Using Color Shading for Pineapple Ripeness Classification

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ABSTRACT

This paper proposes a pineapple ripeness classification in the manufacturing process based on color shading. The pineapple image that is captured in RGB format then converts to HSI format and it is manually segmented. The segmented image is passed to the feature extraction in order to classify the color shade of the pineapple. Mean intensity saturation component of the pineapple color, which is a part of HSI system, is considered as a classifier the pineapple ripeness level. The proposed method then performed testing on the pineapple samples and it can separate the ripeness into 3 levels. Finally, performing the test with pineapple slices and it is found that proposed method can separate the ripeness level of pineapple as same as human does in some degree.

INTRODUCTION

Currently, the use of machine vision system has increasingly used in the agriculture industry particularly in food processing [1] in order to increase the quality of their products while reducing waste and manual labor costs. Color is a significant quality that applies as a criterion in several applications such as fruit [1] and beef [2] grading. Also in the canned pineapple process, the color is used as a key to classify the sliced pineapples before filling into cans in which the slices need to have similar shade of the yellow color. Manual labors are employed to do this repetitive task which involves dozens of people. Color shade of the pineapple is used for classifying by human color perception. Consequently, the automated system which involves identifying a specific shade of a color in an image is required for this task. Digital camera is employed as a sensor of the machine vision system. There are two main sensor technologies: charge coupled device (CCD) and complementary metal-oxide-semiconductor (CMOS) [3] are used in the digital cameras. Both of them, however, capture red, green, and blue (RGB) values of an image. As the colors processing in RGB space, only the differences between colors can be determined but it is not easy to separated shades of the same color [4]. Due to the pineapple have the same color but difference shades therefore the RGB space is unable to do this task. The aim of this study is to investigate the application of digital image processing to measure the color shades of the pineapple slices in order to separate the ripeness level of pineapple.

COLOR MODELS AND CONVERSION

In this section, two color models: RGB and HIS (hue, saturate, intensity) models are explained and discussed. Gonzalez et al. [5] described that “RGB color model is based on a Cartesian coordinate system in which each color appears in its primary spectral components of red, green and blue. The color subspace of interest is in the cube shown in Figure 1 (a). The RGB values are at the three corners; cyan, magenta and yellow are at three other corners. Black is at the original and white is at the corner farthest from the origin. The gray scale in this model extends from black to white along the line joining these two points. Colors are points on inside the cube that defined by vectors extending from the original."

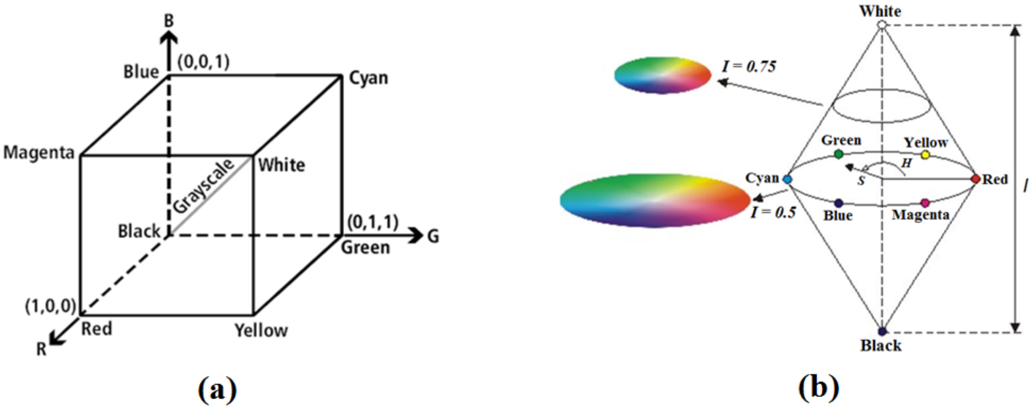

Figure 1. RGB and HIS color models [5,7]

The digital color image ***C*** obtained from the CCD or CMOS camera is in the RGB space that the value of each image pixel can be expressed as [6]:

$$C(x,y) = (R(x,y), G(x,y), B(x,y))^T = (R,G,B)^T \tag{1}$$

HSI (hue, saturation, intensity) color model [6] are used as co-ordinate axes as illustrated in Figure 1 (b). The hue ***H*** is a color attribute that describes a pure color, whereas saturation ***S*** gives a measure of the degree to which a pure color is dilutes by white light. The intensity ***I*** of the color corresponds to the relative brightness. The RGB color image obtained from the digital camera can be converted to the HSI color model for evaluating the hue ***H***, saturation ***S*** and intensity ***I*** values as the following equations [6].

$$H = \begin{cases} \delta & \text{if } B \le G \\ 360° - \delta & \text{if } B > G \end{cases} \tag{2}$$

where

$$\delta = COS^{-1}\left(\frac{(R-G)+(R-B)}{2\sqrt{(R-G)^2 + (R-B)(G-B)}} \right) \tag{3}$$

$$S = 1 - 3 \cdot \frac{\min(R,G,B)}{(R+G+B)} \tag{4}$$

$$I = \frac{1}{3}(R+G+B) \tag{5}$$

and RGB values have been normalized to the range [0,1]. These equations are employed in the next section.

