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Development of an Intelligent Imaging System for Determining Maturity of Copra Flesh in Coconuts Using Shape and Texture Extraction

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Abstract: Copra is dried coconut meat that is used to produce coconut oil. According to the Central Statistics Agency (BPS), Indonesia's copra production in 2020 reached 2.3 million tonnes. This is one form of the process of improving the economy of people living on the coast. This research was conducted to educate farmers in determining the level of maturity of the copra meat produced. This research was conducted using an extraction method that involves shape extraction and texture extraction. the method is used to provide convenience in seeing the level of maturity of the two characteristics of copra obtained in the field, namely texture and shape. The process obtained in the training with one of the images used as a test image in shape extraction produces area, perimeter, metric and eccentricity values in label 3 with values of 651.00, 184.69, 0.24 and 0.89. while in the feature extraction method the results are obtained with an average intensity value of 243.31, standard deviation of intensity 39.76 and entropy value of the tested image 4.57. The method is able to perform a detection process so that it can determine the level of maturity of copra seen from the existing types of copra such as asalan copra, regular copra, black copra and wet copra, each of which provides different functions in the copra processing stage. The process will be carried out using KNN which is seen from all test data and training data stored after the detection process. The results of the process carried out using digital images involving the extraction method for detection and KNN for classification are able to provide the right value. This is evidenced by the better accuracy value of 98%.

Keywords: *Shape extraction, texture extraction, KNN*

INTRODUCTION

One of the countries that have a tropical climate is Indonesia. Coconut plants (Cocos nucifera) thrive in this country (Henrietta et al., 2022). Coconut is one of the plants that has economic value in all aspects, the plant can be utilised by humans in processing(Mat et al., 2022). The fruit of the coconut tree is often used as food, while the leaves of the tree are used for several crafts from various regions (Ulysse et al., 2021). Coconut trunks also function as one of the supports in development. Coconut fruit can also be used as one of the producers of coconut oil. The process of making coconut oil is done with several techniques including smoking coconut meat and drying using sunlight. The result of the smoking and drying process is called copra (Director et al., 2021).

Copra is the dried meat of the coconut that is used to produce coconut oil. Copra is usually produced by drying the coconut meat in the sun, before being processed into coconut oil (Nurhasanah et al., 2021). Coconut oil produced from copra is rich in lauric acid, making it an important commodity in the manufacture of lauryl alcohol, soap, fatty acids, cosmetics, and so on (O’doherty., 2019). According to data from the Central Bureau of Statistics (BPS), Indonesia is the largest coconut producing country in the world with an average production of 18.04 million tonnes of coconut grains per year (Sujarwo et al., 2022). The Philippines ranks second with an average production of 14.4 million tonnes of coconut grains per year. India ranks third with an average production of 11.3 million tonnes of coconut kernels per year. Sri Lanka and Brazil are also among the top five largest coconut producing countries in the world. Papua New Guinea was also the world's largest copra producer in 2016 with total exports of 67,519 tonnes (Jane Alla & Bello, 2021).

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The yield of copra will have an impact on the quality of the oil produced. It is seen from the level of maturity of copra such as shape, texture, and moisture content. Ripe copra usually has a golden brown shape and a dry texture. In addition, the moisture content in mature copra is usually low, which is around 4-5%. Previous research only provided an overview of one of the copra images to be tested, limiting the information obtained by copra producers. The tested copra image is a type of white copra. The stages carried out do not explain the image processing process until it is continued with classification but focus on the copra image classification process only. The classification process is carried out by determining the euclidience value of 5 and obtaining an accuracy value of 93% (Rahayu Marlis et al., 2021.). Similar research was also conducted on copra quality classification based on RGB shape (red, green, blue) and texture (energy, contrast, correlation, homogeneity). The problem is the difficulty of predicting copra quality in category A (80-85%), category B (70- 75%) and category C (60-65%). However, the A, B and C categories are not explained in detail. The method proposed in this research is Nearest Mean Classifier (NMC) with evaluation results using cross validation method obtained an average accuracy of 80.67% with a standard deviation of 1.17%. This research does not explain the type of image processed and functioned by copra producers (Abdullah et al., 2017). Based on this research, there are several research gaps for development, including not explaining the digital process in the copra image data processing stage used by experts before the next process is carried out (Russell et al., 2023). The classification process is carried out on existing images and taken from existing characteristics and there is no detailed explanation of the origin of the image used in the classification stage. Then previous researchers did not explain the types of copra images that were classified such as asalan copra, regular copra, black copra and wet copra (Khairandish et al., 2022).

