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MATURE AND IMMATURE PADDY IDENTIFICATION USING IMAGE PROCESSING TECHNIQUE

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Abstract

Maturity of paddy contributes a very high impact on the production of rice quality. Immature paddy will produce high percentage of broken rice, poor grain quality and more chances of disease attack during storage. This research focuses on the use of image processing technique for paddy maturity identification. Three types of automatic image thresholding techniques had been used during a segmentation process, i.e., Mean, Median and Otsu. The average intensity of paddy image is used as features in development of a decision rule to identify paddy maturity. All of the techniques give small value of standard deviation which is around 0.01 in mature and immature paddy. Results from the test validation had shown that, all of the techniques can identify mature paddy with the percentage of success rate of 92.31%. For immature paddy, features extracted by Median give superior result which is 100% success rate compared to the others. In overall, Median is the most reliable approached for mature and immature paddy identification. It gives the highest average percentage of success rate which is of 96.15% as compared with Mean (86.15%) and Otsu (66.15%).

Keywords: Mean, Median, Otsu, Automatic segmentation.

1. Introduction

Rice is the staple food in Malaysia. Therefore, it is important to ensure enough production to cater market demand. Rice production depends on the quality of paddy during harvesting time. According to the Malaysia Standard MS 84:1998, Specification and Grades for Paddy (First Revision), maturity is one of the important parameters in determining paddy quality. It is because immature paddy not only caused low milling recovery but also give high percentage of broken rice, poor grain quality and more chances of disease attack during storage [1]. The immature paddy defines as a yellow-green grain that contributes to the chalky rice. Every 1% immature paddy will cause 1 kg of 100kg deduction for pricing. In current practice, the process of immature paddy identification is done using eye observation. This practice is laborious, inconsistent and highly subjective.

A non-destructive technique based on machine vision and image processing has been widely used in biological and agricultural research such as for grading [1, 2, 3], sweetness determination [4] and moisture content estimation [5, 6]. It also has been used to evaluate the maturity of tomato [7], date [8], peach [9] and orange [10]. In general, the process of maturity evaluation is divided into two major stages, i.e., the image analysis stage and the test validation stage. During the image analysis stage, images of the samples were acquired using a color digital camera. Then, the image segmentation process will be performed to extract only region of interest. Analysis can be done either using the original RGB (Red, Green and Blue) color image, other color model such as HSI (Hue, Saturation and Intensity) image or pixel intensity of the image. These properties were analyzed and then used to form decision rules.

The application of machine vision for rice quality inspection has been done by several researchers [1, 11-15]. This includes chalkiness [11] and broken rice determination [1, 12, 13]. The segmentation effect of different threshold methods has also being compared to obtain the ideal thresholding method [16]. The best method will be used to threshold the image by evaluating the value obtained. An online machine vision of automatic grain inspection system has been developed by [15]. The rice quality recognition performances of three classification techniques were studied based on 16 brown rice appearance characteristics related to kernel shape, color, and defects. As a result, sound, cracked, chalky, broken, immature, dead, off-type, broken, paddy and damaged brown rice kernels could be recognized and sorted by the system with an accuracy of 91% at a speed of over 1200 kernels/min. Based on these reviews, it can be concluded that the machine vision and image processing approach gave the same and better precision accuracy than manual time consuming technique.

The used of image processing technique for paddy maturity determination is still limited. Therefore, the main objective of this research is to identify the maturity of paddy using image processing technique. The images of paddy samples were selected based on two conditions; mature and immature. The images were segmented using three different automatic image thresholding techniques, i.e., Mean, Median and Otsu. Pixel intensity in the segmented image 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.