EXPERIMENT

A. Sample preparation

The sliced pineapple images are taken a picture in white lighted illumination with illuminance of 5,000 lux. The RGB images are reduced size to 400×350 pixels then manually segmented the pineapple area from the background as shown in Figure 2 (b). Therefore the pineapple area of each sample image is amount the same. The total 22 samples which are 10 unripe, 9 ripe and 3 overripe samples, respectively are used in the experiments.

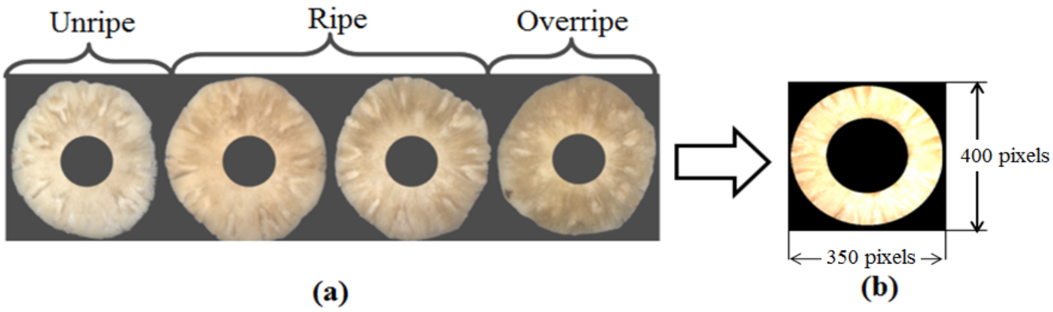

Figure 2. (a) Sliced pineapple image with ripeness stage and (b) An example of segmented sample image

B. Feature Extraction

The segmented image in RGB format is transformed to HSI color space using HALCON. The saturation ***S*** using Eq. 4 is calculated for each and every pixel area to get the average value. Background image with pixel value of zero is not included in the calculation. After the calculation, the mean value of the saturation is provided and then employed to determine the range of pineapple ripeness levels that can separate into 3 levels which are unripe, ripe and overripe, respectively.

RESULTS AND DISCUSION

As the testing results of the samples that are beforehand categorized by human as unripe, ripe and overripe. The saturation ***S*** range can be considered as color shading are established as the follows: i) unripe pineapple has mean saturation value less than 60, ii) ripe pineapple has ***S*** range from 60 to 100 and iii) overripe has ***S*** value of more than 100 as listed in Table 1.

Table 1: Ripeness level and its saturation value range

Ripeness Level	Unripe	Ripe	Overripe
Mean saturation value	<60	60 – 100	> 100

Also Table 2 shows the testing of another 18 samples results using the established range compare to the human opinion.

Table 2: Comparison between human opion and the proposed method in ripeness level of the pineapple

Samples	Human opinion	Mean Saturation value	Proposed method	Samples	Human opinion	Mean Saturation value	Proposed method
1	Unripe	56.6786	Unripe	10	Ripe	91.088	Ripe
2	Unripe	69.7164	Ripe	11	Ripe	78.2671	Ripe
3	Unripe	51.3198	Unripe	12	Ripe	80.8526	Ripe
4	Unripe	51.2022	Unripe	13	Ripe	102.042	Overripe
5	Unripe	75.0431	Ripe	14	Ripe	96.2385	Ripe
6	Unripe	57.6034	Unripe	15	Ripe	93.0435	Ripe
7	Unripe	65.3856	Ripe	16	Ripe	88.5845	Ripe
8	Unripe	88.5257	Ripe	17	Overripe	118.498	Overripe
9	Unripe	76.0188	Ripe	18	Overripe	113.742	Overripe

From the comparison results, it is found that the proposed method provide 6 contrast results to human opinion. These errors may cause from the use of unsuitable lighted illumination that effect to captured RGB color value.

Oral paper

CONCLUSION

The pineapple ripeness classification using HSI color model has been demonstrated and presented. It is found that the mean saturation value *S* could use as a criterion or color shading for classifying the ripeness of the pineapple in some degree. Also there are contrasts results that might cause from the lighted illumination that used direct light to the pineapple. However, this shortcoming is able to be overcame by improve the lighting system. Moreover, the other color models such as HSV (hue, saturation, value) CIE color model will be investigated and applied in the future study.

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