Content Based Image Retrieval for Multi-Objects Fruits Recognition using k-Means and k-Nearest Neighbor

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Abstract—***The uniqueness of fruits can be observed using the colors and shapes. The fruit recognition process consists of 3 stages, namely feature extraction, clustering, and recognition. Each of stage uses different methods. The color extraction process using Fuzzy Color Histogram (FCH) method and shaping extraction using Moment Invariants (MI) method. The clustering process uses the K-Means Clustering Algorithm. The recognition process uses the k-NN method. The Content-Based Image Retrieval (CBIR) process uses image features (visual contents) to perform image searches from the database. Experimental results and analysis of fruit recognition system obtained an accuracy of 92.5% for single-object images and 90% for the multi-object image.***

Keywords— Multi-Object; Feature Extraction; Fuzzy Color Histogram; Moment Invariant; K-Means Clustering; K-NN Classification; CBIR.

I. INTRODUCTION

CBIR is searching image method by performing a comparison between the query image and database image by looking at the characteristic of colors, texture, or shape [1] [2]. *Content-Based* means an object that is analyzed to do the search process itself. Content in this case also refers to the texture, shape, color or other information contained the image [3]. In general, the process that occurs in CBIR is doing the process of feature extraction on the image of test data and image of the training data contained in the database. The process further compares the similarity value between the query image and the training image so that information about query image is examined. The parameter of image characteristic can represent its use in the retrieval on a system that arrangement of colors textures, and shapes of an object in the image [4] [5].

In general, objects recognition was done one by one. This causes the image object recognition process takes a relatively long time. So in this study, the use of CBIR is expected to help in accelerating the level of time efficiency in recognizing many objects in the multi-object fruit image. Architecturally, the CBIR process applied in this study uses a common system. The CBIR system also uses a combination of new feature extraction methods and utilizes grouping algorithms.

The characteristic extraction of the image is a process of extracting a distinctive sign that can differentiate between one image with another image to be processed. Characteristics are divided into 3 that has a sign that is typical. The three characteristics features contained in the image are color, shape, and texture. In this study used the characteristic extraction based on color and shape.

The descriptions of shape can be done at the Feature Extraction stage. The extraction of shape characteristic can be done by various methods. In this study, the extraction of shape characteristics in the image using the method of Moment Invariant. This method can be used as a descriptor of the shape (pattern) based on the Theory of the moment. In one fruit image it is possible to have different fruit positions, different rotations, experience translation, and differentiate the shape of the scaling image scale [6]. In overcoming this, the use of *Moment Invariant method* is the solution to the problem [3].

The color is the most basic characteristic to discriminate against metadata contained in an image. The color information can also be an important role in the use of the CBIR concept. Color Histogram is widely used in the indexing process in *Image Retrieval*, *Video Retrieval*, and *Object tracking fields*. In this study, the method used in the extraction of color features on the image is *Fuzzy Color Histogram* (FCH). FCH can consider the equations of the colors of each pixel allocated to all bin histograms via Fuzzy set membership function [6] [7] [8] [9] . Therefore, FCH has much bin that can accommodate each different color so it can be seen the color that often appears in an image. In FCH, one color can fit into two or more bin histograms with different degrees of membership and also each color is presented with a Fuzzy set.

In this research, k-means clustering algorithm is used to perform image grouping before it is recognized. This is expected to accelerate the computation time required in the process of recognition. One method of classification or matching is k-Nearest Neighbor (k-NN) and with the closest calculation of the Euclidean Distance which used in this study. Pada penelitian sebelumnya Algoritma k-NN diterapkan pada citra single-object [11] penelitian ini diajukan dengan menggunakan multi-object yang diharapkan dapat mempercepat pengenalan objek dalam citra multi-object.