This is one form of proposed development from the research that will be carried out next. The proposed research uses an extraction method involving shape extraction and feature extraction to obtain a specific image from the processing results obtained. The shape extraction method is carried out by labeling the processed image from the preprocessing results and then on each label the area, perimeter, metric and eccentricity values will be determined. The results of the shape detection process will be continued with the feature extraction process until the average value of image intensity, standard deviation of image intensity and entropy value of each tested copra image is presented. These two methods will be able to produce a detection result information in the form of image maturity level such as standards submitted by experts. The detected image will be classified according to the predetermined copra type and used for the distribution process in the container unit using the KNN (K-Nerurest Neigtbour) method. The process is a contribution to this research by providing information in the form of education to copra-producing farmers in determining the maturity level of copra based on the type of copra used.

LITERATURE REVIEW

Shape Extraction

Shape extraction is a process on shape images that have RGB (red, green, blue) shape composition. In the shape extraction process, the distinguishing feature is shape. The shape of the object can be used to detect objects that have a special shape. In addition, shape can also be used to categorise objects based on the shape of the processed image (Patch et al., 2021). The preprocessing stage is carried out by cropping the copra image, followed by resizing to ensure the size of the image to be processed at the extraction stage. In the shape extraction process where the distinguishing feature is the value found in the shape extraction. Shape extraction from objects can be used to detect objects that have special shapes. In addition, shape extraction can also be used to categorise objects based on the characteristics of each input image (Tsourounis et al., 2022).

Texture Extraction

Texture extraction is the process of obtaining specialised information relating to the texture characteristics of an image. Texture includes visible patterns or details within the surface of an object or image area, such as patterns of shape, shape, or structure. Texture extraction aims to describe and represent these features in a form that can be measured or further processed (Ahmed et al, 2019.).

In texture extraction, various features can be tested or extracted from the image to represent the desired texture characteristics. The selection of appropriate features depends on the type of image, the application context, and the purpose of the analysis. In general, a combination of several features provides a better representation of the texture in the image. Some machine learning techniques can also be used to automate feature extraction and improve the fit of the model to the data. Commonly used features are the calculation of energy, contrast, correlation and homogeneity values (Castiglioni et al., 2021).

KNN (K-Nearest Neighbour)

KNN (K-Neurest Neighbour) is a machine learning algorithm used for classification and regression by finding the nearest neighbour. The stated classification process of KNN can be used to predict the class label of an object based on learning data taken from its k nearest neighbours (Hidayati & Hermawan, 2021).

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KNN or K-Nearest Neighbors is one of the classification algorithms used in machine learning and data mining. It can be used for classification, regression, and pattern search problems in data (Abbad Ur Rehman et al., 2021). It is based on the principle that similar objects tend to be in a number of close neighbours in the feature space. Here are the general steps of how KNN works (Lopez-Bernal et al., 2021):

1. Determining the K Parameter
   K in KNN refers to the number of nearest neighbours that will be used to make predictions. The selection of this K value can affect the performance of the algorithm. A value of K that is too small can make the model very sensitive to noise, while a value of K that is too large can produce a model that is too general.
2. Measuring Distance
   For each data point in the feature space, KNN measures its distance to other data points. This distance can be measured by various metrics, such as Euclidean distance, Manhattan distance, or Minkowski distance metrics.
3. Determining the Nearest Neighbour
   After measuring the distance, KNN identifies the K nearest data points that have the smallest distance from the tested data point.
4. Voting or Ponderation
   In this stage, KNN involves the majority vote or ponderation of the nearest neighbours to determine the class or regression value of the tested data point. For example, if K = 3, and two nearest neighbours are class A and one is class B, then the data point will be classified as class A.
5. Prediction
   Based on the previous steps, KNN can be used to make predictions regarding the class or regression value of the tested data point.

