Optimized Estimation of Mangosteen Maturity Stage using SVM and Color Features Combination Approach

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Optimized Estimation of Mangosteen Maturity Stage using SVM and Color Features Combination Approach

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Abstract

Estimation of maturity stage of mangosteen during harvest is critical because it affects the quality of mangosteen. Currently, the estimation is manually performed by labor using visual method. Since the visual method is not precise and consistent, the use of image processing technology promises a better result. The objective of this research is to develop an image processing method to optimize estimation of mangosteen maturity stage by combining Red-Green-Blue (RGB) color features and implementing Support Vector Machine. The methodology involves fruit collection, image acquisition and image processing step. In the image processing step, color features i.e. sum, mean and standard deviation of R, G and B component were extracted from images. These features were then combined and used as parameter input for SVM training-testing. The proposed method yielded a significant improvement on maturity stage estimation and was able to increase its accuracy up to 91% using combination of nine features.

Keywords: mangosteen, maturity stage, image processing, features extraction, SVM

INTRODUCTION

Mangosteen (*Garcinia mangostana* L.) is a tropical fruit and a major commodity for Indonesia export. In 2013, mangosteen export contributed about USD 5.73 million which was the highest contribution of fruit export followed by salak (*Salacca zalacca*) and mangos. Ministry of Trade, Indonesia, also records about 153% of quantity increment of mangosteen export or equal to USD 13.70 in January – Mei 2014 compared to the same period in the previous year. Mangosteen from Indonesia have been exported to Thailand (42%), Malaysia (25%), Hongkong (22.3%), Uni Emirate (3%) and Singapore (2.2%) (Kemendag 2015). Currently, only about 11% of the total mangosteen products are then exported whereas the export price could be 5 – 8 times compared to domestic. This low quantity of export for mangosteen occurred due to the low quality of fruit.

Estimation of maturity stage during harvest is very critical since it affects the quality of mangosteen. If the fruit is harvested too early before its ripeness, it will not be perfectly mature. However, if the mangosteen is harvested overripe, it cannot be exported due to export time constraint (Palapol et al. 2009; Paull & Ketsa 2004). Nowadays, mangosteen is selected for harvest by means of visual estimation performed by labor. This maturity stage estimation is not precise and consistent, especially for long duration and high quantity of harvest. Estimation results in the early morning could be different with results on the afternoon. Different labor also performs different estimation results.

Various image processing technologies had been proposed to overcome manual methods performed by labor for any task during harvest and postharvest. Researchers proposed quality evaluation and grading of fruit and vegetables such as apple (Bennedsen et al. 2005), star fruit (Abdullah et al. 2006), strawberry (Liming & Yanchao 2010), orange (Aleixos et al. 2002), papaya (Riyadi et al. 2007a; Riyadi et al. 2007b; Riyadi et al. 2007c) and potatoes (Barnes et al. 2010). Almost all of fruits inspected are from North America, Europe and East Asia, where only few tropical fruits are studied (Zhang et al. 2014).

Few researchers reported their results of image processing application to estimate the maturity stage of mangosteen. Since the maturity estimation is based on skin surface color of mangosten, all of researchers use color processing to differentiate among the stages. Color features which are color index of red (R), green (G) and blue (B), were conventionally correlated to four stages of mangosteen maturity and then yielded 70% accuracy of maturity stage estimation (Suhandy & Ahmad 2003). Another method proposed RGB score on three maturity stages and used this score as threshold values to estimate the maturity stage of sample mangosteen (Sandra 2011). Since these two methods implemented simple classification technique, consistency of the results highly depend on the selection of data and threshold score. Selection and combination of RGB color features are important to uniquely represent the maturity stage.

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Advanced classification technique, namely artificial neural network, was then used to increase the estimation accuracy. This technique used some color features such as mean of RGB component, hue-saturation-intensity (HSI), energy, entropy, contrast and homogeneity as parameter inputs for training-testing of neural network (Whidhiasih et al. 2012). Instead of artificial neural network for classification task, a modern method, that is support vector machine (SVM), is widely used for various applications. The SVM was implemented to identify skin defect of citrus and performed 96% accuracy for defect and non-defect fruit (Khoje et al. 2013). This method also had a good performance to evaluate 2-4 objects per second which were moving on high speed conveyor belt (Weyricha et al. 2012). In many cases, the SVM method outperformed the artificial neural network (Shao & Lunetta 2012).

