Estimating Maturity of Paddy Using RGB Colour Space

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***Abstract*—Colour plays important role in evaluating quality and maturity level of many agricultural products. Immature paddy has been defined as kernels or pieces of grain kernels that are not fully developed and are yellow-green in colour. Immature paddy will caused broken rice and losses during storage. This paper presents a new technique of paddy maturity estimation using various colour indices extracted from RGB colour spaces. Paddy samples were taken during 96 and 98 Days After Planting (DAP). Results has shown that there are significant relationships between all of the colour indices with the DAP. The strongest significant relationship can be gathered from G-B colour index, with R= -0.924 (p>0.001). A linear regression model was later being developed based on G-B colour index defined as MATURITY=-16.95 (G-B)+101.61.**

***Index Terms*—paddy, maturity, RGB, colour indices, image analysis.**

I. Introduction

Quality of yield is one of the major factors concerned in agriculture. The quality of rice yield is determined by percentage of broken rice. The higher the percentage of broken rice, the lower the quality. Harvesting before maturity will cause a low milling recovery. In addition, it will contains high proportion of immature seeds, high percentage of broken rice, poor grain quality and more chances of disease attack during storage. While delay in harvesting results in grain shattering and cracking of rice in the husk and expose lead the crop to pests attack. Immature paddy has been defined as kernels or pieces of grain kernels that are not fully developed and are yellow-green in colour. When the paddy becomes matured, the florets change its colour from green to golden brown. In order to get high quality milled rice with reasonable amount of broken rice, paddy must be harvested at the optimum moisture content and at suitable stage of maturity [1]. Presently, the percentage of immature paddy in a sample is determined by human inspection, separation, weighing and calculation. These manual operations are tedious, time consuming, labour intensive and costly [2]. With the aid of modern technology, automated device with intelligent computing functions can be used to replace human naked eye in deciding rice maturity for harvesting time.

Colour is important in evaluating quality and maturity level of many agricultural products. It had been applied to many non-contact visual assessment of agriculture sector because colour is often a good indicator of product quality. Colour spaces such as Red, Green, Blue (RGB) and Hue, Saturation, Value (HSV) representing a three-dimensional data. Since most agricultural applications only require analysis on a predefined set or range of colours, the mapping of colours is related to a small number index enables the processing of colour images easily and effectively for quality assessment. An analysis using Principal Component Analysis (PCA) based on transformation of RGB image captured from digital colour camera was used to determine an immature paddy [3]. Some investigations were carried out using colour features for classification of different cereal grains and their varieties for correlating ability and grain hardness of Canada Western Amber Durum (CWAD) wheat [4], [5]. Rice variety can be classified using colour features and shape features based on Bayes decision theory with 88.3% accuracy [6]. A classification model was also been developed by combining two or three features sets i.e. morphological, colour and textural to classify individual kernels of Canada Western Red Spring (CWRS) [7]. Colour also has been used to evaluate the maturity of fruits such as tomato [8], date [9], peach [10] and orange [11].

The use of colour indices to determine maturity of paddy is still limited. Therefore, the main objective of this research is to determine the maturity of paddy using seven different colour indices. The images of paddy samples were acquired at two different days after planting. Average pixel intensity of the paddy image for each colour indices will be used in estimating the maturity of paddy. This paper is organized as follows: the research materials and methodology is presented in Section 2. Section 3 describes the result and discussion. Finally, the conclusions can be found in Section 4.

II. Materials and Method

A. Paddy Sample

Paddy breed type MR220 CL2 was used in this study. The paddy was collected from Sawah Sempadan Tanjung

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Karang, Selangor, Malaysia. The samples were collected on 96 Days After Planting (DAP) and 98 DAP. For each day, 15 samples of paddy with 50 grams each were collected.

B. Image Acquisition

The E-60 FLIR camera was used during image acquisition process. The camera was fixed at a height of 50 cm above paddy sample as shown in Fig. 1. Thirty images were captured and saved in a JPEG (Joint Photographic experts group) format. All of the images were analysed using Matlab R2012b image processing toolbox.

Figure. 1. Experimental setup.

