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Classification of Rice Quality Using Backpropagation Based on Shape and Color

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Abstract

The distribution of mixed rice on the market makes it difficult for consumers to determine the rice quality. In determining rice quality, the consumers consider and compare the texture, size and shape, color, aroma, purity, and homogeneity manually. This process is prone to errors and mistakes, due to the limited ability of each human's vision. Therefore, a method to determine the quality of rice automatically based on the physical characteristics of rice is needed. In this paper, we proposed an automatic rice quality classification method using backpropagation based on the shape and color of the rice. There are four parameters used to determine the classification process, namely compactness, circularity, mean, and skewness. Compactness and circularity were used to determine the ratio between the whole rice and broken rice. While mean and skewness were used to determine the color distribution of the rice. Experiments have been performed on 100 images consisting of 50 premium and 50 medium rice images. The experimental results show that the proposed method can classify rice based on its shape and color effectively with an accuracy rate of 95%.

Keywords: *rice quality, classification, backpropagation, shape feature, color feature*

Abstrak

[Klasifikasi Kualitas Beras Menggunakan Backpropagation Berdasarkan Bentuk dan Warna]
Distribusi beras oplosan di pasaran menyulitkan konsumen dalam menentukan kualitas beras. Konsumen mempertimbangkan dan membandingkan tekstur, ukuran dan bentuk, warna, aroma, kemurnian, dan keseragaman secara manual untuk menentukan kualitas beras. Proses ini rawan terjadi kesalahan dan kekeliruan, karena keterbatasan kemampuan penglihatan setiap manusia. Oleh karena itu diperlukan suatu metode untuk menentukan kualitas beras secara otomatis berdasarkan karakteristik fisik beras. Dalam penelitian ini, kami mengusulkan metode klasifikasi kualitas beras otomatis menggunakan backpropagation berdasarkan bentuk dan warna beras. Ada empat parameter yang digunakan untuk menentukan proses klasifikasi yaitu compactness, circularity, mean, dan skewness. Compactness dan circularity digunakan untuk menentukan perbandingan antara nasi utuh dan nasi pecah. Sedangkan mean dan skewness digunakan untuk menentukan distribusi warna beras. Percobaan telah dilakukan pada 100 citra yang terdiri dari 50 citra beras premium dan 50 citra beras medium. Hasil percobaan menunjukkan bahwa metode yang diusulkan dapat mengklasifikasikan beras berdasarkan bentuk dan warnanya secara efektif dengan tingkat akurasi 95%.

Keywords: *kualitas beras, klasifikasi, backpropagation, fitur bentuk, fitur warna*

1. PENDAHULUAN

Rice is the main food source and one of the most important agricultural commodities in Indonesia. Ministry of Agriculture Republic Indonesia states that there are two rice qualities distributed in Indonesia, premium quality and medium quality. In fact, a lot of mixed rice is found on the market. Mixed rice is the result of mixing high-quality rice and lower quality rice whose food safety is even doubtful. This is done to reduce the price of rice, at the expense of the quality of the rice itself [1].

The distribution of mixed rice makes it difficult for consumers to determine the quality of rice. In determining the quality of the rice, the consumers consider and compare the texture, size and shape, color, aroma, purity, and homogeneity[2]. This process is prone to errors and mistakes, due to the limited ability of each human's vision. Thus, a method to determine the quality of rice automatically based on the physical characteristics of rice is needed.

Some researchers have conducted experiments to classify an object based on its physical characteristics. Son, et al. proposed an approach to recognize and classify two different categories of rice (whole rice and broken rice) based on the rice's size of the national standard of rice quality evaluation in

Vietnam using Deep Learning[3]. The experiment results get 93.85% accuracy. Fajri, et al. proposed a method to classify varieties of mangoes based on the shape and texture features of the mango leaves using Backpropagation Neural Network (BPNN)[4]. Classification results with backpropagation get an accuracy rate of 96%.

In this paper, we propose an approach to classify rice quality using the image processing technique and the Backpropagation method. Image processing is carried out to process images using shape and color feature extraction. The result of the image processing will be used in the classification process using Backpropagation.

2. PROPOSED METHOD

Our proposed method involved several stages. For each image, segmentation and feature extraction calculations are performed. After that, the values of the feature of all images are normalized then classified by using Backpropagation. The stages of the proposed method are shown in Figure 1.