II. Fruit Recognition

A. Data

This study uses the data with a total of 175 images There are two types of the data from the entire image. There are the single-object and multi-object fruits. The data divided into two parts, training data and testing data. A total of 100 single-object images used for training data. 55 single-object images dan 20 multi-object images used as testing data. An example of fruit the data shown in figure 1.

Fig 1. An Example of Training Data

B. Pre-processing

Pre-processing is Image Scaling, Grayscaling, Convert RGB to XYZ, XYZ Color Space Conversion to CIELAB, and conversion to the threshold image.

Image size changes proposed in this study is an image with a size of 100x100 with image scaling techniques. Then the image is converted into a gray image with the grayscaling process. Results of the grayscaling process are transformed into a binary image, to simplify the calculation of the invariant moment method for computing the numbers produced for only two possibilities, namely 0 (black) and 1 (white). The color level thresholding determines determination Award with Otsu thresholding method.

Then, the image of the RGB color space converted into the image of the XYZ color space. XYZ color space conversion can be done using the following formula:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.4124 & 0.3756 & 0.1805 \\ 0.2126 & 0.7152 & 0.0722 \\ 0.0193 & 0.1992 & 0.9505 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{1}$$

XYZ image and then converted into CIE LAB values of the formula :

$$\begin{aligned} CIE\ L* &= (116 * Y) - 16 \\ CIE\ A* &= 500 * (X - Y) \\ CIE\ B* &= 200 * (Y - Z) \end{aligned} \tag{2}$$

C. Feature Extraction

Feature extraction was done using methods Moment invariant and Fuzzy Color Histogram (FCH). Invariant Moment method used as a descriptor form (pattern) based on the theory of the moment. In one image of fruit allows the position of different fruits - different, has somewhat different rotations - different, undergo translationally, and various forms of fruit image scale (scaling) [6]. Stages of this method shown in below.

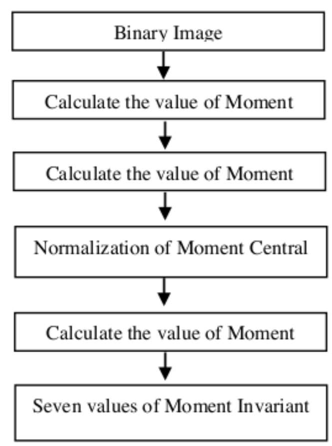

Fig 2. Block Diagram of Invariant Moment Calculation

The set of the two-dimensional moment of order (p + q) of an image with a size of MXN can be defined as follows [12] :

$$m_{pq} = \sum_{x=0}^{H-1} \sum_{y=0}^{W-1} x^p y^q f(x,y) \tag{3}$$

Where H is the image height and W is the width of the image, p = 0,1,2, ... and q = 0,1,2, ... is an integer. Then Moment Central order (p + q) is defined as follows :

$$\mu_{pq} = \sum_{x=0}^{M-1} \cdot \sum_{y=0}^{N-1} (x - \bar{x})^p (y - \bar{y})^q f(x, y)$$

Where :

$$\bar{x} = \frac{m_{10}}{m_{00}} \quad dan \quad \bar{y} = \frac{m_{01}}{m_{00}} \qquad (4)$$

Furthermore, the normalized central moments, which denoted as follows :

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{00\gamma}}$$

With :

$$\gamma = \frac{p+q}{2} + 1 \qquad (5)$$

Thus, the seventh Moment invariant values can be derived from the second and third moment as follows :

$\phi 1 = \eta 20 + \eta 02$

$\phi 2 = (\eta 20 - \eta 02)2 + 4\eta 114$

$\phi 3 = (\eta 30 - 3\eta 12)2 + (3\eta 21 + \eta 03)2$

$\phi 4 = (\eta 30 + \eta 12)2 + (\eta 21 + \eta 03)2$

$\phi 5 = (\eta 30 - 3\eta 12)(\eta 30 + \eta 12)[(\eta 30 + \eta 12)2 - (3\eta 21 + \eta 03)2] + (3\eta 21 - \eta 03)(\eta 21 + \eta 03)[(3\eta 30 + \eta 12)2 - (\eta 21 + \eta 03)2]$

