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Comparison of Pyrus Fruit Classification using K-Nearest Neighbor (KNN) and Adaptive Neuro Fuzzy Inference System (ANFIS) Algorithms

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Abstract. Pears or Pyrus fruits are popular among the public because of their high nutritional content, delicious taste and low calories. Fruit classification can be done visually, but manual classification requires consistent techniques and is often constrained by human aspects. Digital image processing is applied to solve the above problems. The pears identified in this study came from three types, namely the Abate Pear, the Monster Pear and the William Pear. Pre-processing is done by converting the RGB image to L*a*b, then segmenting it using the K-Means Clustering algorithm. The segmented image is extracted into 7 features, namely 6 color features (Red, Green, Blue, Hue, Saturation, Value) and 1 size feature (Area). Classification is carried out using the K-Nearest Neighbor (KNN) algorithm and the Adaptive Neuro Fuzzy Inference System (ANFIS). The results showed that the KNN algorithm had a better performance in classifying the types of pears.

INTRODUCTION

Image processing is a technique for converting an image into a digital image to obtain an increase or to extract some important information from it [1]. The computer tries to simulate the human brain to get the information needed from an image data [2]. Image processing and computer vision have been widely used in agriculture [3]. Various important tasks are carried out automatically with image processing techniques, such as weed detection, food grading, harvest control and fruit picking [4].

The fruit itself has great relevance for humans because of its nutritional value. Therefore, research on fruit processing is very important in various sectors, such as the economic sector [5]. Pears, which have the name Pyrus practice, are popular among the public because of their high nutritional content, taste delicious and are low in calories. Pears have a low protein and lipid content, but are rich in sugars such as fructose, sorbitol and sucrose. Pears also have other nutritional components such as vitamins and antioxidants that are important for health [6].

The fruit classification process can be done based on shape, color and size [7]. Usually this process is done visually. However, manual classification raises many obstacles related to humans and requires continuous and consistent aspect recognition techniques [8].

The purpose of this study was to classify pears automatically using image processing techniques. Three types of pears to be classified are the Abate Pear, the Monster Pear and the William Pear. Color and size features will be extracted for processing using two classification algorithms, namely K-Nearest Neighbor (KNN) and Adaptive Neuro Fuzzy Inference System (ANFIS). Furthermore, the classification results will be compared to determine which algorithm has the best classification performance.

LITERATUR REVIEW

This study uses KNN and ANFIS algorithm to classify the types of pears. Both of these methods have their own advantages and disadvantages, so that by comparing these two methods it will be seen which method is the most

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suitable for the case of pear type classification.

KNN is a supervised algorithm where the test query results are classified by the majority value of the neighbors. KNN will consolidate the calculation results with training data that has the largest number of relatives in the specified range (k) [9]. KNN has advantages such as simple, easy to use [10], unbiased algorithm, high detection precision [11] and does not require time for training [12].

ANFIS was introduced in 1993 as a combination of Artificial Neural Network (ANN) and fuzzy logic approaches [13]. ANFIS can analyze and simulate the mapping relationship between input and output datasets through a hybrid system to determine the optimal membership function distribution [14]. ANFIS has advantages such as estimation speed, simplicity and capacity to allow better combinations of other methods [15]. ANFIS requires fewer customizable parameters than is required in other Neural Network structures, particularly backpropagation MPLs [16].

Previous research [17] classified three types of pears, namely Abate Pear, Red Pear and William Pear using Principal Component Analysis and KNN. The results show an accuracy of 87,5%.

Furthermore [18] developed the Single Shot Multi-box Detector (SSD) to classify apples, persimmons, nectarines and pears. In the pear type, the Improved SSD produces the highest accuracy of 93,2% compared to other algorithms such as CNN, Faster-RCNN, YOLO-v3 or SSD-300.

In addition, research [19] classifies Pear Monster and Pear William with the KNN method and produces an accuracy of 95%. In this study, we will use the same dataset with the addition of the number of images, number of types and other methods, to re-measure the accuracy of the KNN method and compare it with another method, namely ANFIS.

METHOD

The image used in this study is an image of a pear from the Fruits-360 dataset. There were 1.470 training images, consisting of 490 images of Abate Pear, 490 images of Monster Pear and 490 images of William Pear. While the test images were 498 images, consisting of 166 images of Abate Pear, 166 images of Monster Pear and 166 William Pear. Figure 1 is an example of an original image of a pear of each type.