C. Image Pre-Processing

Fig. 2 shows sample of the images at 96 DAP and 98 DAP with its respective histogram. Based on this figure, it has been shown that distributions of the pixels at both maturity stages are almost similar. Valley between two peaks shows separation of the pixel intensity between paddy image and its background image. Peak value can be gathered at a pixel value of 125. The R, G, and B band for each DAP are shown in Fig. 3.

D. Colour Indices

In this study, 30 images were used in order to estimate maturity of paddy at two different stages. Matlab R2012b software was used to calculate colour indices tabulated in Table I. All of the indices were developed using R, G and B band. This process involved a single band and combined band analysis. Combined band analysis includes subtraction and division operations. Mean intensity of each index has been used to represent maturity of the paddy. The SPSS software was used for statistical analysis. Meanwhile, a simple linear regression model was employed to determine the strength of the relationships between colour indices and DAP. The adjusted coefficient of determination (R^2) was used to compare performance of the indices. Colour indices with the best value of correlation would be used to develop a paddy maturity estimation model based on the regression analysis.

TABLE I. COLOUR INDEX

Name	Definition	References
Red	Non- Normalized Red	-
Green	Non- Normalized Green	-
Blue	Non- Normalized Blue	-
Difference between Green and Blue	G - B	Yuanfang*et al.*
Difference between Green and Red	G - R	Yuanfang*et al.*
Green to Blue Ratio	G / B	Yuanfang*et al.*
Green to Red ratio	G / R	Yuanfang*et al.*

III. RESULTS AND DISCUSSION

In this research, capability of seven colour indices in estimating maturity paddy at two different stages has been evaluated. A total of 30 images have been used during image analysis. Fifteen images were taken from each DAP. The purpose of image analysis is to analyse the properties of mature and immature paddy, which thus resulting a decision rule to identify paddy maturity. All of the experiments in this research were conducted on a PC with Core i7 CPU using Matlab 2011b software. Fig. 4 shows results of thresholded image, where the white pixels indicate the object (paddy image) and black pixels as background. Threshold value of 0.34 and 0.32 was used to separate the image and backgrounds of 96 DAP and 98 DAP, respectively. The selection of threshold values was done using a trial and error process based on its histogram. The thresholded image will be used as a mask image. Therefore, only pixels that are overlapped with the white pixels in the masked image will be used in determining the mean intensity of paddy rice for each DAPs.

A. Statistical Description

Summary of descriptive statistic for colour indices at different DAP is tabulated in Table II. Based on this table, it can be seen that G gave the smallest value of standard deviation at both DAPs, which is 0.018 at 96 DAP and only 0.010 at 98 DAP. It also gave the smallest value of percentage coefficient of variations (CV) i.e. 3.12% at 96 DAP and 1.90% at 98 DAP. Coefficient of variation (CV) is defined as the ratio of the standard deviation (σ) to the mean (μ) as presented in (1). Coefficient of variations (CV) for a single variable is intended to reflect the spread of the variables in a way that does not depend on the unit of measurement of these variables. The lower the CV, the smaller the remaining relative with the predicted value. This indicates a good model fit. Therefore, it can be concluded that G gave more consistent results as compared to other indices.