$\phi 6 = (\eta 20 - 3\eta 02)[(\eta 30 + \eta 12)2 - (\eta 21 + \eta 03)2] + 4\eta 11(\eta 30 - \eta 12)(\eta 21 + \eta 03)$

$\phi 7 = (3\eta 21 - \eta 03)(\eta 30 + \eta 12)[(\eta 30 + \eta 12)2 - 3(\eta 21 + \eta 03)2] + (\eta 30 + \eta 12)(\eta 21 + \eta 03)[3(\eta 30 + \eta 12)2 - (\eta 21 + \eta 03)2]$

(6)

The use of FCH to the color space CIELAB color closer because of this method by the vision of the human eye [8]. FCH is used to consider the similarities of colors of each pixel that allocated to all bin histogram through fuzzy sets membership function [7]. FCH produce 15-bit color. The relationship between colors modeled by the membership function of the fuzzy set. In FCH, the image can be interpreted as $F(I) = [f_1, f_2, ..., f_n]$ [9] Where :

$$fi = \sum_{j=1}^{N} \mu ij \, Pj = \frac{1}{N} \sum_{j=1}^{N} \mu ij \qquad (7)$$

Where :

Pj = A probability value of each pixel contained in the image

N = The number of pixels of the image

μij = The membership value of the pixel j in the ith pixel in the color bin

After going through the pre-process, it followed by calculating the value of Fuzzy Color Histogram. Stages of this method shown in Fig 3. [8] :

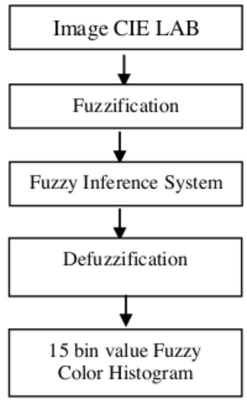

Fig 3. Calculating Fuzzy Color Block Diagram Histogram

1. Fuzzification process
   Change the truth value that is definite (crisp value) in the form of Fuzzy.
2. Reasoning in fuzzy values and fuzzy rules are predetermined and generate fuzzy output. The fuzzy rules that usually written as IF-THEN consequent antecedent.
3. Defuzzification process
   Changing the fuzzy output value that has been found to be a value that is definite (crisp value) by the membership function predetermined.

D. Clustering using K-Means

K-Means Clustering is a clustering algorithm based on a partition with the data is only entered into one group K, the algorithm determines the number of groups at the beginning and defines a set of K centroid [10]. The purpose of clustering is to group its image samples that are similar to other images that can be separated visually in the dataset [13] [14].

The value in the clustering or grouping process comes from each average value of feature extraction has been obtained. K-Means Clustering algorithm influenced by the determination of the number cluster central, initial cluster selection center, and how to collect the sequence of data samples [15]. The stages of K-Means algorithm needs to be done to make the image grouping are [10] [15] :

1. Determining the number of groups
2. Ascertain the value of the central group (centroid)
3. Calculate the distance of each image in the database to any point in the center of the group using the formula *Euclidean Distance*.

$$d(x, y) = \sqrt{\sum_{i=1}^{n} (xi - yi)^2} \qquad (8)$$

4. Classifying the image based on the minimum distance
5. Calculate the center of the new group
6. Repeat from step 3 to position until the image did not move groups

E. Classification using k-Nearest Neighbor

The purpose of the classifier is set a predetermined class on an object using a given feature. This algorithm is also suitable for CBIR system because this research has the element of test image and image of training which must be counting the proximity distance [5]. With the k-NN method, the objects sorted by a majority vote of its neighbors (voting). Object x is still unknown will be drawn to several classes of its closest neighbors as shown in the graph representation of the k-NN [16].