The advantages of KNN include ease of implementation and interpretation, but disadvantages include sensitivity to outliers and performance that can be affected by the number of dimensions in the data. In addition, KNN requires full data storage and distance calculations for each prediction, which can make it less efficient for large datasets (Ibrahim & Abdulazeez, 2021).

METHOD

This research was conducted using several methods proposed in the image processing stage. The methods used include shape extraction and shape extraction. Then the image obtained in the extraction stage will be classified according to the provisions that have been submitted by the expert. The form of the research framework carried out is as follows:

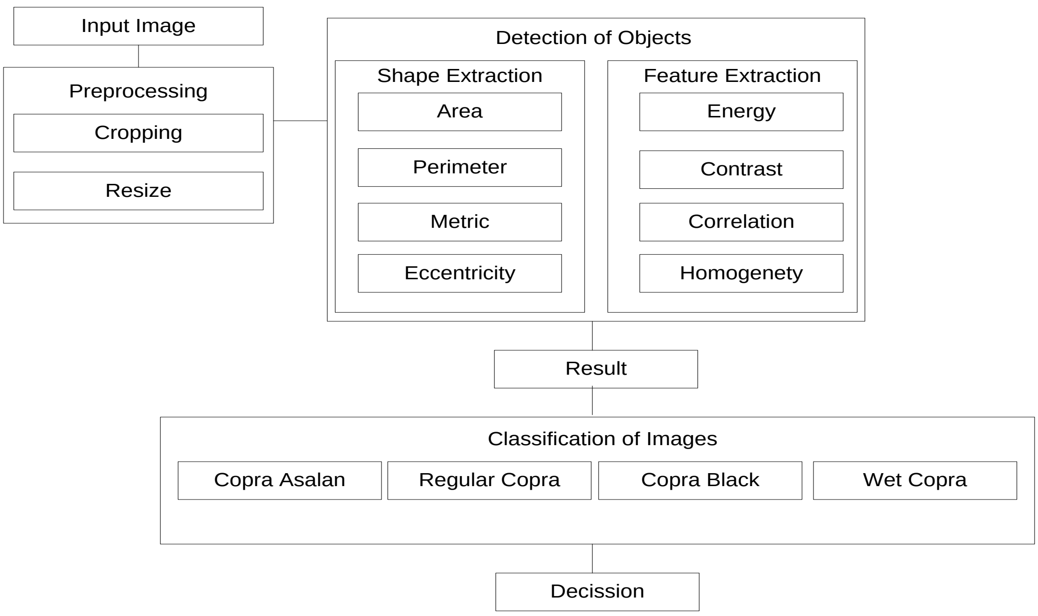

Figure 1: Research Framework

RESULT

The process in this research will be carried out by first inputting the copra image to be processed. Then proceed with the preprocessing stage which involves the cropping stage to take the desired image, after which it is continued with the resize stage to get the image size according to the expert's wishes. This stage in preprocessing needs to be

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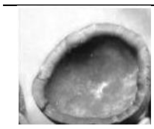
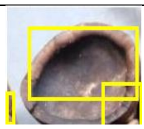
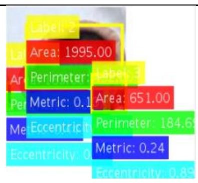
done to facilitate the detection process. The form of the image processed based on the preprocessing stage is as follows:

