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Development of Watermelon Ripeness Grading System Based on Colour Histogram

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Abstract: In general, there are three common types of melon in Malaysia namely as watermelon, rockmelon, and honeydew but the most popular is the watermelon. Although melons are easy to find in the market, one common problem that often arises is how to choose a ripe melon with sweet and juicy taste. In this paper, an image processing procedure based on colour feature extraction approach for classification of watermelon ripeness was presented. The RGB value collected from the colour image histogram was used to determine ripeness grading of watermelon based on three qualities namely; ripe, overripe and underripe. A simple watermelon ripeness grading system was developed using GUI in MATLAB to ease the ripeness classification process. The statistical analysis shows that the system was 100 % accurately classified the ripe and overripe watermelon whereas for underripe, the accuracy was 96.3 %. Therefore, this proposed technique can reliably classified the ripeness of watermelon. Future work may include the implementation of data mining process for feature extraction using neural network or machine learning.

Keywords: MATLAB, Guide User Interface, Colour Features Extraction, Watermelon Ripeness.

1. Introduction

Watermelon is characterized by its not so round shape with bright green and medium or low dark stripes. Fruit ripeness has been one of the quality that can drive the consistent marketing of the watermelon fruit to the local and international markets. Thus, it is very important to determine the ripeness quality of watermelon in order to sustain the watermelon market locally and globally. The quality assessment of watermelon has become a challenge to customers in correctly determining the ripeness of watermelon.There are several traditional methods to determine ripeness such as by the sound caused by slapping or tapping the watermelon or through the visual appearance of watermelon [1-2]. Customers perception of the watermelon quality is much dependant on the colour tone distribution on the skin of watermelon [3]. Nevertheless, these subjective approaches require individuals with experience as well as are subjected to human's perception errors.

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Therefore, various objectives approaches have been explored to evaluate the fruit ripeness either using image and signal processing [4-6], acoustic [7-8], dynamic technology such as by using X-Ray, Computed Tomography as well as near-infrared spectroscopy [9] as well as by implementing artificial intelligence method [10-11]. To understand the information that resides in the image, the extraction of the features and the recognition of the object is a major challenge in the techniques of image processing [12-13].

Based on the problem statement stated previously, an objective approach using a simple colour feature extraction technique has been utilized in this paper for determining the watermelon ripeness. Three objectives have been formulated which is first to determine the ripeness based on the skin color of the watermelon using the colour histogram. Second objective is to develop a grading system to determine the watermelon ripeness and the final objective is to assess the performance of the developed CAD system for ripeness determination through statistical analysis.

The scopes of this project are to employ the MATLAB script coding to import and read the watermelon image, segment the image to separate the desired object from the context, and use the MATLAB functions that come with the Image Processing Toolbox to extract the colour histogram data for ripeness classification. Then, the grading system will be developed based on the graphical user interface (GUI) for capturing images and conducting the image processing. Meanwhile, the watermelon samples will be collected based on the three conditions namely ripe, underripe and over ripe.

2. Materials and Methods

The proposed functional block diagram is shown in Figure 1. Briefly, there were five main steps that need to be done in MATLAB which were: a. image capture and import image, b. image segmentation and noise removal, c. colour feature extraction using color histogram, d. Ripeness classification and e. development of GUI for watermelon ripeness grading system.

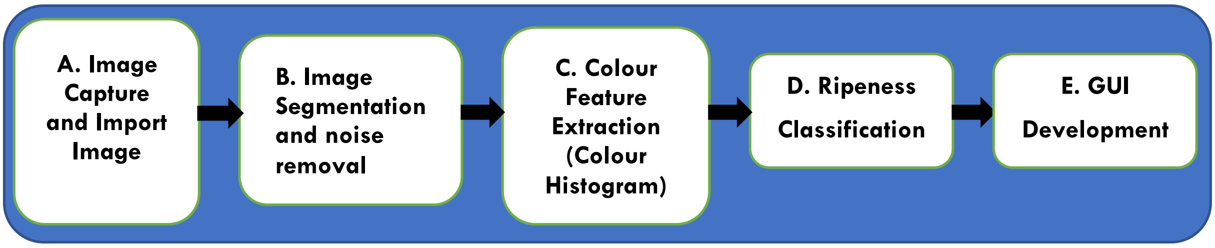

Figure 1: Proposed fuctional block diagram for development of watermelon ripeness grading system