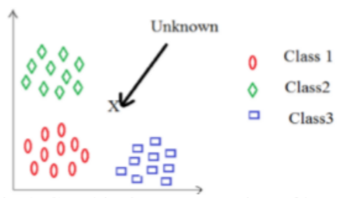

Fig 4. Graphical Representation of k-NN

In determining a proximity distance between two tested and supervised images, we use the formula Euclidean Distance *Distance* [16]. The use of k-NN algorithm will determine the shortest distance of query image k to test data. Then set the query image to the class by class color or shape. Process flow diagrams k-NN algorithm can be seen in Fig. 5

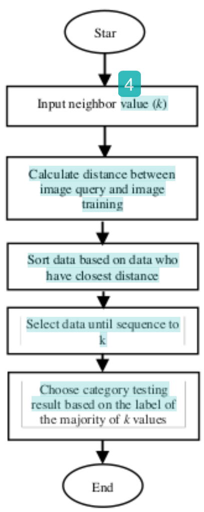

Fig 5. *Flowchart* Algoritma k-Nearest Neighbor

III. Methodology

Content-Based Image Retrieval (CBIR) is a technique that uses image features (visual contents) in search of the database. CBIR works by comparing the query image with the image that is in the database (Query by Example).

How the CBIR work is starting by performing feature extraction on the image in the database so that it gets the feature space that stored in the database of image features. When the query image was given by, the feature will be compared with the features in the database one by one. The image has the same image that has the smallest distance to be retrieved [17].

Furthermore, the process of retrieval and sorting images based on the value generated in the process of comparison of similarity levels. Here is a process diagram of the CBIR system [18] [19].

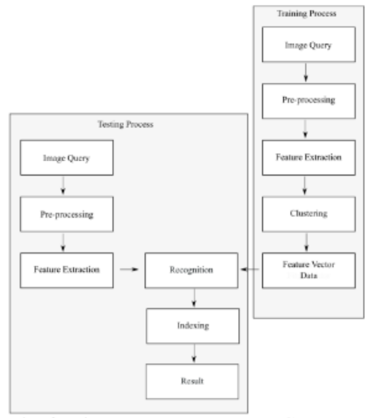

Fig 6. Diagram proses system CBIR

The steps of the training process in this research are as follows:

1. Collect fruits image.
2. The feature extraction process using FCH & MI method to get the characteristic of fruits image then transformed into vector feature form which will be stored in the database.
3. Then do the clustering process using the K-Means Clustering method on the vector of the fruits image in the database. Clustering results that have been obtained later used as a comparator value of calculating the distance for fruit recognition.

The steps of the testing process in this research are as follows:

1. Open file image query to detect fruits. The process of fruits detection and recognition is done.
2. The feature extraction process is done using FCH & MI method to get the feature of the face image then transformed into the vector feature form same as training process.
3. Then, do the process of recognition using the k-NN method by calculating the distance between the new fruits image features and features of the existing on the database by using Euclidian distance which then matched with the clustering results.

IV. Experimental Result

The purpose of the system is to implement and test the fruit recognition software. It consists of 100 fruits images as training data. Total data examined as many as 75 tested data. With a 55 single-object and 20 multi-object of images. Multi-object images which are 5 images with 2 objects, 3 objects, 4 objects, and 5 objects with random pieces like the example in the following figure.

Fig 7. Query Image with Random Fruits

Calculation accuracy percentage used to determine the level of precision in conducting recognition system. The standard formula for the accuracy rate will be used in testing for test images [20] [2].

$$Accuracy = \frac{No.of\ relevant\ objects\ retrieved}{Total\ numbers\ of\ object\ retrieved\ on\ query\ image}\ x\ 100\%$$

Tests carried out on the single-object image and achieve the results the following calculation accuracy.

