. Formulation of the problem
The next stage is to collect various information from related references related to the literature study stage. Based on the problems that have been described, the authors make a problem formulation that will be discussed in this study, namely "The application of the K-Nearest Neighbor (KNN) method in digital image processing using Gray-Level Co-occurrence matrix (GLCM) in the classification of the types of Durian fruit.

c. Data collection
In this stage, the dataset used is a dataset of the types of Durian fruit uploaded by MIHAI MINUT through the website at Kaggle with the title "fruit-262", with 1,600 Durian fruit image datasets.

d. Data analysis
The data analysis contains the pre-processing stages that will be carried out covering several stages.

e. Preprocessing
This stage is processing the initial image data, normalizing by going through the stages of cropping, resizing and conversion.

f. Dataset Sharing
The process of dividing the dataset is dividing the dataset into training data (training data) and testing data (test data). Training data is a dataset that is used to create a model, while test data is a dataset that is used to test the accuracy or performance of the training model. This split dataset contains 4 parameters, namely x_Train, x_test, y_Train and also y_test, where x is the data source variable and y is the target data variable. In x_Train contains data source to be trained, x_test contains target data to be trained, while y_Train contains data source used for Testing and y_test is target data used for Testing.

g. GLCM feature extraction
The feature extraction stage in Preprocessing is processed using the GLCM method to obtain features from an image texturally. Performing image analysis based on the statistical distribution of the pixel intensity, can be done by extracting the texture features.

h. K-Nearest Neighbor (KNN) Classification
The K-Nearest Neighbor (KNN) Classification Stage is a process for a collection of data based on data learning. Has a value attribute The value of k used is odd and performs tests using different values of k. Euclidean concept used for calculations in the approach to the distance between the test data and the training data.

i. Implementation and Testing
The process of implementing and testing the system is in accordance with the analysis and design that has been discussed in the previous chapter. In this stage, it aims to display the results and conduct tests on the system that was made in order to be able to test the percentage accuracy of predictions and the accuracy of the final display of the system built.

j. Conclusions and recommendations
This stage is the last stage of the research conducted which at this stage contains conclusions from the research processes that have been carried out as well as suggestions for the continuation of future research.

4. Results and Discussions

A. Research Tools

In this study, the requirements for software specifications for system design in this study are:

Table 1 - Software

No.	Software	Specification
1	Operating system	Windows 10 64-bit
2	Programming language	Google Colabolatory
3	Storage	Google Drive
4	Browser	Google Chrome Vertion 103.0.5060.114 (Official Build) (64-bit)

B. Implementation And Testing

- Implementation
  The implementation stage is a procedure that must be carried out to complete the application design that is in the design listed in Chapter III. Researchers use the python programming language to display the results of a process can be seen in this test snippet.

- Preprocessing
  In the image cutting stage using Snipping tools software to help an image cutting process to be able to produce the right part in the image identification process.