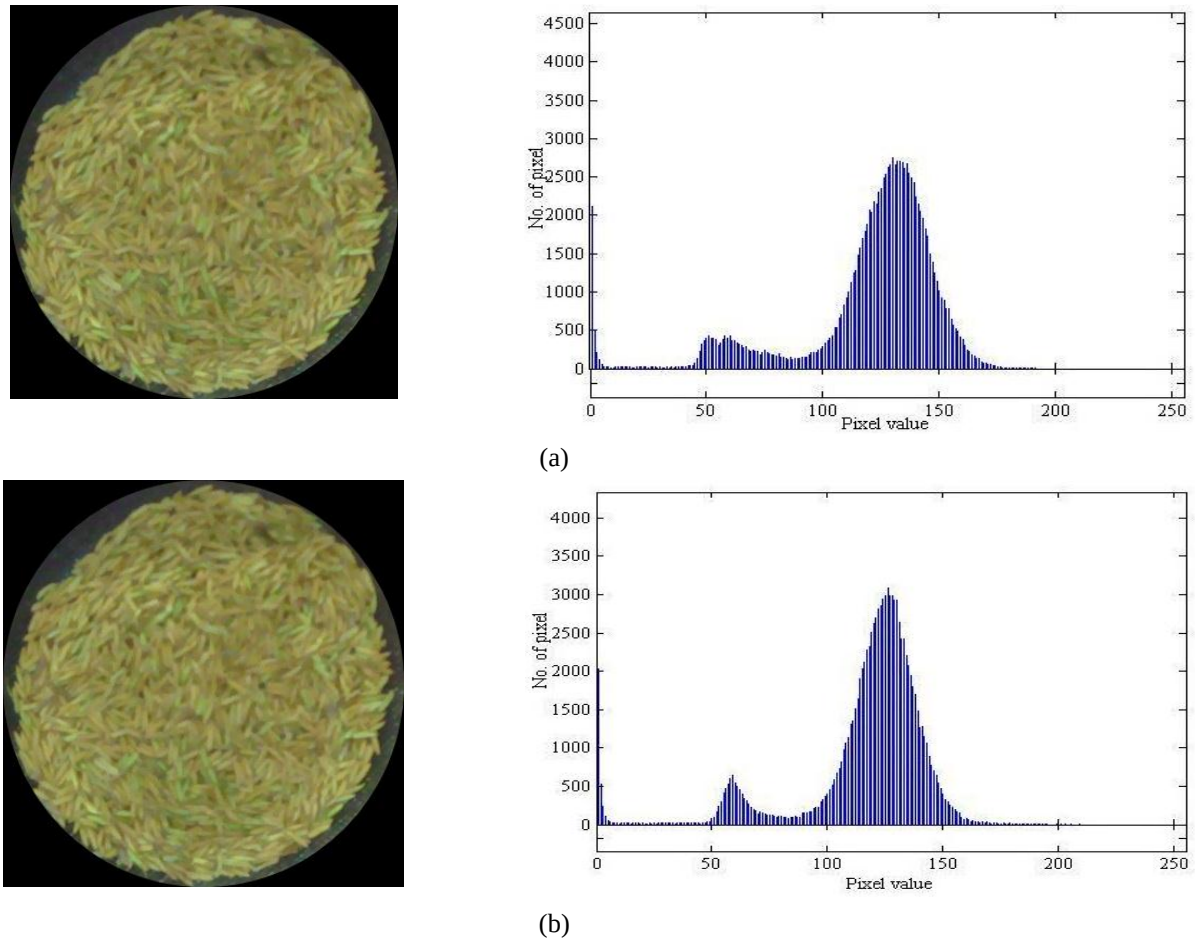


Figure. 2. Sample of paddy images and its histogram. (a) 96 DAP. (b) 98 DAP.