2.1 RICE QUALITY

The rice quality is determined by the physical characteristics of the rice. The characteristics of the rice quality are written in SNI 6128: 2015[5]. Standar Nasional Indonesia (SNI) is a standard made by the National Standardization Agency of Indonesia that aims to determine the quality of rice on the market. According to these standards, the rice quality is classified into premium and three medium classes based on the contents are requirements for quality and food safety. In this study, we used several existing requirements, such as the quality components of broken grains and yellow/damaged grains. Premium quality rice has a maximum of 5% broken grains and 0% yellow/damaged grains. Good to poor quality included in medium quality which is classified into three classes. It has a maximum broken grain of 20% - 35% and 2% - 5% of yellow/damaged grains. Table 1 shows all the specific requirements of premium and medium rice. The example of premium and medium rice is shown in Figure 2.

Table 1. The Specific Requirements of Premium and Medium Rice

Quality Component	Unit	Quality			
		Premium	Medium		
			I	II	III
Milling degree (min)	(%)	100	95	90	80
Water content (max)	(%)	14	14	14	15
Whole rice (min)	(%)	95	78	73	60
Broken grain (max)	(%)	5	20	25	35
Grain groats (max)	(%)	0	2	2	5
Red grain (max)	(%)	0	2	3	3
Yellow/ damaged grain (max)	(%)	0	2	3	5
Limestone grain (max)	(%)	0	2	3	5
Unknown object (max)	(%)	0	0.02	0.05	0.2
Unhulled rice (max)	(grain /100g)	0	1	2	3

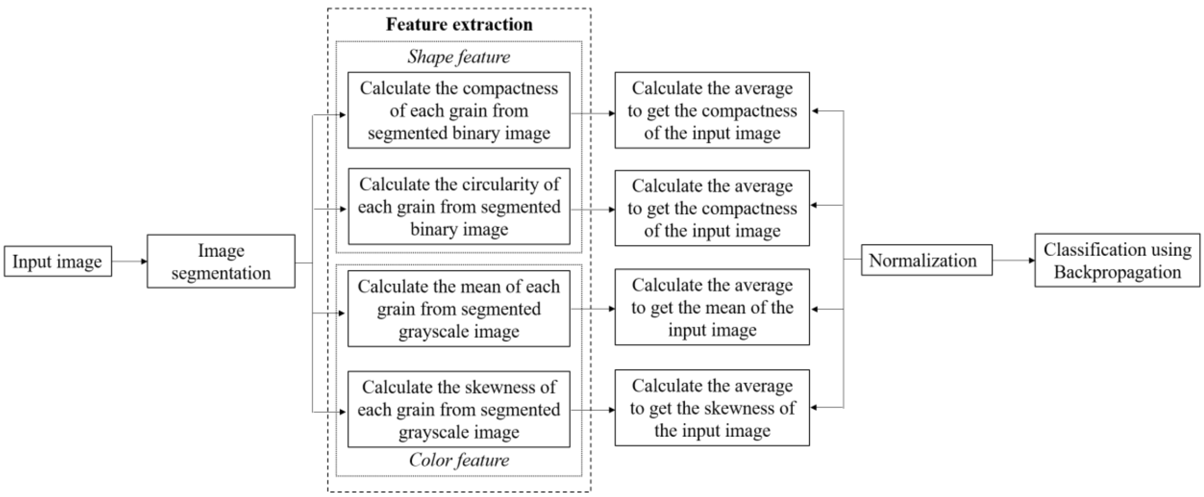
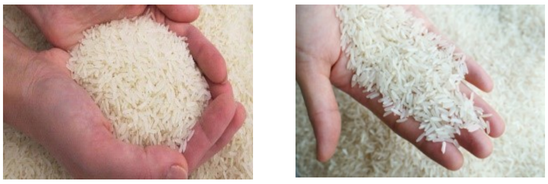
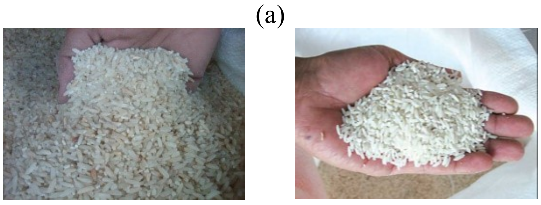


Figure 1. Proposed method



(a)



(b)

Figure. 2. The Example of (a) Premium and (b) Medium Rice.

2.2 Segmentation

To calculate the shape and color features of a rice image, the image must be segmented into an image of a rice grain. This segmentation process begins with converting the input image into a binary image. Then, we label all connected components from the binary image. In this way, we get an image of each rice grain present from the input image. This segmentation stage produces two images, namely a binary image of rice grains and a grayscale image of rice grains. These two images will be used at the feature extraction stage.

2.3 Feature Extraction

In image processing applications, feature extraction is a special step to obtain the most relevant information from the original raw data and represent the information in a lower dimensionality space[6]. Results from the feature extraction step should contain the information that is required to distinguish between classes from the dataset. It is important to focus on the feature extraction step as it has an observable impact on the efficiency of the classification system.

