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Pineapple Maturity Recognition Using RGB Extraction

J. I. Asnor, S. Rosnah, Z. W. H. Wan, and H. A. B. Badrul

Abstract**—**Pineapples can be classified using an index with seven levels of maturity based on the green and yellow color of the skin. As the pineapple ripens, the skin will change from pale green to a golden or yellowish color. The issues that occur in agriculture nowadays are to do with farmers being unable to distinguish between the indexes of pineapple maturity correctly and effectively. There are several reasons for why farmers cannot properly follow the guideline provide by Federal Agriculture Marketing Authority (FAMA) and one of reason is that due to manual inspection done by experts, there are no specific and universal guidelines to be adopted by farmers due to the different points of view of the experts when sorting the pineapples based on their knowledge and experience. Therefore, an automatic system will help farmers to identify pineapple maturity effectively and will become a universal indicator to farmers.

Keywords**—**Artificial Neural Network, Image Processing, Index of Maturity, Pineapple.

I. Introduction

PINEAPPLE (*Ananas comosus L.*) is one of the most popular tropical fruits for consumption around the globe. Pineapple is a family of bromeliad species originally cultivated at Brazil [5]. Pineapple has been placed as the third most produced tropical fruit in the world after banana and citrus as mentioned by Van [1], [4]. In China, approximately 1.4 million tons of pineapple had been recorded that being produced in 2008 and in worldwide production, over 18.0 million tons of pineapple were produced based on FAOSTAT [4], [6]. Pineapple products can be seen in the form of juice, cookies, canned products, and as well as the fresh product. For the year 2011, Malaysia exported fresh pineapple worth more than RM26 Million and Singapore is one of the highest importers from Malaysia. However, although pineapple is one of the highest exported products, part of production didn't meet the standards for exporting purpose and some of the processing methods involved with pineapple production are still done manually and for that, the efficiency of production will not be maximized [6]. Using manual labor also increases the labor cost and the output or judgment of the workers will not be accurate or consistent all the time. Therefore, using a machine system will help to increase the production and also will set a good benchmark for the product to be marketed. Malaysia has authorized FAMA to manage agricultural marketing throughout the country. The reason why only FAMA has the expertise to determine the maturity index of pineapple is because they are the only authorized and entrusted agency to coordinate and manage agricultural activities and the members of this agency consist of various experts in the agricultural sector. FAMA has also been given responsibility to ensure all agricultural products comply with a set of standards before being marketed. Therefore, using automated production system to evaluate pineapple condition will help to maximize the quality of production and also reduce human subjectivity and inconsistency [9].

The maturity of pineapple can be determined based on the change of color of the skin of the fruit. Pineapple can be said to be mature when there is skin color change at the base of the fruit from green to yellow as mentioned by Rosnah and Ramallo [2], [7]. As the fruit ripens, the index of maturity is classified into seven stages. Index 1 represents the early stage of maturity and Index 7 represents the fully ripened stage. For Index 1 and Index 2, the fresh pineapple is suitable for export purposes due to being capable of surviving a long transit time. For Index 3 and Index 4, these are suitable for domestic fresh pineapple. For Index 5 to Index 7, these are suitable for production of fruit-based products such as juice and canned products.

Pineapple's colors reflect the pigments that exist in the skin of the pineapple also known as pigmented. For example, in red color of the fruits, the present of anthocyanidin and for orange color is beta-carotene and the present of chlorophyll is due to green color [8].

Red, Green, and Blue (RGB) can be used to describe the amount of red, green, and blue color components forming a composite color based on the fusion of these three components and forming a 3D space as mentioned by Blotta and Cheng [3], [10]. The RGB value defines the level of the red, green, and blue color components that form a composite color for each pixel in an image [11]. The range for each RGB component is 0 to 255 as it is stored in an eight-bit byte as mentioned by Blotta [3]. In this project, the green and red colors will be evaluated to determine the amount of green (G) component and red (R) component for each index of maturity of the pineapple. The evaluation can be done by separating two regions of interest in the image of the fruit and analyzing each region for the amount of green color pixels. Once the data has been collected, an Artificial Neural Network (ANN) will be used to classify the information as after training, an

J.I Asnor, Z.W.H Wan, and H.A.B. Badrul are with the Department of Electrical & Electronic Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia (phone: 603-89464323; fax: 603-89466327; e-mail: asnorji@eng.upm.edu.my, wan@eng.upm.edu.my).

S. Rosnah is with the Department of Food and Process Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia (phone: 603-89466366; fax: 603-89466366; e-mail: rosnahs@eng.upm.edu.my).

ANN can mimic a biological neural network which is the human brain.

An ANN is a set of inter-connected nodes that relate between the input and output for a system. An ANN is suitable for this system because it will imitate the human brain based on how it is programmed. The human brain consists of a vast network of neurons that are highly interconnected with each other.