Estimation of mangosteen maturity stage using image processing method is promising. Therefore, the objective of this research is to optimize the maturity estimation by combining features of RGB color component and implementing the SVM. Three RGB features namely sum, mean and standard deviation of R, G and B component were used and combined to create features sets. The best combination that produces the best estimation accuracy was also studied. According to Ministry of Agriculture, Indonesia, six stages of maturity standard is used in this research.

METHODS

This research was conducted in Laboratory of Postharvest, Department of Agrotechnology and Laboratory of Advanced Multimedia, Department of Information Technology, Universitas Muhammadiyah Yogyakarta. It involved several steps i.e. fruit collection, image acquisition and image processing.

Fruit collection

Mangosteen fruits were collected from a mangosteen farm in Purworejo, Central of Java, Indonesia. Every mangosteen was then manually classified to the respective stage according to its color. This manual classification is the ground-truth which will be compared to the classification by the proposed method. For initial research, a number of 24 mangosteens were selected for further step which are consisting four mangosteens per stage.

Image acquisition

The next step is image acquisition to obtain images of fruit using equipment setup shown in Figure 1. A lighting chamber equipped with lamps was used to control and make a uniform intensity of light. A digital camera was prepared in front of the open side of chamber. A tripod was also used to adjust position and direction of camera properly. The fruit was then put inside the chamber and the acquisition of images could be performed. To obtain the whole surface of mangosteen, the fruit was rotated 90° and captured every rotation.

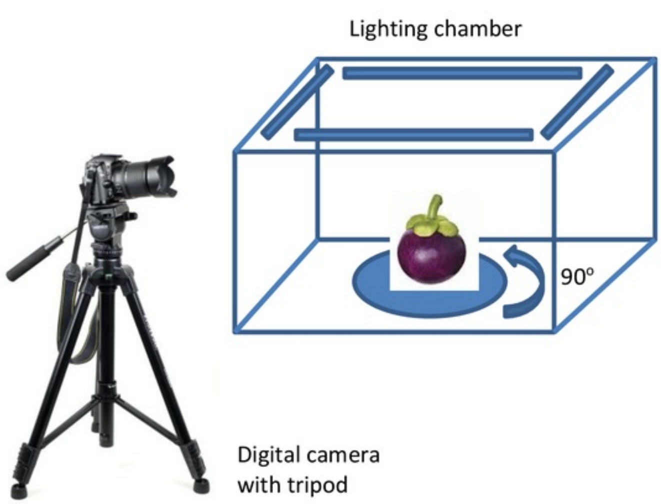

Figure 1: Equipment setup for image acquisition consists of lighting chamber and digital camera with tripod. Mangosteen was rotated 90° to obtained whole surface images.

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Image processing

Images obtained from the previous step were then processed using Matlab software. The image processing task consists of two steps, i.e. color features extraction and SVM training-testing. In the extraction of color features, three features were computed, namely sum, mean and standard deviation of R, G and B component, or in short SRGB, MRGB and SDRGB, respectively. It should be noted that every feature related to R, G and B component. Therefore, the total features produced are nine. These nine features were then combined to create features sets containing six features (SRGB & MRGB, SRGB & SDRGB and MRGB & SDRGB) and nine features (SRGB, MRGB & SDRGB). Every feature set was used as parameter input for SVM training and testing.

RESULTS AND DISSCUSION

From the fruit collection, a number of 24 mangosteens were selected and they consisted of four mangosteens per stage. In the images acquisition, every mangosteen was rotated 90° and captured using digital camera. Therefore, a total of 96 images were produced from the images acquisition steps.

Three features (sum, mean and standard deviation) were computed from R, G and B component then produced nine features. For instance, Figure 2 shows scatter plot of mean of R, G and B component that shows distribution of features for every image. It can be seen that the scatter plot of features for sum of R and G are similar. These features produce a pattern that is able to differentiate between stage 1, 2 and 3, while pattern for stage 4, 5 and 6 are overlap each other. From Figure 2(c), it can be seen that scatter plot of sum of B does not indicate good distribution to differentiate among stages. However, based on RGB color theory, a color pixel does not only depend on one or two color components but depend on all of three color components. Therefore, all of features are appropriate for SVM parameter input. Similar discussion is also applied on the sum and standard deviation of R, G and B.

