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STAGE OF MATURITY BANANA FRUIT CLASSIFICATION USING IMAGE PROCESSING

Nadia Kasim[1], Siti Nazifah Zainol Abidin[1], Nur Nabilah Abu Mangshor[1], Hazwa Hanim Mohamed Hamzah[1] and Nurul Zahirah Abd Rahim[1]

[1]Faculty of Computer and Mathematical Sciences,
Universiti Teknologi MARA Melaka, Jasin Campus,
77300 Merlimau, Melaka, Malaysia.
Author Correspondence, e-mail: sitinazifah@melaka.uitm.edu.my

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ABSTRACT

Maturity stage of fresh banana fruit is a crucial aspect of import and export industry. The ability to identify maturity stage of banana will be a great support but only experts can determine the maturity stage accurately. Lack of knowledge and skill of maintaining fruit quality standard to match the international standard is a problem faced by the farmers. This study attempted to propose a system that uses image processing to detect the maturity stage of banana based on its color and size using Support Vector Machine (SVM) learning algorithm. Human errors and cost of hired expert in detecting maturity of fresh banana fruit can be reduced. A total of 45 images are tested and only three stages are considered in this study which are stage one, stage two and stage six out of seven stages. Stage one and stage two is the stage suitable for the international standard, while stage six is for a national standard of import export activities. The system showed 88.89% accuracy classification by comparing the result yield by the system with results offered by the experts. Hence, the proposed system can be commercially used for export and import activities as it can automatically determine the maturity stage of fresh banana and help the farmers in making the right decision on harvesting.

Keywords: Banana Fruit, Classification, Image Processing, Stage of Maturity, Support Vector Machine.

1. INTRODUCTION

The major countries that grow and produce banana primarily are India, Brazil, Philippines, Indonesia, China, Ecuador, Cameroon, Mexico, Columbia and Costa-Rica but some of these countries are not the major banana exporters in the world [1]. This shows that large growth does not imply large export market. One of the key factors that determine the quality of fruit during ripening and overall marketability is the maturity of the banana bunches [1].

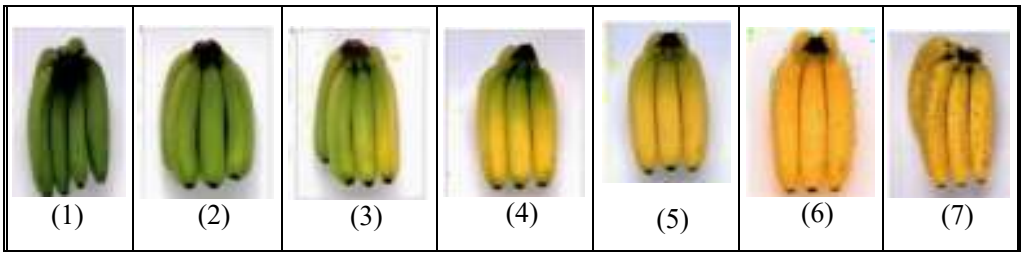


Fig. 1. Maturity stages of banana

Source: [2]

Figure 1 shows the seven maturity stages of banana following the color changes in the banana peel [2]. The first image represents the first stage, where the peel is all in green while in the second stage there is a trace of yellow among the green. In the third stage and fourth stage, the color of the banana peel is mixed with both green and yellow but there is more green than yellow in the third stage while it is the opposite in the fourth stage. In the fifth stage, the peel is almost all yellow with a trace of green. As for the sixth stage, the banana peel is completely in yellow, similar to the seventh stage but in the seventh stage there are brown speckles emerges on the peel.

Surya & Satheesh [1] claims that it will be a great help for farmers in optimizing harvesting phase if they can obtain the skill of identifying the maturity of fresh banana. In other words, this skill is beneficial in avoiding the harvest of under-matured and over-matured banana. Stage one and stage two from the seven maturity stages banana are identified as the most suitable harvesting stage for import export activities.

Farmers in Malaysia depend on manual detection by naked eyes which lack of accuracy in identifying the maturity stage in large amounts [3]. One of the main factors on why the major countries that grow and produce banana primarily are not necessarily the major banana exporters in the world has been identified as the lack of knowledge and technical skill of understanding fruit quality standard to match the international standard [1]. The factors mentioned above are the main problem in identifying maturity stage of banana. Therefore,

there is a need to acquire a new technique for automatic detection to assess banana maturity stage [1]. This paper aims to design and develop system to classify the banana maturity stage.

2. RELATED WORKS

One of the techniques that is being used in agriculture field is NIR Spectroscopy. This technique can be used to check the maturity of fruit. It emerges as an appealing analytical technique for measuring quality parameters in food as it does not damage the food products as it requires little or no sample preparation [4]. Another technique is known as Hyperspectral Image (HI). Both of NIR Spectroscopy and HI techniques require customized devices in its usage. According to [5], HI may potentially extract more accurate and detailed information compared to NIR Spectroscopy technique.