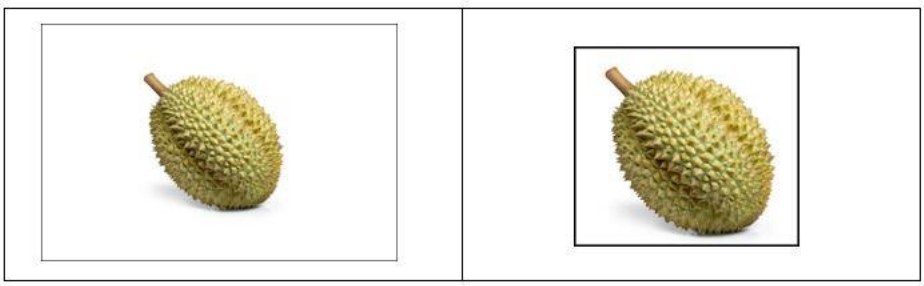
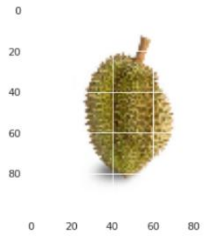
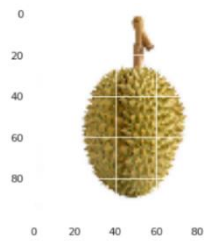
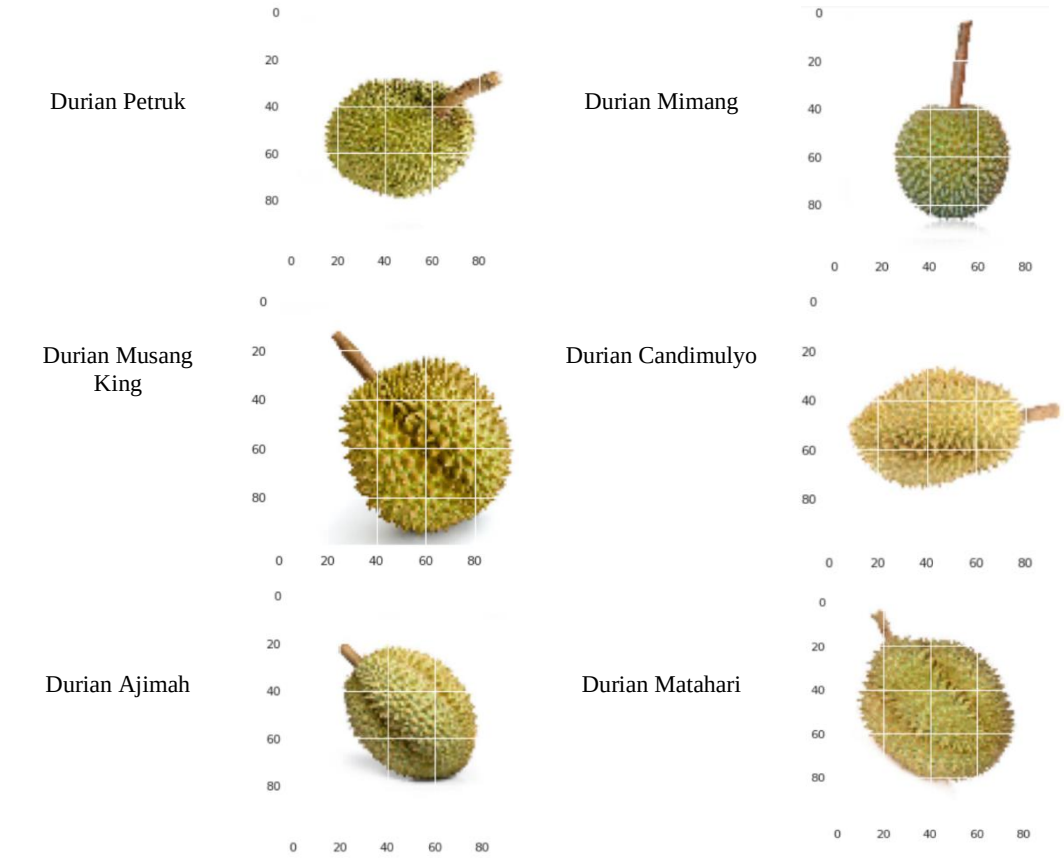


Fig 3. Example Of Image Cropping

- Image Size Normalization
  Image size normalization is very necessary for the image segmentation process stage. Therefore, Google Collabs is used in this image size normalization process. Resize the pixels so that they are the same size in the dataset which is 100x100 pixels.

Table 2 - Results of normalization of Durian fruit image

Durian fruit data 100x100 pixel			
Durian Montong		Durian Bawor	



The results of the success of the process of normalizing the image size to 100x100 can be seen through the image shape information and the appearance of the image that appears.

- Grayscale
  Grayscale is the initial stage of image processing, namely Preprocessing. With the image of Durian fruit in RGB color, it is converted into a gray image (Grayscale). In order to facilitate the image processing. The results of the grayscale image are shown in Figure 4.

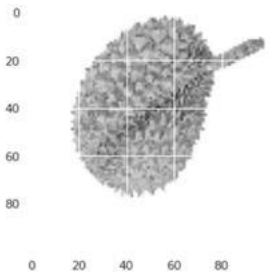


Fig 4. Grayscale Image of Durian Fruit

And the following is the result of an array convert from one of the Durian fruit images that have been Grayscaled with a scale of 0 – 255. With an explanation on a scale of 0 which is a dark color and 255 is a white color.

```
[[255 255 255 ... 255 255 255]
 [255 255 255 ... 255 255 255]
 [255 255 255 ... 255 255 255]
 ...
 [255 255 255 ... 255 255 255]
 [255 255 255 ... 255 255 255]
 [255 255 255 ... 255 255 255]]
```

Fig 5. Output array of grayscale image results

C. Testing

- Gray Level Co-occurrence Matrix (GLCM) Testing

  Gray Level Co-occurrence testing is a feature extraction in a process to find information from an image. In this study using GLCM with a matrix formed from four angle directions, namely 0 , 45 , 90 and 135 . So there are four corners of the co-occurrence matrix. After that, to get the texture value from GLCM use . Researchers used four statistical features, namely Contrast, Homogeneity, Energy and Correlation. GLCM texture metric data that has been processed can be seen the data displayed 8 data from the total data of 1309 images in Figure 6.