2.1 Image capture and import image

Figure 2 shows the images of watermelon (image size of 1080 by 608 pixels) which were captured by using a smartphone camera. Then, the *imread* command read the image and transformed it into a three-dimensional matrix of RGB colour space 1080 x 608 x 3 (Rows x Columns x RGB). Figure 2(a), 2(b) and 2(c) show examples of watermelon images based on three ripeness grading namely ripe, underripe and over ripe.

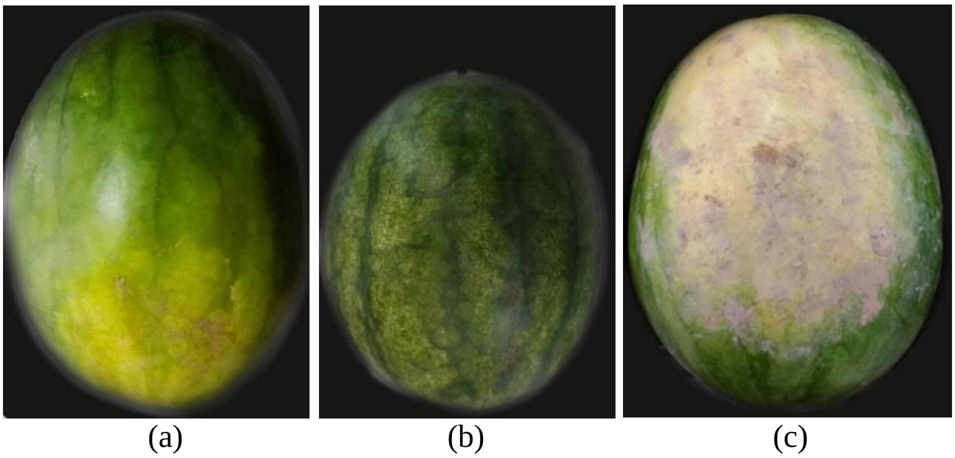

Figure: 2 Example of the original images of watermelons captured using a smartphone. (a) ripe, (b) under ripe and (c) over ripe

2.2 Image segmentation

The image segmentation is the transition between low image processing and image analysis. The input of a segmentation block is the pre-processed image while the output is a representation of the regions within this image. Using image segmentation, the image of watermelon was extracted from the background image by using a simple adaptive thresholding algorithm. The image thresholding takes an image of intensity and makes it a binary image based on the desired level.

2.3 Colour feature extraction using colour histogram

Colour Histogram has been used to extract the colour feature of an image as it is enable to show the frequency distribution of colour bins by counting similar pixels and store it [14-15]. In this project, the global colour histogram was used to extract the red, green and blue of the watermelon image.

2.4 Watermelon ripeness classification

Figure 3 illustrates the process involves for watermelon ripeness classification. 26 watermelons consist of 7 ripe, 10 under ripe and 9 over ripe were used to obtain the RGB grayscale intensity values. Then, the minimum and maximum of the RGB values were decided according to the three grading qualities (under ripe, ripe and over ripe).

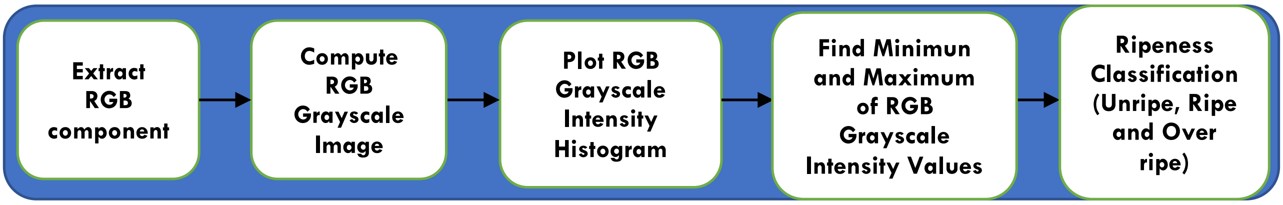

Figure 3: Process for watermelon ripeness classification using colour histogram technique