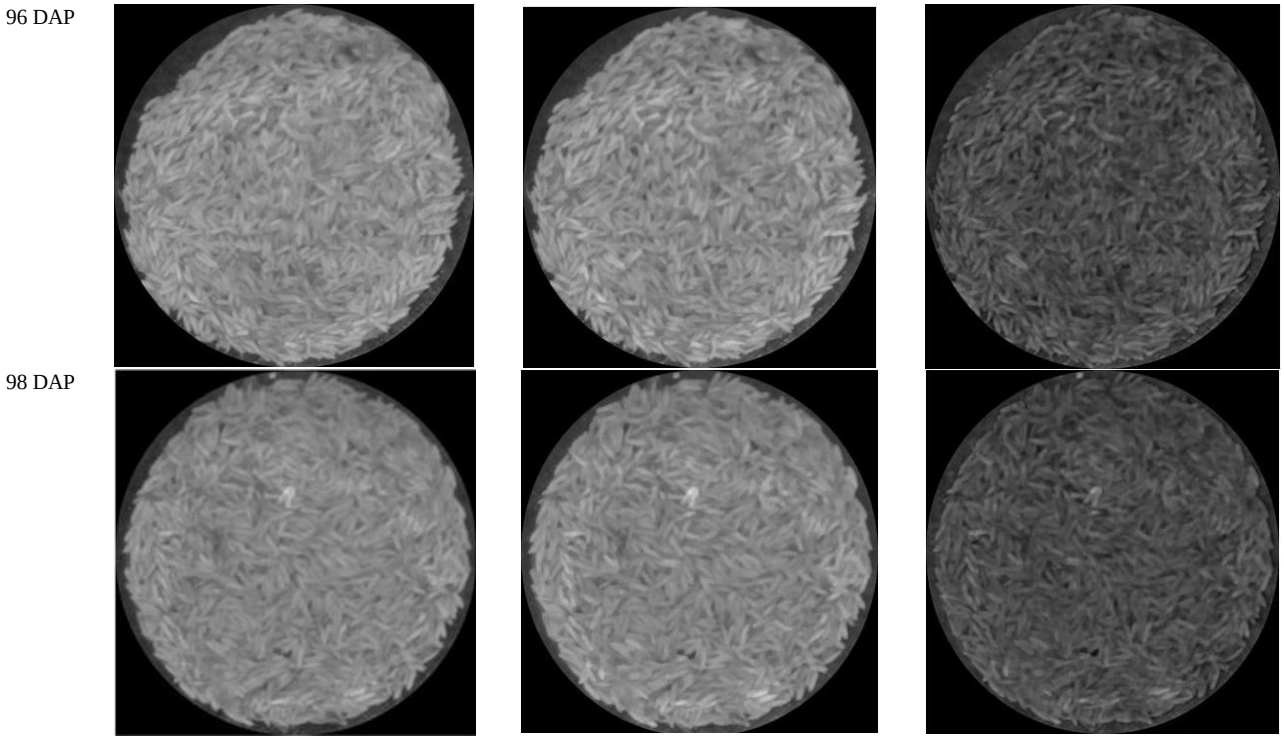
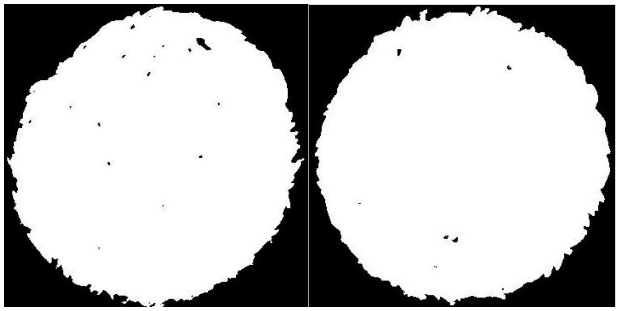


Figure. 3. Sample of paddy images taken from 96 DAP and 98 DAP. (a) Red band. (b) Green band. (c) Blue band.



(a) (b)

Figure. 4. Thresholded image of the object and background for (a) 96 DAP and (b) 98 DAP. This image will be used as a mask image during analysis.

$$CV = (\sigma/\mu)\times 100 \quad (1)$$

Fig. 5 shows graph of the average of each indices at 96 DAP and 98 DAP. Based on this figure, it has been shown that R, G, G-B and G/B decreases when the maturity stages increased. This is due to the decreasing value of G (no. 2). It is clearly shown at G, where the values of mean decreased from 0.57 at 96 DAP to 0.52 at 98 DAP. Index R and G have almost similar value of mean, which is 0.59 and 0.57, respectively. It is clearly showed at G-R (no.5), where the difference is only 0.02. Meanwhile, the value of B (no.3) increased as the maturity stage increased. Therefore, when the paddy become matured, the value of G is decreased, the value of B increased, resulting decreasing value of G-B and G/B. The decreasing value of G is due to the degradation process of chlorophyll concentration in pericarp.

B. Correlation of the Colour Indices

Table III shows correlation coefficient between colour indices and maturity stages calculated using Pearson two-tailed correlation. The closer the value of correlation to 1, the closer the two variables to a perfect positive correlation, while the closer the value to -1, the closer the two variables to a perfect negative correlation. From this analysis, it has been shown that all of the seven colour indices gave significant correlation. B, G-R and G/R gave positive correlation, while R, G, G-B, G/B gave negative correlation. The value of negative correlation in all indices is higher as compared to the positive correlation. This could be because before the paddy is getting matured, the chlorophyll concentration of rice is higher producing a darkergreenness [12]. When it became matured, the greenness level will be reduced. A highest significant correlation was found between the G-B (-0.924). It is followed by G/B (-0.881), G (-0.847), R (-0.844), B (0.806), G-R (0.723) and G/R (0.651).

