Implementation of Learning Vector Quantization (LVQ) Algorithm for Durian Fruit Classification Using Gray Level Co-occurrence Matrix (GLCM) Parameters

Sutarno¹, Sara Putri Fauliah²

¹, ² Department of Computer Engineering, Faculty of Computer Science, Sriwijaya University, Indralaya, Palembang, Indonesia
sutarno@ilkom.unsri.ac.id

Abstract. Diversity on durian varieties makes it difficult to distinguish between durian varieties. In addition, some durian varieties also have similarities which further complicate the classification process, and are known as typical tropical fruits, these fruits are native to Southeast Asia and have been introduced throughout the world. The ability to recognize objects is needed by humans. Recognition can facilitate human daily activities. Pattern recognition is often applied to a variety of objects, one of which is pattern recognition on fruit. There is some limitations of human memory in remembering object features. Based on this problem, research was conducted to identify fruit plants based on its features using digital image processing techniques, Learning Vector Quantization (LVQ) algorithm and Gray Level Co-occurrence Matrix (GLCM). Each type of plant has different shapes, colors, and textures; this is what makes the durian unique to other durians. The program was created using Microsoft Visual C # 2010 software. The test results achieved an 89% success rate in recognizing fruit plants based on the fruit.

Keywords: durian fruit, shape; texture; color, GLCM, LVQ.

1. Introduction
Durian (Durio zibethinus Murr.) Is a species of the genus Durio and is cultivated in Southeast Asia. Known as a typical tropical fruit, this fruit is native to Southeast Asia and has been introduced throughout the world [1]. Around the world, there are 30 varieties of durian. Among the 30 varieties, 14 varieties are found in Kalimantan [2]. Durian diversity causes some people to have a difficulty to distinguish between durian varieties. In addition, some durian varieties also have similarities which further complicate the classification process. Classification is done using the image-based LVQ method. The advantage of using this method is that the error value is smaller compared to artificial neural networks such as backpropagation, while the disadvantages is the accuracy of the model is depended on the initialization of the model and the parameters used (learning rate, iteration, etc.) [3]. An image can be identified visually based on its features. Selection of the right features will be able to provide detailed information about the class of an image and can distinguish it from the other classes. Some of the example of the features that can be extracted from an image are color, shape, and texture [4]. The main drawback of this method is spatial distribution and local variations of color in the image are ignored.

Texture analysis is done in an effort to extract features or characteristics of an image so that the image recognition or distinction can be carried out on from a class in comparison to the other classes. From a statistical point of view, image texture is a complicated pattern, so statistics can be used to extract its characteristics. GLCM and geometric integration is the best method to classify tuna in addition to just one method. This is also influenced by the results of good segmentation. So that the classification results
have a high degree of accuracy [5]. GLCM proved to be very powerful as a feature descriptor in representing the texture characteristics of an image. However, the GLCM which works on the grayscale domain has the disadvantage that the color component of the image is ignored so that some researchers try to combine the characteristics of the GLCM texture and color characteristics to describe the colored texture of the image. The features generated by feature extraction methods will be used as input for the classification process. The classification method used in this study is LVQ.

2. Related Work
In previous studies the object studied was citrus fruit. In the segmentation process, Payne's A. B., et al in 2013 used several manual segmentation methods in their research [6], additional common problems in fruit detection were partial occlusion and fruit grouping. Using a perimeter-based detection method to detect fruit in groups. This approach increases the results for images obtained under variable lighting conditions and where occlusion exists and is added by using a simple circle detection algorithm to make distinction. These approaches are very relevant to the mango identification application in the mango tree canopy image [7]. After pre-processing, the image will be cropped manually to separate the object area from the background. The next step is to extract the feature to get the value of shape features, color features, and texture features. The results of the feature extraction process will then be used as an input to be trained with a network learning vector quantification approach that is carried out in order to identify input patterns and pairs of output patterns.

3. Materials
3.1 Framework
In the execution of this research, it will go through several phases, both software design, and hardware design, therefore a framework will be created so that this research becomes structured and follows the predetermined path.