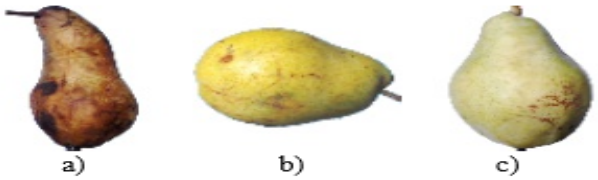

FIGURE 1. Original Image of Pear Fruit (a) Abate Pear (b) Monster Pear (c) William Pear

Image processing is carried out in several stages, including RGB to L*a*b conversion, segmentation, feature extraction, classification using 2 algorithms, to comparison of results. The proposed method is depicted in Figure 2.

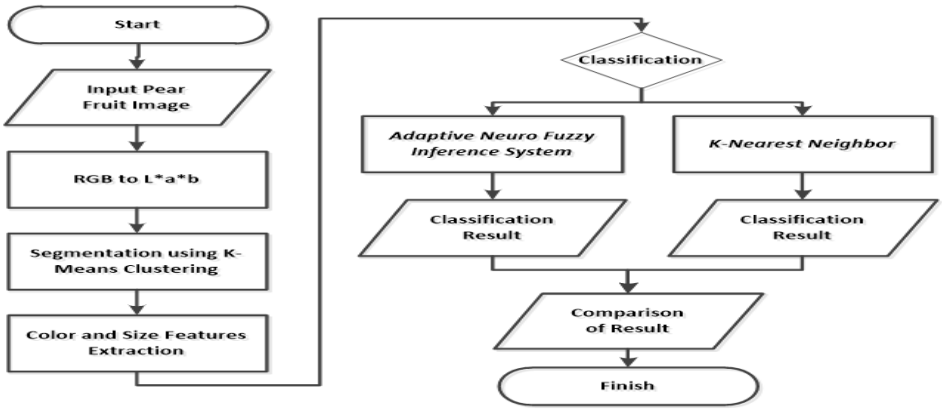

FIGURE 2. Flowchart of Identification Pear Fruit

The first process of identifying pears is to input the original pear image into the Matlab program that has been created. The original image in RGB format is then converted to L*a*b in the pre-processing stage. Furthermore, the image is segmented to separate the object to be studied with an unnecessary background. This segmentation process uses the K-Means Clustering method. The segmented image will be displayed again in RGB format.

After the segmentation process, then the feature extraction is carried out on the color and size features. This process produces 7 features, namely Red, Green, Blue, Hue, Saturation, Value and Area. The features that have been obtained are then processed at the classification stage using 2 algorithms, namely the KNN and ANFIS. The classification results of the two algorithms will be compared to find out which method has the best accuracy.

RESULT AND DISCUSSION

The original image in RGB format is then converted to L*a*b. Furthermore, the image is segmented using the K-Means Clustering method. Image processing is shown in Figure 3.

FIGURE 3. Image processing

The segmented image is then processed in the feature extraction stage which produces 6 color features (Red, Green, Blue, Hue, Saturation, Value) and 1 size feature (Area). The feature value of each training image will be used as a learning tool for the test image feature in the classification process.

After feature extraction is carried out, the classification process is then carried out. At this classification stage, the image being tested will be identified as belonging to the Abate Pear, Monster Pear or William Pear. The classification process uses two algorithms, namely KNN and ANFIS.

In the training process with the KNN algorithm, the feature extraction results are converted into a principal component, where the principal component is reduced to 2, namely PC1 and PC2. The same process applies to the testing process with the KNN algorithm. After the feature extraction results are converted into 2 principal components, then the classification is carried out based on the number of closest neighbors. In this study, the K value in KNN is 3. The distribution of training and testing data is shown in Figure 4.

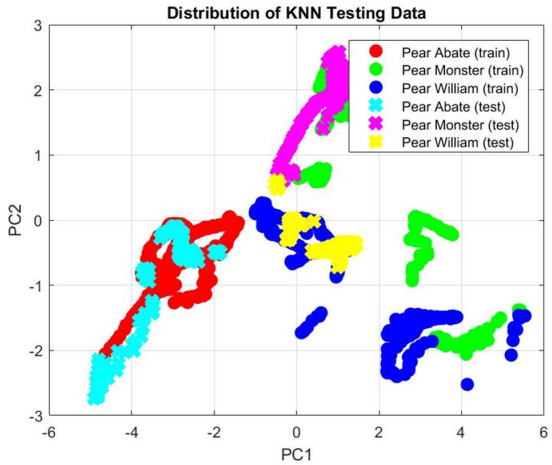

FIGURE 4. Distribution of KNN Training Data and Testing Data

In the ANFIS algorithm, the training results from 1.470 training images show a training accuracy of 100%. In the training process, two membership functions are used for each input with the type Generalized Bell-shaped Membership Function (gbellmf). The process, starting from image input, pre-processing, segmentation, feature extraction, to the classification above is carried out with the Matlab R2017a program that has been created. Figure 5 shows the Matlab program for identification of pear fruit.