2.5 GUI development for watermelon ripeness grading system

Figure 4 shows the interface design of the watermelon ripeness grading system developed by using the GUIDE toolbox available in MATLAB R2017b. As can be seen in Figure 4, the main GUI consisted of three main segments label as A, B and C. The A label represents the menu selection that consist of import image menu (“Load Image” pushbutton), colour graph generator menu (“Red”, “Green” and “Blue” pushbuttons), and analyze watermelon ripeness menu (“Analyze” pushbutton). Meanwhile, the

B label shows the corresponding images and histogram graph. Finally, the C label indicates the outcome of the ripeness classification.

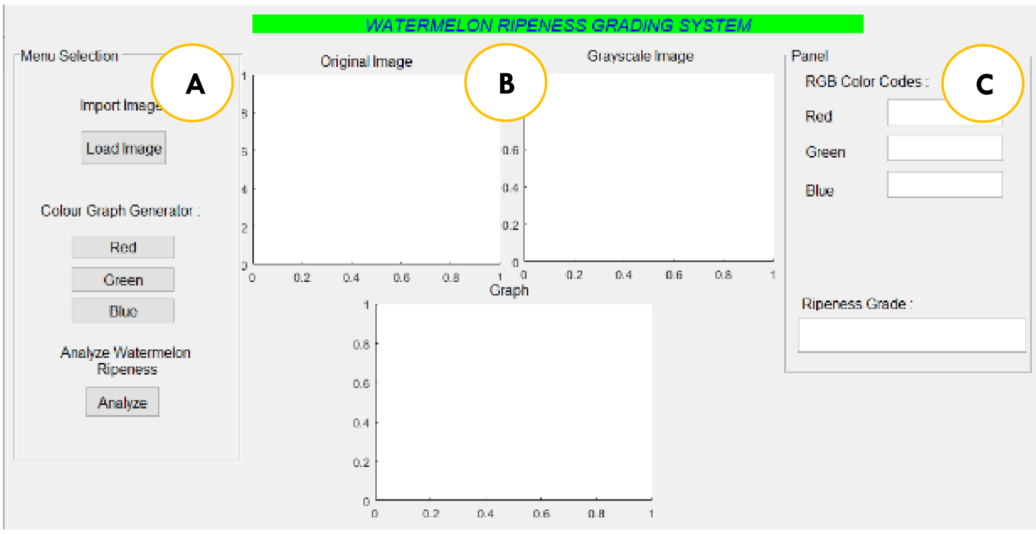

Figure 4: The GUI interface layout for watermelon ripeness grading system

2.6 Statistical analysis

The performance of the developed system is evaluated based on the accuracy of the system when it is correctly predicted the ripe, under ripe and over ripe of the watermelons after comparing them with the actual taste. Table 1 tabulates the confusion matrix following the accuracy description and formula as well as example of definitions on True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN) based on ripe cases. Based on the Table 1, accuracy of the system can be calculated by using Eq. 1. Accuracy is the ability to correctly classify the ripe, over ripe and under ripe conditions.

Table 1: Confusion matrix for statistical analysis

		Predicted	
		Negative	Positive
Actual	Negative	True Negative (TN)	False Positive (FP)
	Positive	False Negative (FN)	True Positive (TP)

$$\text{Accuracy} = [(TP+TN)/(TP+FP+FN+TN)] \times 100\ \% \qquad \text{Eq. 1}$$

where
True Positive (TP): These are cases in which the system correctly predicted ripe watermelons and they do actually ripe.
True Negative (TN): The system predicted other than ripe watermelons (under ripe or over ripe watermelons), and they are actually under ripe or over ripe watermelons.
False Positive (FP): The system predicted ripe watermelons, but they are under ripe or over ripe watermelons.
False Negative (FN): The system predicted other than ripe watermelons (under ripe or over ripe watermelons) but they do actually ripe.