II. Methodology

A. Overview

The overall system can be considered in three main parts which are pre-processing, feature extraction and the classification technique. For pre-processing, this will explain how the image is manipulated to ensure all images are in same category. For feature extraction, this describes how information about interesting features is retrieved from the image. In classification, this explains how the information is classified. Fig. 1 shows the flow chart of the system.

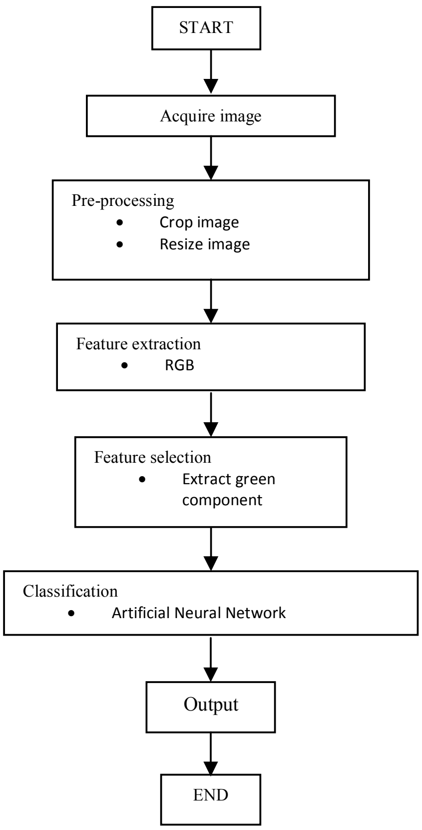

Fig. 1 Flow Chart of the System

B. Data Collection

Data collection refers to the technique of collecting images of the pineapples and some general information regarding the pineapples. Acquiring the image is the first process in the system development. The images used in this project were collected with the help of the Malaysian Pineapple Industry Board (LPNM) by providing pineapples of type Josapine.

A professional photography service was used to ensure the captured images were clear and suitable for processing in a database. The position of the fruits was in a fixed location for the image capture. Using a high definition camera with a distance of 1.5 meters from the fruit, and with an angle of 90° to the flat ground, the images of the pineapples were captured with a constant light exposure throughout the process. This is an important aspect when capturing images for processing in order to avoid any noise that will compromise the image condition due to not controlling the environmental factor.

C. Pre-Processing

For the pre-processing section, each image will undergo several stages of filtering to remove any unwanted information. The reason why the filtering is needed is because it will reduce the data size of the image and will make the processing time much faster. In pre-processing, the background will be cropped to reduce the size of the image from the original before cropping as shown in Fig. 2 (a) and (b) is the result after cropping. After the background has been reduced, the size of the image will be standardized to ensure all images pass through the system with the same size as shown in Fig. 2 (c). After all the images are the same size, color extraction which in this project means the green color from the RGB channel will be done. The extracted color will be converted into a grayscale to show the intensity of the green component of the image.

Fig. 2 (a) Original Image

Fig. 2 (b) Cropped Image

Fig. 2 (c) Resized Image

D. Feature Extraction

To extract information needed from the image, a feature extraction technique will be carried out. The features are extracted is the number of green pixels and the number of red pixels from a selected region of the image. The coordinates of the extraction will be pixel number 250 on the x-axis and for the y-axis, the coordinates will be divided into 2 regions, namely Region A for coordinates from 91 to 270, and Region B for coordinates 271 to 450.

E. Feature Selection

In this section, each item of data will be analyzed to meet the requirements of the project. Each pixel will contain information of the RGB color space and each component color will be in the range of 1 to 255. Therefore, the specific range will be a target to obtain a specific color. The colors of interest will be the red and green color. The range of the yellow color is between R=1, G=1, B=1 to R=250, G=250, and B=150. For the green color, the range is R=1, G=1, B=1 to R=150, G=250, and B=150. When a certain pixel lies in the required range, respective counters will count the number of red color pixels and green color pixels.

F. Classification

In this section, an Artificial Neural Network will be used to imitate the human brain when differentiating the index of maturity in the pineapples. Fig. 3 shows overall process that been proposed in this paper.