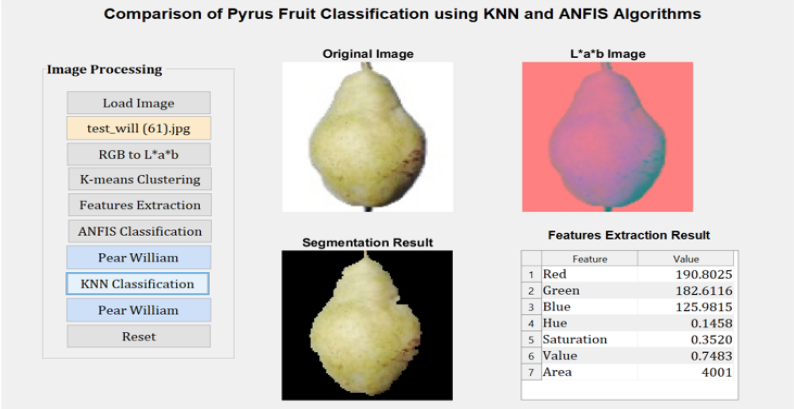

FIGURE 5. Matlab Program for Pear Fruit Identification

From the program above, it will be seen the classification results of the test image, both by the KNN and ANFIS methods. Then a configuration matrix is created to display the classification results. The test configuration matrix with the KNN and ANFIS algorithms is shown in Table 1 and Table 2, respectively.

Table 1. *Confusion Matrix* KNN Algorithm

Original Class		Prediction Class a	b	c
a	Abate Pear	166	0	0
b	Monster Pear	0	160	6
c	William Pear	0	0	166

Table 2. *Confusion Matrix* ANFIS Algorithm

Original Class		Prediction Class a	b	c
a	Abate Pear	137	5	24
b	Monster Pear	8	158	0
c	William Pear	0	0	166

From Table 1 above, the results of the classification using the KNN algorithm show that in the Abate Pear class and William Pear class, all test image are correctly classified, namely as many as 166 images for each class. In the Monster Pear class, 160 images are correctly classified, and 6 images are incorrectly classified. From these results, the overall KNN algorithm resulted in 492 images that were identified as correct and 6 images identified as incorrect from a total of 498 test images.

Table 2 show classification result using ANFIS algorithm. 137 images of the Abate Pear class were correctly classified, 5 images were incorrectly classified into Monster Pear and 24 images were incorrectly classified into William Pear. Then, 158 images of the Monster Pear class were correctly classified and 8 images were incorrectly classified into Abate Pear. Meanwhile, in the William Pear class, all test images were classified as correct, namely 166 images. From these results, the overall ANFIS algorithm resulted in 461 images that were identified as correct and 37 images identified as incorrect from a total of 498 test images. The percentage of research accuracy is calculated as follows:

$$\text{Accuracy of KNN algorithm} = \frac{492}{498} \times 100\% = 98{,}80\%$$

$$\text{Accuracy of ANFIS Algorithm} = \frac{461}{498} \times 100\% = 92{,}57\%$$

After knowing the results of the accuracy of each algorithm, then the results are compared. From the above calculations, it is found that the accuracy with the KNN algorithm is higher than the ANFIS algorithm, which is 98,80%. This means that the KNN algorithm can classify types of pears with better classification performance than the ANFIS algorithm.

CONCLUSION

Various studies in the field of image processing have been developed to help solve problems in various fields of life. One of the popular fields using image processing techniques is agriculture. This research was conducted to identify three types of pears, namely the Abate Pear, the Monster Pear and the William Pear, using image processing techniques. With the proposed method, obtained a fairly high accuracy value with the KNN and ANFIS algorithms. After testing each algorithm, it is known that the KNN algorithm has a better classification performance than the ANFIS algorithm in classifying pears.

In further research, other features that may have an effect can be added, as well as experiments with other classification algorithms.

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