3. Results and Discussion

This section discusses the results and analysis obtained from the developed ripeness grading system.

3.1 Findings from colour features extraction

As mentioned previously, the colour histogram was selected to extract colour features from 26 watermelons samples (7 ripe, 10 under ripe and 9 over ripe). Table 2 shows the resulted minimum and maximum of RGB intensity values extracted from the peak of colour histogram to be used for determining the ripe, under ripe and overripe conditions.

Table 2: The RGB minimum and maximum value colour codes

Ripeness of watermelon	Minimum Colour Codes			Maximum Colour Codes		
	Red	Green	Blue	Red	Green	Blue
Ripe	90	100	19	119	115	64
Under ripe	86	88	47	93	113	77
Over ripe	92	90	37	98	118	71

3.2 Watermelon ripeness grading system

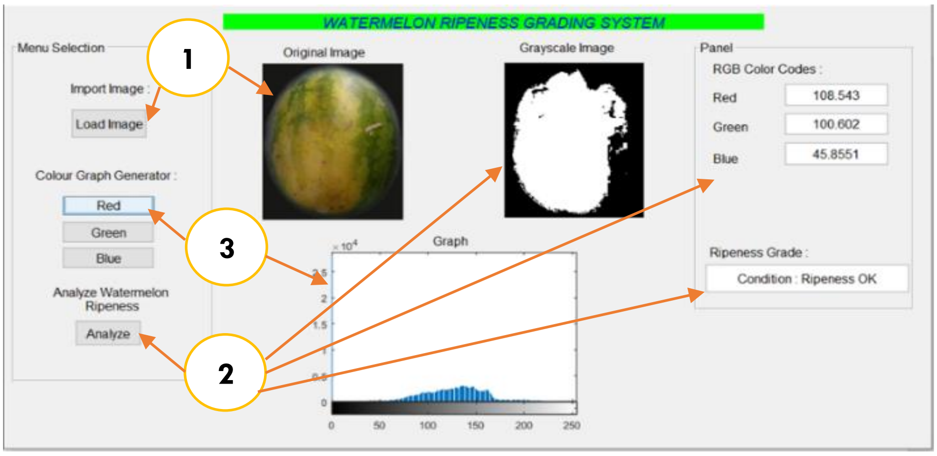

Figure 5: An example of resulted outcome using developed watermelon ripeness grading system

A watermelon ripeness grading system was built using the GUIDE in MATLAB and Figure 5 shows an example of resulted output from this developed system. The following explanation describes the function of the numbered labels as depicted in Figure 5. First of all is Label #1 which shows the "Load Image" that will open the query pictures menu. Once the watermelon image is selected, the query image will be loaded in the original image. Next is Label #2 which shows the "Analyze" pushbutton. Once clicked, it will process and output the grayscale picture, the RGB colour codes as well as the Ripeness Grade. The condition to determine the watermelon's ripeness is based on Table 1. Finally is Label #3 represents corresponding histogram graph of the selected RGB colour.

3.3 Performance evaluation

Table 3 shows the accuracy results of developed watermelon ripenesss classification. For ripe and over ripe watermelon, the accuracy of the system to correctly classified is 100 % whereas for the under ripe watermelon, the accuracy only yielded 96.3 %.

Table 3: Accuracy analysis

Category \ Performance	Statistical Analysis
	Accuracy (%)
Ripe	100
Under ripe	96.3
Over Ripe	100

4. Conclusion

In conclusion, all three objectives setup in the beginning of the research have been successfully achieved. The colour histogram was used to extract the RGB values from the 26 watermelon samples. The system successfully showed 100 % accuracy for ripe and over ripe watermelon. Future works will involve implementation of artificial intelligence such as neural network or fuzzy logic in determining the ripeness of watermelon and to improve the accuracy of under ripe watermelon since the current method can only achieve 96.3 % of accuracy.

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