2. Materials and Methods

2.1. Paddy samples

A total of 78 paddy samples (MR 219) with 10 gram each, consist of mature (43 samples) and immature (35 samples) were obtained from Gelam, Alor Star, Kedah on 3 February 2012. Immature paddy has been defined as kernels or pieces of grain kernels that are not fully developed and are yellow-green in color. When the paddy becomes matured, the florets change its color from green to golden brown. In this study, the sample images have been captured within 48 hours after harvested. The harvesting time was determined using manual practice, which is by counting number of days after planting. Therefore, there are some mixed mature and nearly mature (immature) paddy. The process of separating mature and immature paddy has been done manually by the expert. Seventy percent of the samples had been used during image analysis stage while the remaining 30% were used during test validation stage. Figure 1 shows example of the mature and immature samples. Based on this figure, it is clearly shown that both samples are almost similar, and hardly to be classified using the naked eye observation.

(a) (b)

Fig. 1. Sample of Paddy Image. (a) Mature. (b) Immature.

2.2. Automatic image thresholding

Automatic image thresholding is an important technique in image segmentation and machine vision application. The basic idea of automatic thresholding is to automatically select an optimal grey-level threshold value for separating object of interest in an image from the background based on their grey level distribution. In this study, Mean, Median and Otsu threshold selection has been used.

Mean

Mean is the average value of the pixel in the image, calculated as follows:

$$\mu = \sum_{i=0}^{n} \frac{P(i)}{n} \quad (1)$$

where P(i) is the pixel value at i and n is the total number of pixel.

Median

Median is the middle value of the histogram.

If n is odd, median, m = value of $\left(\frac{n+1}{2}\right)^{th}$ item. If n is even, the median is the value of $\frac{1}{2}\left\{\left(\frac{n}{2}\right)^{th} \text{item} + \left(\frac{n+1}{2}\right)^{th}\right\}$ (2)

Otsu

Otsu method assumes that the image to be thresholded contains two classes of pixels or bi-modal histogram. It will calculate the optimum threshold separating those 2 classes so that their combined spread (intra-class variance) is minimal.

Let q_1 and q_2 represent the estimate of class probabilities defined as:

$$q_1(t) = \sum_{i=1}^{t} P(i) \text{ and } q_2(t) = \sum_{i=t+1}^{I} P(i) \quad (3)$$

and sigmas are the individual class variances defined as:

$$\sigma_1^2(t) = \sum_{i=1}^{t} [i - \mu_1(t)]^2 \frac{P(i)}{q_1(t)} \text{ and } \sigma_2^2(t) = \sum_{i=t+1}^{I} [i - \mu_2(t)]^2 \frac{P(i)}{q_2(t)} \quad (4)$$

and the class means:

$$\mu_1(t) = \sum_{i=1}^{t} \frac{iP(i)}{q_1(t)} \quad \text{and} \quad \mu_1(t) = \sum_{i=t+1}^{I} \frac{iP(i)}{q_2(t)} \quad (5)$$

Here, P represents the image histogram. The problem of minimizing within class variance can be expressed as a maximization problem of the between class variance. It can be written as a difference of total variance and within class variance:

$$\sigma_b^2 = \sigma^2 - \sigma_w^2(t) = q_1(t)[1 - q_1(t)]\,[\mu_1(t) - \mu_2(t)]^2 \quad (6)$$

Finally, this expression can safely be maximized and the solution is t that is maximizing $\sigma_b^2(t)$.