The implementation process of feature extraction in this study is divided into two parts, namely shape and color feature extraction. Compactness and circularity features are used as shape feature extraction, calculated from the segmented binary image. Meanwhile, mean and skewness features are used as color feature extraction, calculated from the segmented grayscale image. All features of the input image are calculated from the average value of each features of the grain image on the input image.

Compactness is the pixel density in an image object to describe the characteristics of the shape of the object [7]. Compactness is the ratio between the area of the object and its circumference which can be calculated by

$$Compactness = \frac{P^2}{A} \qquad (1)$$

Circularity is a form feature that represents the roundness of an object[7]. Circularity can be determined by

$$Circularity = \frac{4\pi A}{P^2} \qquad (2)$$

Mean is the average pixel's value *(Pij)* of an image and indicates the brightness of an image[8]. The high mean shows that the image is bright, and vice versa. Mean is given by

$$\mu = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} P_{ij} \qquad (3)$$

Skewness is a measure of the symmetry of an image[8]. An image is symmetric if it has an even distribution of the image's histogram. *Skewness* is defined by

$$\theta = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(P_{ij}-\mu)^3}{MN\sigma^3} \qquad (4)$$

2.4 Normalization

The values obtained from the calculation of compactness, circularity, mean, and skewness are normalized before the data is used in the classification process. It aims to scale the attribute values of the data so that they have the same certain range. In this study, we use standard deviation for data normalization. The standard deviation is a measure of the distribution of statistics that calculates how data values are distributed.

2.5 Classification using Backpropagation

Backpropagation is one of the supervised neural networks. Generally, in backpropagation, the error between the output pattern and the associated target will be propagated to the layer below. The weight of each unit will be updated so that it can minimize the error and get a closer result[9].

Backpropagation is a multi-layer neural network. Fig. 2 is the architecture of *backpropagation* with *n* input (the X units), *m* output (the Y units), and one layer of a hidden unit (the Z units). The v_{ij} is the weight of input units to the hidden units (v_{j0} the bias of the typical hidden units Z_j) while w_{ij} is the weight of hidden layer units to the output units (w_{k0} is the bias of the output units Y_k) [10].

There are three stages of training a network in backpropagation's algorithm. The first stage is the feedforward of the training input pattern. During the stage, each input unit receives signal and sends it to each hidden unit. Each hidden unit computes the activation function and forwards the the signal to the output unit. Each output unit calculates the activation function then it will be the response of the network. The second stage is the backpropagation of the error between the response pattern and the associated target. At this stage, calculate the error of each output unit and distribute it to the layer below, then calculate the error of each hidden unit. The third stage is the adjustment of the weights. At this stage, all of the weights will be updated based on the error and its activation function. All of the weights from the last iteration (epoch) are used in the testing process.

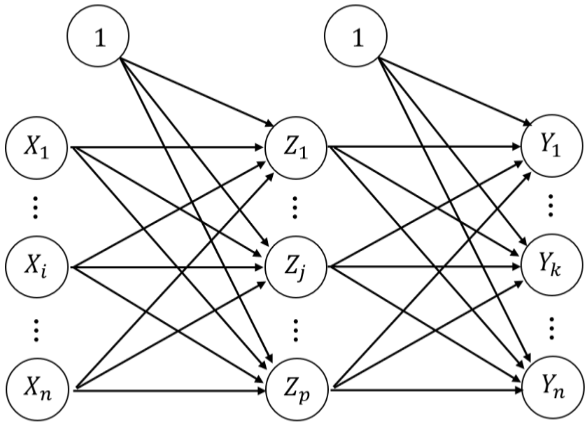


Figure 3. Architecture of Backpropagation

3. RESULTS AND DISCUSSION

In this study, we used 50 images of 300x400 pixels for each premium and medium rice. From 100 images, there are 80 images and 20 images are used for training and testing, respectively. In each image, there are about 90-120 grains. Some of the images are shown in Figure 4.

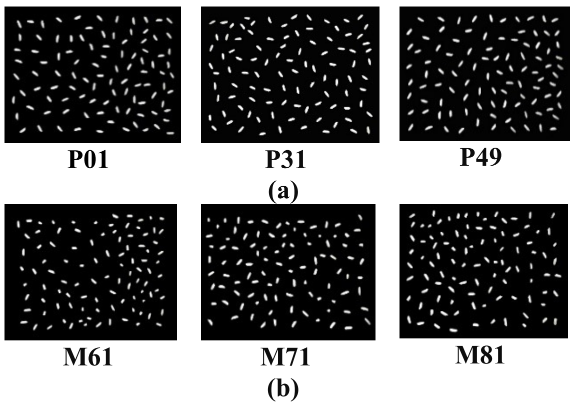


Figure 4. Some Image of (a) Premium and (b) Medium Rice.