Meanwhile, according to [6], there are many agriculture and food industry that use computer vision to find information on crops such as vegetables, grains and potatoes. Computer vision is a field of study in obtaining information from video, as in to emulate the human vision. Computer vision is used in many applications such as documentation, remote sensing, radiology, and microscopy and robot guidance [7].

Image processing, on the other hand, is a technique of enhancing, analyze and interpreting images which takes image as input and return another image as output. In agriculture, as mentioned by [8], image processing can be used to improve the accuracy and consistency in agricultural process while reducing the farmers' manual surveillance, including the process of identifying the maturity stage of banana. Among all the techniques mentioned above, image processing is reckoned as the most suitable method due to its simplicity and affordability.

One of the methods in image processing is Artificial Neural Network (ANN) used to classify mature and immature of peach fruits based on color feature [9]. The test resulted in total accuracy of 94.1% and 98.5% in identifying mature and immature fruits respectively as opposed to another test classification performed based on shape features that resulted in total accuracy of 83.7% in identification of mature fruits and 71.9% in identification of immature fruits. Goel & Sehgal [10] used fuzzy classification, an approach using decision tree, on pre-harvest tomatoes using four learning algorithms and resulted in average accuracy of 86.4%. Another test was using Support Vector Machine algorithm (SVM) to classify cotton leaf spot disease with accurate result in 97.2% [11].

This paper proposed a system that could classify the stage of maturity banana fruit using image processing method and SVM as the techniques of classification. SVM can deliver a unique solution since the optimality problem is convex, compared to ANN that takes time of

the training and semantically poor. The performance of the proposed system is measured by comparing the result from the system with the result acquired from the experts.

3. METHODOLOGY

This section discusses the methodology used in this study. Figure 2 shows the process flow for the proposed algorithm to classify maturity stage of banana.

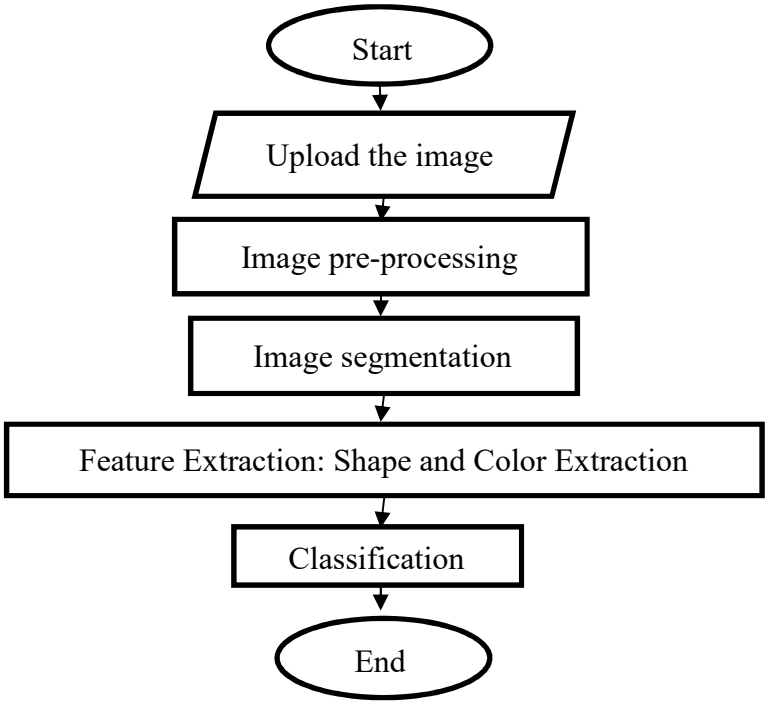


Fig. 2. Stage of Maturity Banana Fruit Classification Flowchart

According to Figure 2, the user must upload the image into the system for first step. Secondly, for image enhancement, imsharpen technique is used to make the image clearer. Then the image will be segmented using K-Means Clustering technique in the third stage to acquire the image of the banana without the background. Values that represent color and shape are then extracted to be used to classify the image using SVM technique in the last stage.

3.1 Data Collection

In this study, 45 test images were used to run this system. The images were taken in banana farm at Nyalas, Jasin. This proposed system focuses on Musa SPP, one of the scientific names of *Pisang Berangan* and the images were for the naturally ripened type without carbide.

3.2 Image Pre-Processing

A familiar example of enhancement is increment of the contrast of the image which is then filtered to remove the noise to make it looks better. Improvement in quality of these degraded images can be achieved by using application of enhancement techniques. The unsharp masking technique is applied on the images to make them sharper compared to the original images by subtracting a blurred version of the original image.