3.2 Hardware design
Hardware plays an important role in this research because the system that is built requires hardware in its operation. The hardware used in building this system are a webcam, white cardboard, acrylic, USB cable, PC, and monitor.

3.3 Software design
The design of this software consists of sampling images, pre-processing images, segmentation images, feature extraction and finally the application of LVQ algorithms for training and classification.

3.4 Sampling process
The test datas used in this study are the image captured from the webcam. Durian fruit is placed on white carton paper at a distance of 50 cm in an upright position from the object. The format of the captured image camera is *.bmp with RGB color formats and an image resolution of 640 x 427 pixels.

3.5 Image segmentation
The phase of the method that must be done in the image segmentation is Grayscaling, Gaussian smoothing and Image thresholding. Fig. 1 show block diagram of the image segmentation process.

3.6 Feature extraction
This process is carried out by taking the values from the characteristics that appear on the durian fruit. The shape feature is called the morphological characteristics of the durian fruit. The shape features to be extracted are slimmness, roundness, rectangularity, narrow factor, circumference ratio, and diameter and perimeter ratio with length and width. Fig. 2 show physical morphology of durian fruit with length and width perimeter.
Fig. 1. Image segmentation process in system block diagram

Fig 2. Physical morphology of durian fruit

The color features taken are the mean, skewness, and kurtosis. While the texture feature uses the GLCM method. Overall there are 17 features that are taken for weighing in the LVQ training.

3.7 LVQ algorithm training
Data training used 50 sample data taken randomly with 5 durians for each fruit plant. Fig. 3 show sample data that will be used in data training and testing.

Fig. 3. Sample data after grouping and naming

4. Method
4.1 Grayscale image
The Grayscale image is a digital image that only has one channel value in each pixel, in other words, the value of the section red = green = blue. This value is used to indicate the level of intensity. Grayscale images can be obtained from RGB imagery. Grayscale image intensity value (gray) is calculated from the value of RGB image intensity [8].
\[ I_{BW}(x, y) = \frac{I_R(x, y) + I_G(x, y) + I_B(x, y)}{3} \]  

where \( I_R(x, y) \) = red point pixel value \((x, y)\), \( I_G(x, y) \) = green pixel value point \((x, y)\), \( I_B(x, y) \) = blue point pixel value \((x, y)\) while \( I_{BW}(x, y) \) = pixel value black and white \((x, y)\).

4.2 Gaussian filter
The Gaussian technique is used to smooth out greyscale images to reduce noise from the image, can be minimized or even lost.

\[ G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}} \]  

where \( G(x, y) \) is a Gaussian element in position \((x, y)\), \( \pi = \frac{22}{7} \), \( e = 2.71828182846 \), \( \sigma \) is the standard deviation (sigma). In this study, the Gaussian filter matrix uses a 5x5 kernel with \( \sigma = 1 \).

4.3 Thresholding
Thresholding is the process of converting a gray image into a binary image so that it can separate the background from the actual object or the information used from an image. The thresholding result image is used as a reference to find the feature values contained in the image. Thresholding produces a black and white image that has a pixel scale of 0-255; the value 0 represents black while 255 is white.

4.4 Feature extraction
Feature extraction is a process to retrieve or view characteristic values contained in an image. The value that appears or is extracted will be used for the training process. The feature extraction process is a very important process for training the identified input objects. This time the extraction research was carried out, namely the extraction of features in shape, color, and texture.

4.4.1 Shape feature extraction. Shapes are physical characteristics that can be seen using human senses or commonly called plant morphological features. Feature extraction is not only long and wide but many other aspects of durian morphology are used in distinguishing features of one another. Shape feature extraction used consists of six types of features, including: slimness, roundness, rectangularity, narrow factor, roving ratio and parameters, perimeter ratio with length and width. [9].

4.4.2 Color feature extraction. In the color feature extraction, there are three parameters that can be used in this final project research. This feature consists of the mean, skewness, and kurtosis.

4.4.3 Extraction of texture features. The texture feature used is the GLCM statistical method. There are several formulations of GLCM calculation to find features that appear on an object among others, namely: variance, contrast, correlation, energy, homogeneity, maximum probability and entropy [10].