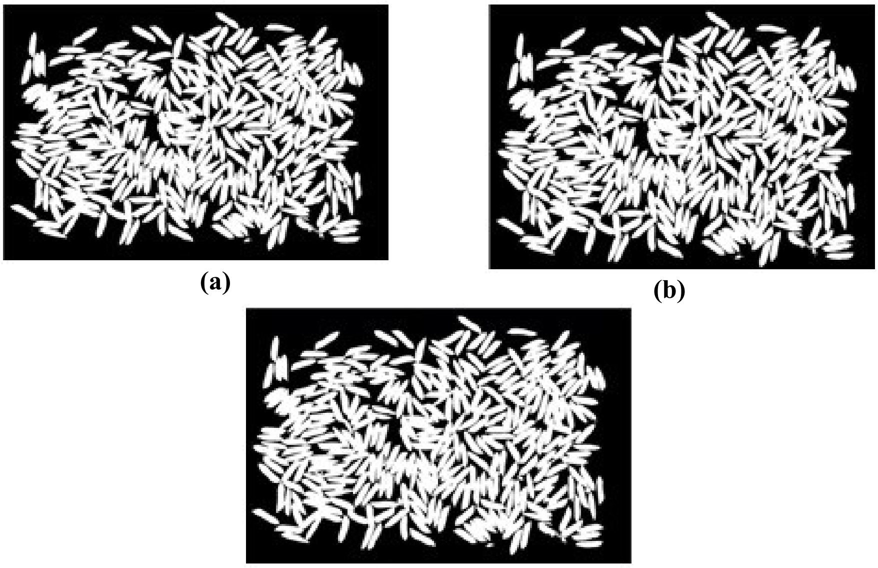
3. Results and Discussion

In this research, three different approaches of mature and immature paddy identification have been evaluated. Seventy percent of the samples has been used during image analysis (30 samples for mature and 25 samples for immature), while remaining 30% during test validation (13 samples for mature and 10 samples for immature). 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 Duo CPU using Matlab 2011b software. Figure 2 shows sample of the results for segmented image taken from Mean, Median and Otsu image thresholding. The paddy and background image was separated automatically without requires a trial and error process. Based on the visual interpretation of the results, all of the techniques gave similar output. However, Otsu gave faster time to complete the process of segmentation, which is only three seconds as compared to Mean and Median (five seconds).

These segmented images were then analysed based on its value of average pixel intensity. It was done by dividing the total value of pixel intensity at the segmented image with its total number pixels as in Eq. (7).

$$\text{Average}(\mu_s) = \sum_{i=0}^{N_s} \frac{P_s(i)}{N_s} \quad (7)$$

where P_s is the pixel intensity at the segmented image and N_s is the number of pixels inside the segmented image.

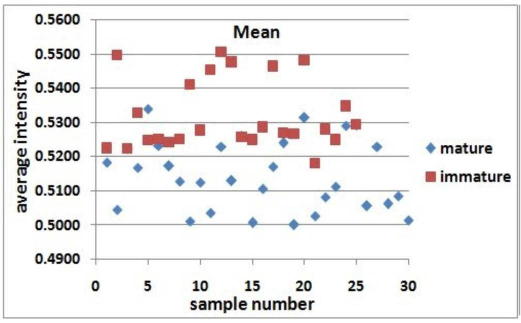


(c)

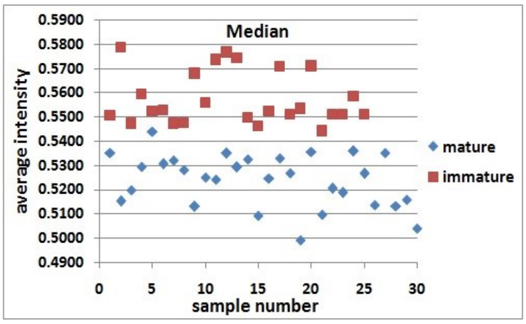
Fig. 2. Example of the Segmented Image Taken from all Techniques.
(a) Mean. Time Taken to Complete the Process of Segmentation: 5 seconds.
(b) Median. Time Taken to Complete the Process of Segmentation: 5 seconds.
(c) Otsu. Time Taken to Complete the Process of Ssegmentation: 3 seconds.

Figure 3 shows scatter plot for the average intensity in two classes, i.e., mature and immature paddy extracted from the segmented image of Mean, Median and Otsu. In general, all of the techniques gave similar pattern of scatter plot where the value of average pixel intensity in immature paddy is higher than mature paddy. Median seemed can distinguish the mature and immature paddy since there's no overlapping data between these two classes. Meanwhile, some of the data of mature and immature produced by Mean and Otsu were scattered together. This condition happened at the boundary of the class. Based on Figure 3(a) and (c), Mean gave smaller range of overlapping data compared with Otsu.