3.3 Image Segmentation

In this phase, the enhanced image from the previous phase were segmented to secure the area with banana fruit image only without the background by using K-Mean Clustering. The clustering was done 3 times to avoid local minima. Since the color was a main feature on this study, color pixels area on the images were looped to get a color image as the result. Figure 3 illustrated the three images by using K-Mean techniques.

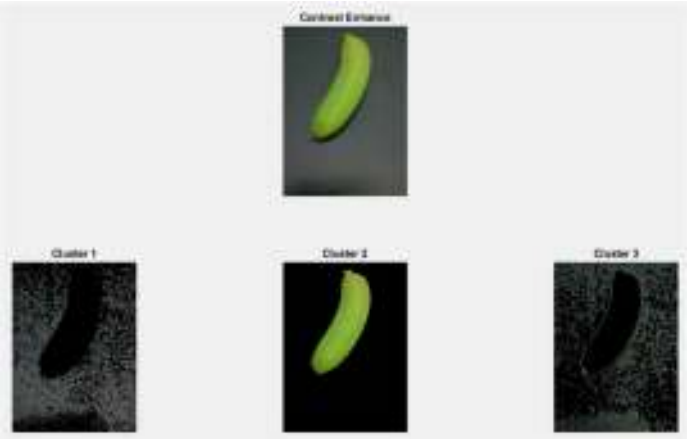


Fig. 3. Result of the K-Mean Techniques

Cluster 2 was chosen for this study because this study focuses on the color and shape detection.

3.4 Feature Extraction

Information was extracted from the segmented images in order to be classified. The features to be extracted for this study were shape and color. From the image segmented, images were converted from strings to array strings to get the value of the image. The value then was saved to spreadsheet as reference to classify the image. The method that being used was *regionprops* to extract shape value and GLCM to extract color value from the image. The shape extraction

was done by determining the area and parameter of the image. Meanwhile, color extraction was determined by pixel value of R, G, and B representing red, green, and blue. These values would deduce the mean, standard deviation, variance, homogeneity, correlation, contrast and skewness values.

	A	B	C	D	E	F	G	H	I	J
1	717049	4835.77	0.000868	0.996519	0.999566	16.32687	43.61304	1378.842	2.6175	255
2	1	0	0.008513	0.974519	0.995744	57.02035	30.83458	658.8759	-1.03367	255
3	934535	5667.979	0.001019	0.996694	0.999491	20.36676	46.33815	1401.071	2.143777	255
4	812254	6736.35	0.00138	0.995002	0.99931	17.37796	43.17184	1668.113	2.446711	255
5	590113	5317.449	0.000961	0.995455	0.999519	13.97575	42.01242	904.5322	3.042988	255

Fig. 4. Sample Value after Image Segmented

Based on Figure 4, column A and B represented an area and parameter value of the image. Column C and D represent contrast and correlation value of the image. Homogeneity and mean value were represented by column E and F respectively while column G and H represented standard deviation and variance value. The last two columns represent the skewness and image difference-measure (IDM).

3.5 Classification

In this phase, SVM technique was used to classify the banana images by using the value from the feature extraction phase. The trained value was converted into string format to obtain the result. Figure 5 illustrated the system of classification of maturity stage of banana fruit.

Fig. 5. Stage of Maturity Banana Fruit Classification System

According to Figure 5, the result of the classification appeared after the image was segmented and extracted.

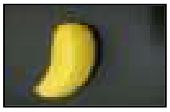
3.6 Testing

In the testing phase, results from the system were compared to results from experts. The classification accuracy was calculated using (1), where t represents the number of sample cases that were correctly classified and n is the number of total sample cases.

$$A = \frac{t}{n} \times 100 \quad (1)$$

The total of 45 images were tested and Table 1 shows the sample result of maturity stage of banana classification system.

Table 1. Sample Result from Experts Compared to Sample Result from Proposed System

Original Picture	Result from Experts	Result from System	Accurate
	Stage 1	Stage One	True
	Stage 1	Stage One	True
	Stage 6	Stage Six	True
	Stage 2	Stage Two	True

4. RESULTS AND DISCUSSIONS

This section discusses the results obtained from the experiments conducted. A complete system to classify maturity stage of banana fruit has been developed on MATLAB platform using the proposed methodology in Figure 2. The totals of 45 tested images were used to evaluate the results by comparing the results from the system and results acquired from the experts. Overall accuracy results as calculated by using (1) yield 88.98% in accuracy which shows that the system proposed is highly accurate and can be reliably used to classify the maturity of banana fruit.

5. CONCLUSIONS

This study helps farmers to determine the maturity stage of banana that satisfies the

requirement standard of export and import without relying on manual skill of observation. The classification system includes four steps which are image pre-processing, image segmentation, feature extraction and classification. The system was developed using SVM algorithm and the test showed that the results from this system is reliable.

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