4.5 Learning Vector Quantization Algorithm.
LVQ algorithm is supervised learning. This type of learning uses data that already provided. This output layer will generate an output pattern that will be matched with the target output pattern. If there is a difference between the output produced and the desired target, the error value will appear, then further training is needed. After learning, the LVQ layer divides the input vector by placing the LVQ layer into the same class as the output unit which has the closest weight vector to the input vector.

The LVQ algorithm recognizes patterns based on the proximity of the two vectors. If the two input vectors are close, the vector will be grouped into the same class [11]. As for, the steps of the LVQ algorithm are:

Step 1: Initialize, Determine the initial weight, maximum epoch (number of training processes to be repeated), eps (expected minimum error) and the learning rate (alpha) value.
Step 2: If repetition conditions are fulfilled, do steps 2-8.
Step 3: Set initial conditions epoch = 0.
Step 4: If the condition (epoch < Max Epoch) or (error < eps), then: epoch = epoch + 1
Step 5: Calculate the minimum distance \(||xi - wij||\) (referred to as \(C_i\)) using Euclidean distances equation.

\[ \text{distance} = \sqrt{(x_{11} - w_{11})^2 + \cdots + (x_{1m} - w_{1m})^2} \]  

(3)
Step 6: Update weight $w_j$ with the conditions:

If $T = C_j$, then: $w_j(\text{new}) = w_j(\text{old}) + \alpha (x - w_j(\text{old}))$

If $T \neq C_j$, then: $w_j(\text{new}) = w_j(\text{old}) - \alpha (x - w_j(\text{old}))$

Step 7: Reduce learning rate ($\alpha$) = $\alpha - (0.1 \times \alpha)$

Step 8: Stop condition test: the condition where the learning rate ($\alpha$) and the error reach the specified target value.

5. Result and Discuss

5.1 Segmentation phase testing

Image segmentation applies is done to separate objects from the background, Fig. 4 show the process of image segmentation.

![Fig. 4. Phase of image segmentation process (a) RGB, (b) Grayscale, (c) Gaussian filtering, (d) Thresholding](image)

5.2 Testing feature extraction phase

Feature extraction phase in 50 samples of test data must go through a good image segmentation phase. The extracted value of the feature is obtained from extraction into an excel file with *.xls format.

5.3 LVQ training phase

LVQ is an algorithm that focuses on training on new information that can always be updated. Initial and target weight of one sample data for each type of plant, whereas the four data samples and heavy data that will be generated. Table 1 shows data vector input ($x$) for safe training 17 pieces, while the target ($y$) is 10 targets. The training process this time uses error tolerance value = 0.00001, learning rate = 0.5 and iteration = 10000.

| No  | Nama File    | Slimness | Roundness | Rectangularity | Narrow Factor | Ratio | Ratio Perimeter |
|-----|--------------|----------|-----------|----------------|---------------|-------|-----------------|
| 1   | Durian Baturaja | 1,57944  | 3,04786   | 1,598          | 0.78505       | 2,57143 | 0.78261        |
| 2   | Durian Bengkulu | 1,69388  | 3,41931   | 1,49467        | 0.84694       | 2,40964 | 0.75758        |
| 3   | Durian Jambi   | 1,69159  | 3,27764   | 1,53414        | 0.84112       | 2,44444 | 0.76389        |
| 4   | Durian Lahat   | 1,77885  | 3,25821   | 1,62035        | 0.88462       | 2,32609 | 0.74048        |
| 5   | Durian Lampung | 1,34959  | 2,62551   | 1,53889        | 0.6748        | 3,03614 | 0.87197        |
| 6   | Durian OKU     | 1,61062  | 3,41572   | 1,45548        | 0.80531       | 2,50549 | 0.77288        |
| 7   | Durian Padang  | 1,70588  | 3,36161   | 1,56342        | 0.85294       | 2,36782 | 0.74638        |
| 8   | Durian Riau    | 0,81595  | 1,93836   | 1,27509        | 0.40491       | 5,0303  | 1,12162        |
| 9   | Durian Sibolga | 2,07843  | 3,5584    | 1,76508        | 1,03922       | 1,96226 | 0,66242        |
| 10  | Durian Ujanmas | 1,52679  | 3,03064   | 1,52764        | 0,75893       | 2,68235 | 0,80565        |