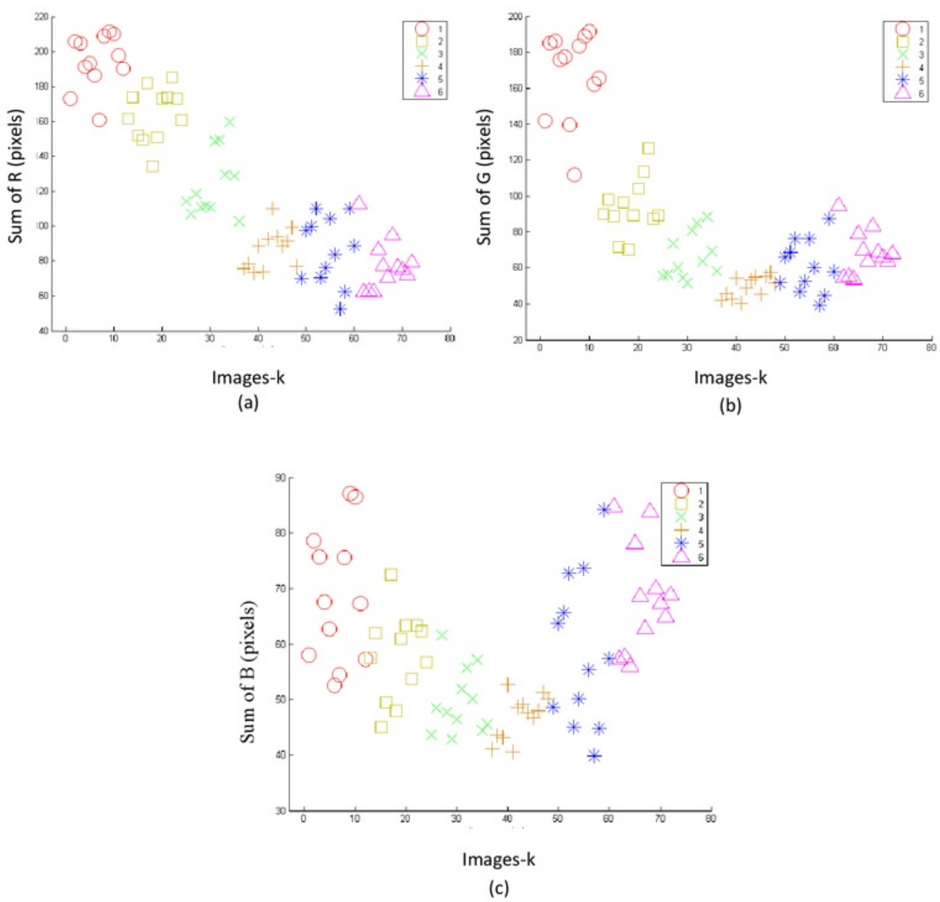

Figure 2: Scatter plot of mean of (a) red (R), (b) green (G) and (c) blue (B) from the images

Nine color features obtained were then used as parameter input for SVM training-testing. A half of the total images were selected as training data and the rest as the testing data for SVM. Tabel 1 shows the accuracy result of maturity stage estimation for every features set. It can be seen that the highest accuracy was obtained by combining all of nine features those are sum, mean and standard deviation of R, G and B component.

Tabel 1: Accuracy of maturity stage estimation

	Features set			
	SRGB & MRGB	SRGB & SDRGB	MRGB & SDRGB	SRGB, MRGB & SDRGB
Accuracy	83%	87%	87%	91%

CONCLUSION

The development of image processing method by combining color features and implementing SVM classification method to optimize estimation of maturity stage of mangosteen has been discussed. The color features i.e. sum, mean and standard deviation of R, G and B component were extracted from images. The combination of sum and mean, sum and standard deviation, mean and standar deviation and all of nine features were used as parameter input for SVM training and testing. The result confirmed that the combination of nine features is able to increase the accuracy of estimation up to 91%.

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