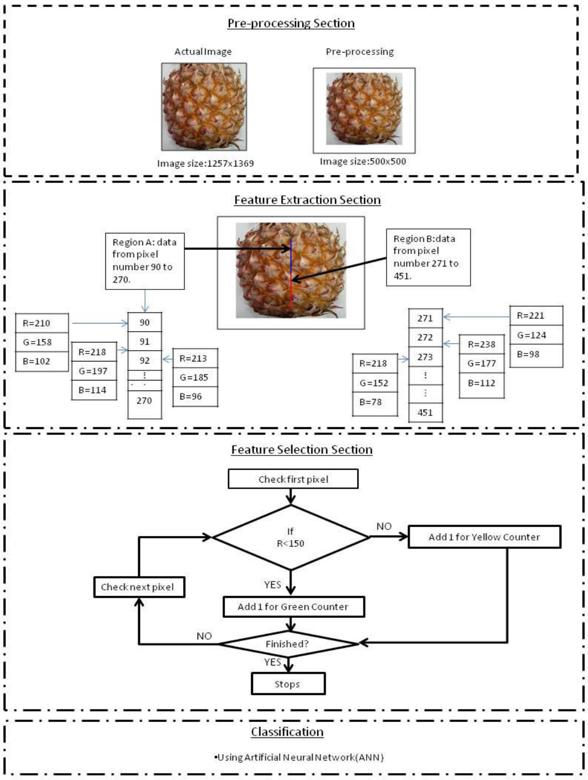

Fig 3 Overall Process of the System

III. Results and Discussions

From the feature selection, the results show that there is a change in the number of yellow pixels and green pixels that have been extracted in these two regions. Fig. 4 shows a number of green pixels and red pixels through Index 1 to Index 7. The number of green pixels starts to decrease at Index 4 and also at the same time, the number of yellow pixels increases. This shows that at Index 4, the ripeness of the pineapples has reached the level of Region 1 which is at pixel 90 to 270 and the fruit starts to change color to being yellowish which shows that existence of red pixels.

In Fig. 5, the result shows the number of green pixels and red pixels for Region 2 which is between pixel numbers 271 to 451. The result shows that there is a reduction in the number of red and red colour pixels when reaching Index 5, Index 6 and Index 7. As the Region 2 is at the lower part of the image, the beginning of ripeness occurs in this area. Therefore, as the fruit ripens, the number of yellowish pixels is higher that green pixels starting from Index 4 onward.

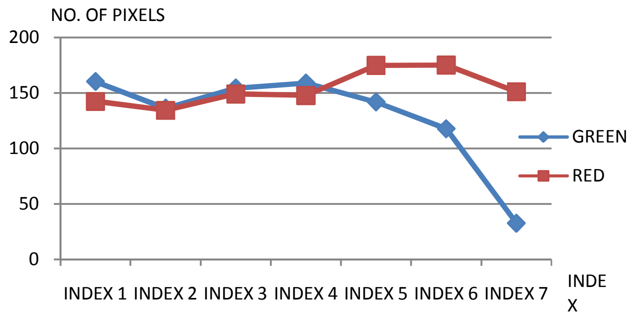

Fig. 4 Number of red pixels and green pixels in Region 1

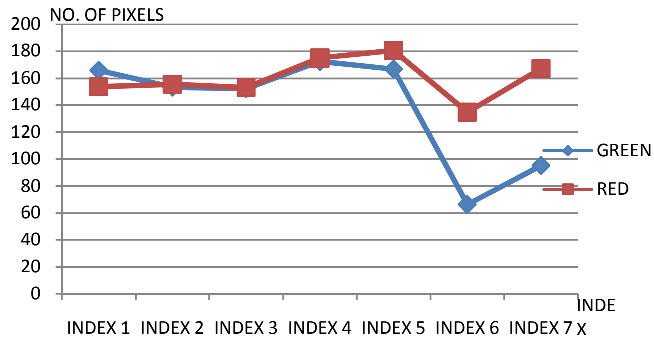

Fig. 5 Number of red pixels and green pixels in Region 2

From the ANN result, as this system evaluates the image of the fruit by a comparison of color change on the skin of the fruit, this system is only able to differentiate 4 index maturity of pineapples rather than 7, this is because from Index 1 to Index 3, the number of red pixel is less than Index 4 to Index 7 as shown in Fig. 6 for training the database. Another reason is, starting from Index 4, the fruit will become yellowish until Index 7 but for Index 1 to Index 3, the fruit remain greenish. Table I shows the result of the ANN for this system.

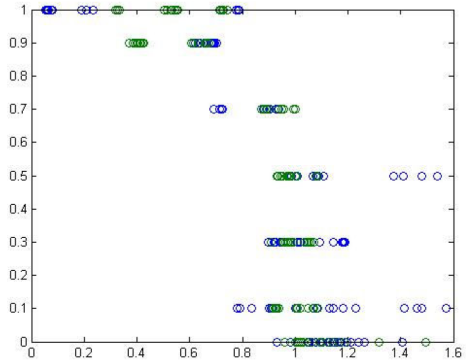

Fig. 6 Training using ANN

TABLE I
RESULTS FOR CLASSIFICATION

Index of Maturity	4	5	6	7
Result of Classification (%)	75	25	65	60

IV. CONCLUSION

In this paper, a system for grading pineapples based on color is presented. Image pre-processing techniques are applied to aid the process of data extraction to be much more accurate and easy. During the sorting stage, the color values obtained are saved in a database for training the Neural Network (NN) process. The test results show the highest accuracy for grading pineapples is 75%.

For future work or continuation of this research, the main factors that contribute the accuracy of this system are the method of collecting data and the amount of data collected. This is because as this system uses the properties of the captured image, especially the color of the subject, the image must be clearly captured with a low amount of noise in the image and a constant environment at the point when the image is captured. Data also must be of a sufficiently high quality to ensure the system is able to produce an output with a high accuracy.

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