Initial Image **Cropping Image** **Resize Image**

Figure 2. Preprocessing Results

The next process continues with the detection stage using shape extraction and feature extraction. The shape extraction stage is carried out to obtain the area, perimeter, metric and eccentricity values in each image that is labelled which indicates the condition of the copra image after the resize process. The test image carried out at the preprocessing stage provides information in the detection process which produces label 1, label 2 and label 3. The results of each label have different values including:

Table 1. Shape Extraction Results

Processed Image	Shape Detection Image	Position		Area	Perimeter	Metric	Eccentricity
		Label 1		163.00	68.58	0.44	0.97
		Label 2		1995.00	492.00	0.10	0.91
		Label 3		651.00	184.69	0.24	0.89

The image results that have been processed using the shape extraction process will be continued by performing the detection process using shape extraction. It is necessary to know the energy, contrast, correlation and homogeneity values of each image that has been processed using shape detection. The results obtained are as follows:

Table 2: Shape Extraction Results

Initial Image	Detection Result Image	Angels				
			0	45	90	135
		Energy	0.4885	0.48437	0.48823	0.48412

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	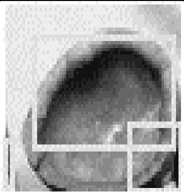	Contrast	341.7379	550.391	284.233	545.354
		Correlation	0.95007	0.91984	0.95851	0.92057
		Homogeneity	0.81154	0.78952	0.80623	0.78726

Energy (E) measures the homogeneity or uniformity of pixel intensity in the image. A value closer to 1 indicates that the image has a more homogeneous intensity distribution. The results obtained from the 4 angels used are 0, 45, 90 and 135 with energy values of 0.4885, 0.48437, 0.48823, 0.48412. Contrast measures how much difference there is in the intensity of neighbouring pixels. A high contrast value indicates a significant intensity difference between neighbouring pixels. The contrast results obtained are 341.7379, 550.3917, 284.2339, 545.3542. The correlation (rho) value measures the extent of the linear relationship between pixel intensities in the image. Values close to 1 indicate a more linear relationship. The results obtained are 0.95007, 0.91984, 0.95851, 0.92057. Homogeneity measures how close the pixel intensities in the image are to the centre value. A higher value indicates that the intensity distribution is more uniform. The resulting values are 0.81154, 0.78952, 0.80623, 0.78726.
The image results obtained in the detection stage using shape extraction and feature extraction will be stored and classified using KNN (K-Neurest Neighbour). The number of neighbours (K) used for class determination. Then the process of calculating the distance from the bar data to each data point in the dataset is carried out. The next step is to take a number of K data with the closest distance. The euclidience distance calculation process can be done using the following formula:

$$d = \sqrt{(x2 - x1)^2 + (y2 - y1)^2}$$

The algorithm used in this research in the classification process using KNN is as follows:
1. Read the training image and calculate the features (Area, Perimeter, Eccentricity) of each training image.
2. Stores the resulting features into the training variables.
3. Determines the label for each training image and stores it in the group variable.
4. Displays a scatter plot of the generated features.
5. Reads the test images and calculates the features (Area, Perimeter, Eccentricity) of each test image.
6. Stores the generated features into the sample variable.
7. Perform copra type classification on the test image using the KNN algorithm.

This research was conducted using 4 classes including original copra, regular copra, black copra and wet copra. Each of them will be determined and placed on the following graph:

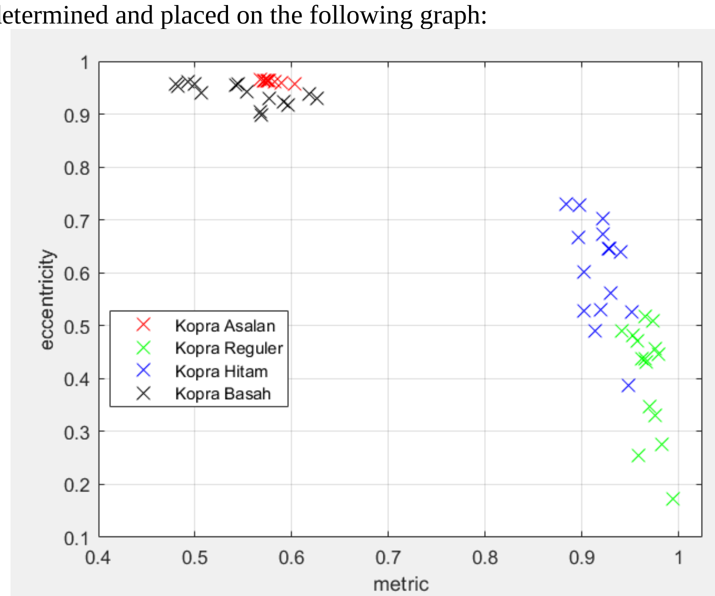

Figure 3. Grafik Scatter Plot

This graph can be used to classify the types of copra based on the features extracted from the image. The K-Nearest Neighbor (KNN) algorithm can be used to perform copra type classification on the test image. The data for "Asalan Copra" is concentrated around a metric value of 0.5 - 0.6 and an eccentricity of 0.9 - 1. The data for "Regular Copra" is concentrated around a metric value of 0.8 - 0.9 and an eccentricity of about 0.7. The data for "Black

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Copra" is widely dispersed with the main concentration around metric values between 0.7 - 0.8 and eccentricity between about 0.4 - 0.6. The data for "Wet Copra" is also widely dispersed with major concentrations around metric values between about more than >0.8. Eccentricity is one of the features used in digital image processing. The eccentricity value describes how far an object is from a perfect circle. Eccentricity values range between 0 and 1, where a value of 0 indicates that the object is a perfect circle, while a value of 1 indicates that the object is very far from a perfect circle 1. On the scatter plot graph the eccentricity value is displayed on the y-axis, ranging from 0.1 to 1.

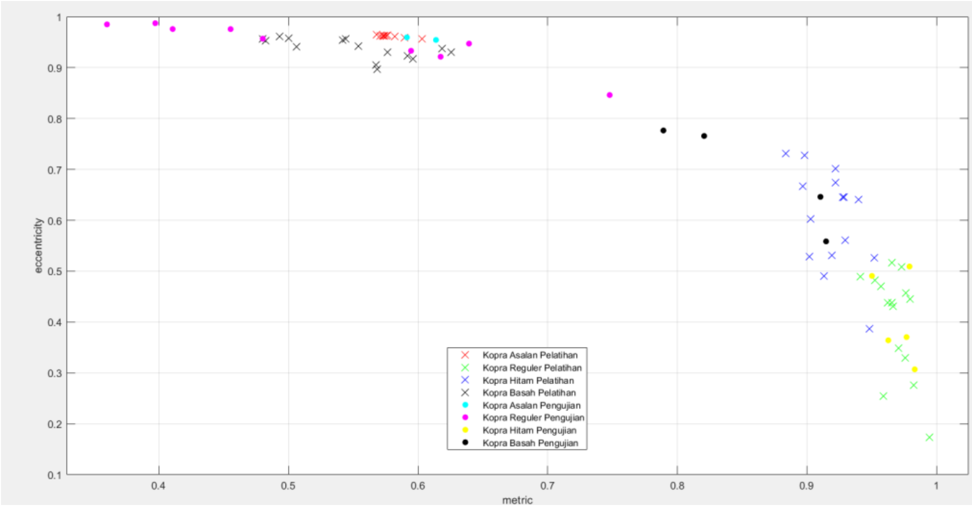

Figure 4. Classification results

The scatter plot graph shows data for four different categories such as Asalan Copra (red), Regular Copra (blue), Black Copra (black), and Wet Copra (green). Metric values are shown on the x-axis, ranging from 0.4 to 1, while eccentricity values are shown on the y-axis, ranging from 0.1 to 1. The training data is represented with cross symbols, while the test data is represented with dot symbols. The following is an explanation of the values on the graph:

1. Training Asalan Copra (red) has an eccentricity between 0.9-1 and a metric between 0.4-0.6.
2. Training Regular Copra (purple) has an eccentricity of around 0.9-1 and a metric of around 0.4-0.6.
3. Training Black Copra (dark blue) has an eccentricity of about 0.7-0.8 and a metric of about 0.8-1.
4. Training Wet Copra (light blue) has an eccentricity of about 0.3-0.5 and a metric of about 0.8-1.
5. Testing Asalan Copra (yellow) has an eccentricity between 0.2-03 and a metric between 08.-1.
6. Testing Regular Copra (black) is at an eccentricity of around 08.-09, with metric in the same range.
7. Testing Black Copra is not present in this graph.
8. Testing Wet Copra (light green) has an eccentricity value between 02.-03, with metric in the same range.

The results of the classification process will be carried out the accuracy stage using the following command:

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

The accuracy result obtained in this study is worth 98%. The shape of the confusion matrix produced in this study is:

	Asalan copra	Regular Copra	Black Kopra	Wet Copra
Asalan copra	8	0	0	12
Regular Copra	0	20	0	0
Black Copra	0	0	16	4
Wet Copra	0	0	0	20

DISCUSSIONS

This research was conducted using image reading with shape and form extraction methods. The results obtained in shape extraction are area, perimeter, metric and eccentricity values based on the labelling process in the detected image. The image that has been detected in the shape extraction image will continue with shape extraction to obtain energy, contrast, correlation and homogeneity values at angels of 0°, 45°, 90° and 135°. The image resulting from the shape extraction and shape extraction process will be classified using KNN (K-Neurest Neighbour) by

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determining the value of K = 20. The results obtained at the classification stage are able to provide information in the form of copra images that are processed according to what is conveyed by the expert. Types of classification are asalan copra, regular copra, black copra and wet copra. The accuracy level of the classification results is calculated on the amount of data with 8 asalan copra, 20 regular copra, 16 black copra and 20 wet copra. The accuracy value of 98% is obtained on the results of image classification carried out using test data and training data that has been provided.

CONCLUTION

Based on the results of research on image processing in determining copra on coconut, it can be concluded that the proposed research with image reading is carried out using the shape extraction method, shape extraction and classification process using KNN (K-Neurest Neighbour). The first test using the shape extraction method from the results of preprocessing carried out such as cropping and resizing resulted in 3 labels being detected. Label 1 on the detected image produces an area value of 163.00, perimeter 65.58, metric 0.44 and eccentricity 0.97. The image labelled with label 2 has an area value of 1995.00, perimeter of 492.00, metric of 0.10 and eccentricity of 0.91. Label 3 gives area 651.00, perimeter 184.69, metric 0.24 and eccentricity 0.89. The results obtained in shape extraction will be stored and further processing is carried out using shape extraction to determine the characteristics of each processed image. Shape extraction will show the image with indicators of determining energy, contrast, correlation and homogeneity. The results of the shape extraction process will be tested using angels of 0°, 45°, 90° and 135°. The process produces energy values of 0.4885, 0.48437, 0.48823, 0.48412. The contrast values obtained are 341.7379, 550.391, 284.233 and 545.354. The correlation value is 0.95007, 0.91984, 0.95851, 0.92057 and the homogeneity value is 0.81154, 0.7895, 0.80623 and 0.78726. The image results at this stage will be classified using KNN (K-Neurest Neighbour) determining the value of K = 20. The results obtained at the classification stage are able to determine the maturity of copra based on the type of copra processed including asalan copra, regular copra, black copra and wet copra. The accuracy level is obtained by involving test data and training data on 8 asalan copra, 20 regular copra, 16 black copra and 20 wet copra. The accuracy value of 98% is generated from the image classification process carried out.

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