C. Models for Maturity Estimation

A model to estimate maturity stages of paddy was developed in this research. G-B index was chosen as an input parameter to develop this model because it gave the highest correlation compared to other indices. The regression analysis of the G-B data showed a significant negative linear model (n= 30, R^2=-0.854). The developed linear model equation of maturity estimation can be shown in equation (2). The slope of the regression line is -16.95 and the interception is at 101.61.

$$MATURITY=-16.95\ (G-B)+101.61 \quad (2)$$

where *MATURITY* is the maturity stage of paddy rice represented by Day After Planting.

TABLE II. SUMMARY OF DESCRIPTIVE STATISTIC FOR COLOUR INDICES AT DIFFERENT DAY AFTER PLANTING (DAP)

No.	INDEX	96 DAP			98 DAP		
		Mean	StdDev	CV(%)	Mean	StdDev	CV(%)
1	R	0.589	0.029	4.94	0.493	0.034	6.93
2	G	0.568	**0.018**	**3.12**	0.518	**0.010**	**1.90**
3	B	0.266	0.030	11.29	0.334	0.021	6.33
4	G-B	0.302	0.027	8.83	0.183	0.024	13.09
5	G-R	-0.021	0.020	-97.28	0.028	0.028	98.10
6	G/B	2.235	0.230	10.30	1.577	0.117	7.43
7	G/R	0.967	0.034	3.53	1.057	0.070	6.59

TABLE III. CORRELATION COEFFICIENT OF COLOUR INDICES WITH DAY AFTER PLANTING

INDEX	R	R^2
R	-0.844**	0.712
G	-0.847**	0.764
B	0.806**	0.650
G-B	**-0.924****	**0.854**
G-R	0.723**	0.523
G/B	-0.881**	0.776
G/R	0.651**	0.424

**. Correlation is significant at the 0.01 level (2-tailed).

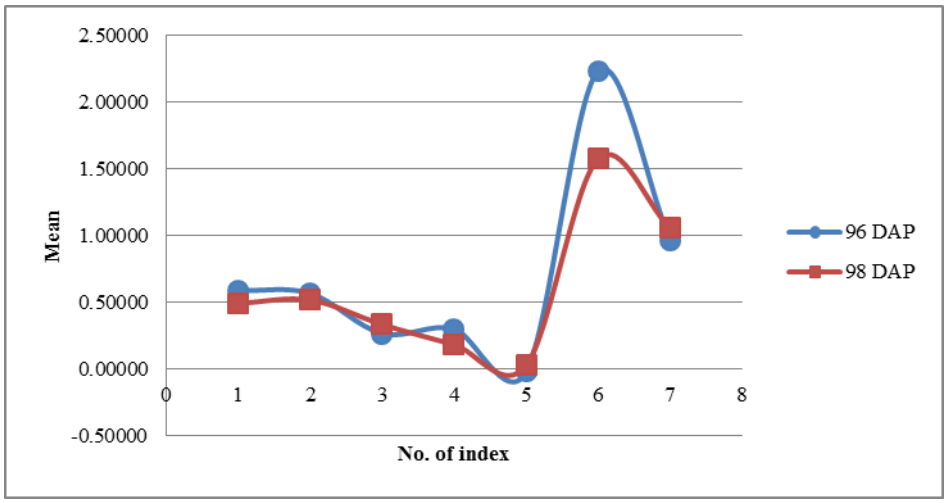


Figure 5. Mean of colour index for each DAP

IV. Conclusion

In this research, the capability of seven colour indices in estimating seven different stages of paddy maturity has been analysed. The practical insights into effectiveness of the proposed method are verified through Person Correlation coefficient value. Based on the results, it has been shown that R, G, B, G-B, G-R, G/B and G/R colour indices give significant correlation with the maturity stage of paddy. All indices with negative correlation gave higher value of correlation as compared to the indices with positive correlation. The G-B had the highest value of correlation (-0.924) at a 0.01 level of significant. Model for maturity estimation has been developed based on the G-B indices. The model can be used to ensure the paddy is harvested during right maturity stage. This will help us in getting high production of rice yield.

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