Table 3 - GLCM Extraction Results

Label	Durian Ajimah	Durian Bawor	Durian Candimulyo	Durian Matahari
Correlation_0	0.782811	0.798728	0.813709	0.824309
Correlation_45	0.780278	0.806552	0.767140	0.805944
Correlation_90	0.843678	0.806281	0.823430	0.838910
Correlation_135	0.783234	0.753076	0.841234	0.812182
Homogeneity_0	0.545471	0.613748	0.681118	0.641271
Homogeneity_45	0.536817	0.603101	0.666633	0.619334
Homogeneity_90	0.566903	0.613980	0.691679	0.635405
Homogeneity_135	0.532864	0.586876	0.684543	0.618505
Contrast_0	1.458.618.526	1.763.624.842	829.085.474	1.586.842.000
Contrast_45	1.500.382.161	1.723.214.193	1.047.716.797	1.785.738.715
Contrast_90	1.049.845.789	1.697.442.526	775.872.842	1.455.432.632
Contrast_135	1.480.197.483	2.199.570.964	714.340.929	1.728.335.720
Energy_0	0.512719	0.597773	0.664177	0.599557
Energy_45	0.494072	0.586897	0.652862	0.587147
Energy_90	0.515908	0.598191	0.676803	0.605100
Energy_135	0.492884	0.573464	0.669008	0.587347

Label	Durian Mimang	Durian Montong	Durian Petruk	Durian Musangking
Correlation_0	0.874707	0.800645	0.815925	0.744019
Correlation_45	0.869044	0.761337	0.773738	0.790763
Correlation_90	0.840148	0.840714	0.794122	0.755664
Correlation_135	0.819599	0.840272	0.812791	0.685692
Homogeneity_0	0.574114	0.702834	0.647171	0.489008
Homogeneity_45	0.559408	0.685805	0.627093	0.485994
Homogeneity_90	0.557964	0.710780	0.644578	0.490056
Homogeneity_135	0.544275	0.703572	0.637703	0.452920
Contrast_0	1.417.677.474	1.196.330.316	1.140.713.368	2.356.733.568
Contrast_45	1.510.798.503	1.462.158.854	1.426.077.691	1.948.905.599
Contrast_90	1.826.335.684	955.878.947	1.275.267.684	2.255.583.474
Contrast_135	2.081.719.076	978.562.934	1.179.936.198	2.930.312.717
Energy_0	0.479243	0.688179	0.631434	0.415801
Energy_45	0.465829	0.670773	0.613787	0.423540
Energy_90	0.467531	0.695648	0.630378	0.436457
Energy_135	0.458341	0.686807	0.622893	0.397921

Then the extraction results go through the min-max scaling stage, work by adjusting the data within a certain range or range (range of minimum values to maximum values), with the range commonly used is 0 to 1.

```
array([[0.49845292, 0.5572787 , 0.70831699, ..., 0.58216357, 0.5954305 ,
        0.57904177],
       [0.53221545, 0.65634198, 0.53687308, ..., 0.75880214, 0.75521329,
        0.74113811],
       [0.40334585, 0.51902251, 0.6942496 , ..., 0.80683213, 0.81862469,
        0.80197739],
       ...,
       [0.51785162, 0.67346075, 0.57305096, ..., 0.57339132, 0.57768608,
        0.55567739],
       [0.51785162, 0.67346075, 0.57305096, ..., 0.57339132, 0.57768608,
        0.55567739],
       [0.47063638, 0.34201948, 0.46567199, ..., 0.64533751, 0.66646178,
        0.66788867]])
```

Fig 6. Min - max GLCM array output

The normalized dataset in the new framework produces a matrix value between 0 - 1.

Table 4 - Normalization of Dataset

Label	Durian Ajimah	Durian Bawor	Durian Candimulyo	Durian Matahari
Correlation_0	0.782811	0.798728	0.813709	0.824309
Correlation_45	0.780278	0.806552	0.767140	0.805944
Correlation_90	0.843678	0.806281	0.823430	0.838910
Correlation_135	0.783234	0.753076	0.841234	0.812182
Homogeneity_0	0.545471	0.613748	0.681118	0.641271
Homogeneity_45	0.536817	0.603101	0.666633	0.619334
Homogeneity_90	0.566903	0.613980	0.691679	0.635405
Homogeneity_135	0.532864	0.586876	0.684543	0.618505
Contrast_0	0.313942	0.309565	0.408461	0.478319
Contrast_45	0.252205	0.216402	0.305498	0.452401
Contrast_90	0.174704	0.294243	0.207817	0.389055
Contrast_135	0.308536	0.444038	0.412740	0.532152
Energy_0	0.512719	0.597773	0.664177	0.599557
Energy_45	0.494072	0.586897	0.652862	0.587147
Energy_90	0.515908	0.598191	0.676803	0.605100
Energy_135	0.492884	0.573464	0.669008	0.587347