To extract the features from the input image, we need to segment the rice and the background using Otsu's Algorithm. Then we separate the rice into each grain by labeling all connected components from the rice. The results of the segmentation stage are in the form of two types of segmented images, such as binary and grayscale images. Each segmented image contains several labeled grain objects that can be accessed individually. The result of image segmentation is shown in Figure 5.

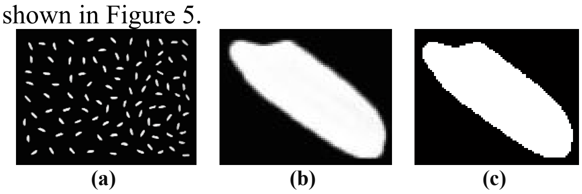


Figure 5. The Result of Image Segmentation

For each labeled grain object from the binary image, compactness and circularity calculation are performed.

While for each labeled grain object from the grayscale image, we calculate the mean and skewness. The results of the compactness, circularity, mean, and skewness calculation of each grain in an input image are then averaged to get the final value of all the features in the image. This is done because it is not practical to perform rice quality classification only using one grain of rice image. The results of the feature extraction process are shown in Table 2.

Table 2. The Results of Shape and Color Features of Some Premium and Medium Rice

Name	Shape feature		Color feature	
	Compactness	Circularity	Mean	Skewness
P01	16.1006	0.1775	0.1380	42.0267
P31	15.5873	0.1823	0.1375	42.5040
P49	16.0965	0.1630	0.1499	40.2117
M61	13.3489	0.2406	0.1024	50.3502
M71	13.9681	0.1916	0.1307	44.7163
M81	14.1116	0.1882	0.1328	44.1706

From Table 2, we know that the higher compactness value indicates that the input image contains more whole rice. Higher circularity means that the input image contains more broken grain. Meanwhile, a higher mean value indicates that more white grain is present in the image. A higher skewness value means that the white color distribution is more spread and make the histogram skew to the left side. In other words, a lower mean value and higher skewness value indicates that more yellow grain is present in the image.

In the classification process, from a total of 100 images, 80 images are used for training and 20 images for testing. Based on Fajri's experiment, the optimal hidden layer is 19 with 1000 epochs[4]. Figure 6 shows the results of the tests carried out on all test data. Backpropagation can precisely classify all 20 images used for testing.

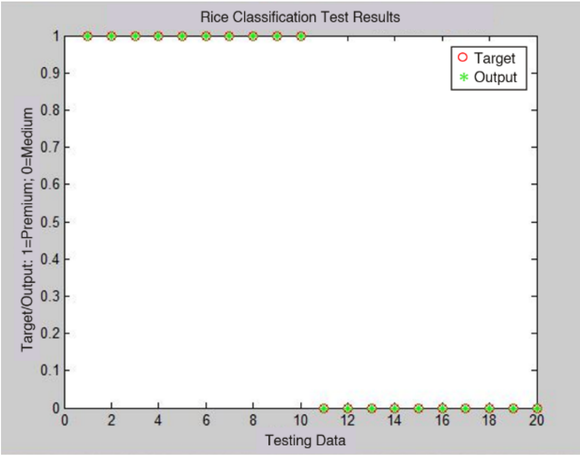


Figure 6. The Result of Rice Classification of the 20 Traning Data

We conducted experiments to test the accuracy of the classification. From the 50 experiments, there was one experiment that could not correctly classify the entire testing data. In the experiment, one of the 20 test images is not classified in the correct class. Hence, we can conclude that backpropagation can be used to classify the quality of rice based on its shape and color with an accuracy rate of 95%

4. CONCLUSION

This research proposes an automatic rice quality classification method using backpropagation based on the shape and color of the rice. Based on the standards made by the National Standardization Agency of Indonesia, we classify rice into two grades, premium and medium quality. The classification of rice can be determined by its physical characteristics. There are four parameters used to determine the classification process, namely compactness, circularity, mean, and skewness. Compactness and circularity are used to determine the ratio between the whole rice and broken rice. Meanwhile, mean and skewness are used to determine the distribution of rice color. To evaluate the proposed method, we used 100 images consisting of 50 premium and 50 medium rice images. From the 100 images, 80 were used for the training stage and 20 for the testing stage. According to the analysis, by using 19 hidden layers and 1000 epochs on backpropagation, it can be concluded that backpropagation can classify rice based on its shape and color with an accuracy rate of 95%.

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