5.4 Simulation and testing phase

Real-time system testing is influenced by the intensity of light on the object received by the webcam. The least amount of light affects the quality of the data tested because light creates shadows on the edges of objects, as well as the irradiation angle and poor image taking. Based on the results of the tests that have been carried out, the success rate reaches 89% for 250 test data conducted in real-time. This level
of accuracy is influenced by lighting and procedures for placing durian fruit, the angle of irradiation and retrieval of test data.

6. Conclusion
Learning vector quantization algorithms can be applied for classification and grouping of durian fruits extracted. Features shape, color, and texture (GLCM) method can be used to identify plants. The ideal LVQ learning rate for the training process, is 0.05-0.6, with a minimum error of 0.001-0.00001 and 5000-15000 iteration is the best value for the training process. The best conditions for testing are in good light conditions without creating any shadow with the level of success accuracy of the system to recognize durian fruit is 89%.

Acknowledgments
This experiment supported by Laboratory of Automation and Industry, Department of Computer Engineering, Sriwijaya University, and acknowledging the help or encouragement of peers.

References
[1] J. Feng, X. Yi, W. Huang, Y. Wang, and X. He, “Novel Triterpenoids and Glycosides from Durian Exert Pronounced Anti-Inflammatory Activities,” Food Chem., Vol. 241, No. June 2017, pp. 215–221, 2018.
[2] J. Siriphanich, Durian (Durio zibethinus Merr.). Woodhead Publishing Limited, 2011.
[3] P. Melin, J. Amezcue, F. Valdez, and O. Castillo, “A New Neural Network Model Based on The LVQ Algorithm For Multi-Class Classification of Arrhythmias,” Inf. Sci. (Ny.), Vol. 279, No. April, pp. 483–497, 2014.
[4] X. Liu, H. Du, G. Wang, S. Zhou, and H. Zhang, “Automatic Diagnosis of Premature Ventricular Contraction Based on Lyapunov Exponents and LVQ Neural Network,” Comput. Methods Programs Biomed., Vol. 122, No. 1, pp. 47–55, 2015.
[5] W. A. Saputra and D. Herumurti, “Integration GLCM and Geometric Feature Extraction of Region of Interest for Classifying Tuna,” Proc. 2016 Int. Conf. Inf. Commun. Technol. Syst. ICTS 2016, pp. 75–79, 2017.
[6] A. B. Payne, K. B. Walsh, P. P. Subedi, and D. Jarvis, “Estimation of Mango Crop Yield Using Image Analysis-Segmentation Method,” Comput. Electron. Agric., Vol. 91, pp. 57–64, 2013.
[7] E. H. Yossy, J. Pranata, T. Wijaya, and H. Hermawan, ScienceDirect 2nd International Conference, “Mango Fruit Sorting System using Neural Network and Computer Mango Fruit Sorting System using Neural Network and Computer Vision,” Procedia Comput. Sci., Vol. 116, pp. 596–603, 2017.
[8] U. A. Nnolim, “An Adaptive RGB Color Enhancement Formulation for Logarithmic Image Processing-Based Algorithms,” Optik (Stuttg.), Vol. 154, pp. 192–215, 2018.
[9] H. Kebapci, B. Yanikoglu, and G. Unal, “Plant Image Retrieval Using Color, Shape and Texture Features,” Vol. 54, No. 9, 2011.
[10] R. K. Dewi and K. Kunci, “Klasifikasi Tanaman berdasarkan Fitur Bentuk dan Tekstur pada Daun menggunakan Decision Tree,” Vol. 3, No. 2, pp. 9–15, 2015.
[11] S. Kusumadewi, Artificial Intelligence (Teknik dan Aplikasinya). Yogyakarta: Penerbit Graha Ilmu, 2003.