Label	Durian Mimang	Durian Montong	Durian Petruk	Durian Musangking
Correlation_0	0.874707	0.800645	0.815925	0.744019
Correlation_45	0.869044	0.761337	0.773738	0.790763
Correlation_90	0.840148	0.840714	0.794122	0.755664
Correlation_135	0.819599	0.840272	0.812791	0.685692
Homogeneity_0	0.574114	0.702834	0.647171	0.489008
Homogeneity_45	0.559408	0.685805	0.627093	0.485994
Homogeneity_90	0.557964	0.710780	0.644578	0.490056
Homogeneity_135	0.544275	0.703572	0.637703	0.452920
Contrast_0	0.244360	0.206878	0.206878	0.343790
Contrast_45	0.184376	0.229433	0.229433	0.221763
Contrast_90	0.135173	0.253349	0.253349	0.293580
Contrast_135	0.233780	0.199960	0.199960	0.393128
Energy_0	0.479243	0.688179	0.631434	0.415801
Energy_45	0.465829	0.670773	0.613787	0.423540
Energy_90	0.467531	0.695648	0.630378	0.436457
Energy_135	0.458341	0.686807	0.622893	0.397921

- Split Image Dataset
  At this stage the author divides the Durian fruit image dataset into 80% for training data and 20% for test data, as for the training stage of the training data classification model and test data used to test the model's performance. The train-test-split process uses the scikit-learn library. Figure 4.6 shows the view of the split image process That is 1281 for training data and 321 for test data.

```
490     DurianCandimulyo
43          DurianAjimah
600     DurianCandimulyo
716       DurianMatahari
611       DurianMatahari
            ...
157         DurianAjimah
755       DurianMatahari
1269        DurianPetruk
260          DurianBawor
29          DurianAjimah
Name: label, Length: 1281, dtype: object
```

```
589     DurianCandimulyo
176         DurianAjimah
1310        DurianPetruk
3           DurianAjimah
567     DurianCandimulyo
            ...
270          DurianBawor
31          DurianAjimah
1001    DurianMusangking
1457       DurianMontong
1003    DurianMusangking
Name: label, Length: 321, dtype: object
```

Fig 7. The dataset that has been split from the entire dataset

- KNN Classification Test
  Furthermore, the analysis technique is carried out by calculating the performance of the KNN method where the performance measured is accuracy, precision, recall and f-measure. The whole stage of this research uses the scikit-learn library as machine learning tools. The initial stage is to collect data, the data obtained. The next stage is to split the data where 80% is used as training data and 20% as testing data. The description of the data is shown in Table 1.
  The next stage is to apply the KNN method using training data and test data that have been prepared previously. In the last stage, the performance calculation of all testing data is carried out with various neighboring simulations using the KNN method.

D. Final Test Results
The results of the dataset how much the success rate and the level of accuracy of various neighboring values of the KNN method with a value of K = 1 to a value of K = 9 are obtained using a confusion matrix, which is as shown in Figure 10.

	precision	recall	f1-score	support
DurianAjimah	0.95	0.98	0.96	54
DurianBawor	0.88	0.94	0.91	31
DurianCandimulyo	0.98	0.90	0.94	50
DurianMatahari	0.87	0.94	0.90	35
DurianMimang	0.89	0.95	0.92	44
DurianMontong	0.97	0.90	0.94	41
DurianMusangking	0.94	0.94	0.94	31
DurianPetruk	0.94	0.86	0.90	35
accuracy			0.93	321
macro avg	0.93	0.93	0.93	321
weighted avg	0.93	0.93	0.93	321

Fig 8. The final results of the KNN confusion matrix test K=3

From the report above, it can be interpreted that the classification report made for Durian Ajimah received 96% accuracy, Durian Bawor 91%, Durian Candimulyo 94%, Durian Matahari 90%, Durian Mimang 92%, Durian Montong 94%, Durian Musangking 94% and Durian Petruk. 90% so overall, using K = 3 as the best classification model has an accuracy of 93%.

5. Conclusion

From research on Classification of Durian Types Using Extraction Features of Gray Level Co-Occurrence Matrix (GLCM) and K-Nearest Neighbors (KNN) it can be concluded that, In the process of classifying Durian types based on the types and attributes obtained in the Gray-level Co-occurence Matrix stage. The K-Nearest Neighbor method is able to classify based on color similarity to produce a good image classification with training data and test data that have been obtained. Based on the test results on the training data and test data, the accuracy results from the K=1 to K=10 trials obtained are the best test results, namely at K=3 the accuracy percentage is 93%.

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