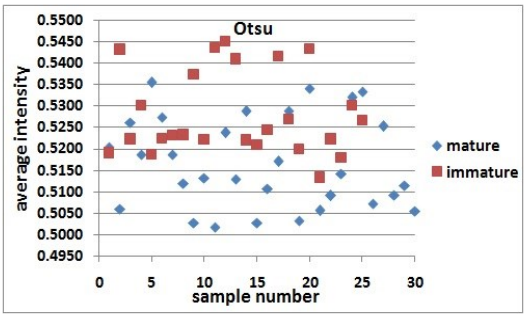
Table 1 shows descriptive statistics for segmented image of Mean, Median and Otsu technique in mature and immature paddy. For mature paddy, Otsu gave the highest value of minimum (0.5017) followed by Mean (0.5001) and Median (0.4993). Meanwhile, Median gave the highest value of maximum (0.5441) followed by Otsu (0.5355) and Mean (0.5340). Immature paddy gave the same trends of minimum and maximum values where the highest values were gathered from Median, which is 0.5443 for minimum and 0.5789 for maximum. It was followed by Mean with 0.5180 and 0.5575 for minimum and maximum, respectively. Finally, Otsu gave the lowest value of minimum and maximum which is 0.5133 and 0.5451, respectively. Results of the average intensity per sample had shown that Median gave the highest value in mature and immature paddy which is 0.5239 and 0.5575, respectively. Otsu and Mean gave a slightly similar value in mature which is 0.5166 and 0.5146, respectively. Meanwhile for immature paddy, the average intensity per sample of Mean is higher than Otsu which is 0.5321 and 0.5281, respectively. All of the techniques gave small value of standard deviation which is only around 0.01 in mature and immature paddy.



(a) Mean



(b) Median



(c) Otsu

Fig. 3. Scatter Plot of the Results using (a) Mean, (b) Median and (c) Otsu.

Table 1. Descriptive Statistics for Segmented Image of Mean, Median and Otsu Technique in Mature and Immature Paddy.

Maturity	Technique	Minimum	Maximum	Average intensity (μ_{sa})	Standard deviation (std)
Mature	Mean	0.5001	0.5340	0.5146	0.0102
	Median	0.4993	0.5441	0.5239	0.0108
	Otsu	0.5017	0.5355	0.5166	0.0107
Immature	Mean	0.5180	0.5507	0.5321	0.0102
	Median	0.5443	0.5789	0.5575	0.0108
	Otsu	0.5133	0.5451	0.5281	0.0098

The decision rule of automated technique for mature and immature paddy identification was later developed based on a threshold value of μ_{sa} + std. Therefore, samples with the average pixels intensity less than 0.5248, 0.5347 and 0.5273 in Mean, Median and Otsu, respectively will be considered as mature. Others, it will be considered as immature. Table 2 shows the results acquired during a test validation process. Mean, Median and Otsu gave higher percentage of identification in mature paddy which is 92.31%. For immature paddy, Median is superior compared to the others with 100% success rate. Mean gave 80% success rate. Otsu gave the lowest value which is only 40%. Based on the average of success rate, Median is superior with 96.15%, followed by Mean (86.15%) and Otsu (66.15%).

Table 2. Percentage of success rate.

Technique	Threshold	Mature (%)	Immature (%)	Average (%)
Mean	0.5248	92.31	80.00	86.15
Median	0.5347	92.31	100.00	96.15
Otsu	0.5273	92.31	40.00	66.15

4. Conclusions

Some concluding observations from the investigation are given below.

- Paddy maturity identification is important to ensure high quality rice.
- In this research, the image processing technique has been used to identify mature and immature paddy. The decision rule has been developed based on its average pixel intensity.
- Three different approaches of mature and immature paddy identification had been evaluated, i.e., Mean, Median and Otsu. Among these approaches, Median with a threshold value of 0.5347 gave superior results with the average percentage of success of 96.15% during test validation. It only took 5 seconds to complete the process.
- Therefore, it can be concluded that the image processing technique using Median approach of automatic segmentation is efficient and thus can be applied for maturity paddy identification.

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