TABLE 1.
ACCURACY ANALYSIS SINGLE-OBJECT IMAGE

No.	Fruits	No. of Testing Image	Image Relevant	Accuracy (%)
1.	Apple	6	5	83
2.	Banana	6	5	83
3.	Green Paprika	6	6	100
4.	Lemon	6	4	66.6
5.	Lime	7	7	100
6.	Orange	6	6	100
7.	Pear	5	5	100
8.	Pumpkin	6	6	100
9.	Strawberry	7	7	100
		Average		92.5%

TABLE 2.
RESULT ANALYSIS AND COMPARISON WITH SOME SELECTED SIMILAR EXISTING WORK

Research By	Method	Accuracy (%)
Arivazhagan (2010) [21]	Minimum Distance	87
Zhang (2012) [22]	kSVM	88.2
Dubey (2015) [23]	MSVM	94
Shukla (2016) [11]	KNN	91.3
Proposed Work	K-Means + k-NN	92.5

The proposed research is the testing done using the multi-object image. With the ongoing process of training images in the database, the system was also tested and get the recognition accuracy of the fruit with a value of k = 1,3,5,7. The following test results presented in tabular form.

TABLE 3.
ACCURACY ANALYSIS MULTI-OBJECT IMAGE

Image Query	Accuracy (%)			
	K = 1	K = 3	K = 5	K = 7
2 Object, Image 1	50	50	50	100
2 Object, Image 2	100	100	100	100
2 Object, Image 3	100	100	100	100
2 Object, Image 4	50	50	50	50
2 Object, Image 5	100	100	100	100
Avarage	**80**	**80**	**80**	**90**
3 Object, Image 1	100	100	100	100
3 Object, Image 2	33,3	33,3	33,3	33,3
3 Object, Image 3	66,6	100	100	66,6
3 Object, Image 4	100	33,3	66,6	100
3 Object, Image 5	66,6	33,3	66,6	100
Avarage	**73,3**	**60**	**73,3**	**80**
4 Object, Image 1	75	100	100	100
4 Object, Image 2	75	75	75	75
4 Object, Image 3	75	100	100	75
4 Object, Image 4	25	25	25	25
4 Object, Image 5	50	25	25	100
Avarage	**60**	**65**	**65**	**75**
5 Object, Image 1	80	80	80	80
5 Object, Image 2	80	100	100	80
5 Object, Image 3	40	40	40	40
5 Object, Image 4	40	60	60	40
5 Object, Image 5	60	60	60	60
Avarage	**60**	**68**	**68**	**60**

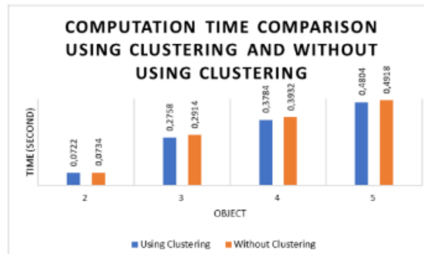

Fig 7. Computation Time Comparison

V. CONCLUSION

The CBIR method achieved recognition to achieve the highest accuracy value of 92.5% for single-object imagery and 90% on average by using multi-object imagery. The highest accuracy results obtained an image of the object of 2 objects with K = 7. So, it can be concluded that:

1. Determining the value of K affects the outcome of a multi-object image recognition significantly.
2. The less the object, the higher recognition accuracy value. The more objects, the lower recognition accuracy value.
3. The image that has a color saturation, split pixel, forms inadequate, and lack of income would be difficult to detect light and recognized.
4. The resulting color feature value has strongly influenced the rules on the color feature extraction method FCH.
5. Clustering can speed up the process of recognition
6. Computing time is dynamic

Suggestions for further development:

1. The further research can develop to recognize more fruits images, such as apples and other types of apples.
2. The software can be developed by adding a feature extraction which is based on texture.
3. Research can be developed by multiplying objects on multi-object imagery with changing positions.
4. Research can be developed by adding a more variable color bin to the FCH method.

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