Fruit Sorting Based on Machine Vision Technique

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***Abstract*—Nowadays, most of the industries have started to use the automation system instead of manual operating system. Fruit sorting by machine vision technique is a potential automation system which is able to obtain their target in term of productivity and quality. This paper proposes the techniques to differentiate the type of apple based on size. A set of image processing algorithm is designed in order to classify the apple according to the information provided from an image. The image processing techniques such as image enhancement, morphological, image segmentation and HSV image conversion are used for the purpose of differentiating the type of apple based on size. Meanwhile, an experiment is carried out in order to determine the capability of designed image processing algorithm. There are a plenty of problems found during the experiment due to some technical error such as shadow and object surface reflection. From the errors, different methods such as HSV conversion method are used to optimize the performance of fruit classification. As short, the image processing algorithm is able to detect the size of apple**

***Index Terms*—Automation System; Image Processing; Machine Vision.**

I. INTRODUCTION

There are several handling steps of fruit process in fruit processing industries [1]. The fruit after collecting from farm, it will undergo the process of washing, sorting, grading, packing, transporting and storage before going to sell in market. Fruit sorting and grading can be considered as the heaviest processing task compared to the other steps. Normally, more time and effort will be invested in this process. This process can be either operated in manual sorting method or automatic sorting method. Manual fruit sorting is a method operated by human to identify and separate fruit in manual way while automatic fruit sorting is a method can be operated by using the technique of machine vision. Machine vision has been used in the research of mango inspection and grading system, mango maturity prediction and vegetable automation sorting by machine vision [1]. Besides, the fruits such as citrus fruits, apple and strawberry have been used as well. In order to control the quality of fruits, a distributed computer machine vision system for automated inspection and grading of fruits was presented [2]. The automation system is designed for food industries so that the quality of food is able to meet the international standards. Generally, the maturity of fruits requires human's expertise for justifying. Manual sorting is time cosuming, laborious process and diffult to judge by human according to fruit maturity. Hence, maturity prediction system is proposed for predicting the maturity of harvested mango [3].

There are thousand types of camera in the market. Different cameras have different image processing quality. Camera quality is a constraint that should be considered in machine vision system. Normally, high Mega-Pixels of camera will cause a challenge in having too much information. In real system operating time, high resolution camera will cause unacceptable processing time [4]. Large image sizes take longer time to compute and collect data from camera. Thus, selecting an appropriate type of camera based on the requirement is able to improve a vision system in term of efficiency. Besides, another problem should be overcome is the illumination conditions that surround the camera. The colour detection and ability to distinguish an object are can be affected by the surrounding environment [5]. The surrounding lighting condition should be standardized in order to get precise analysis result.

II. METHODOLOGY

A. Description of Image Processing Algorithm Flow

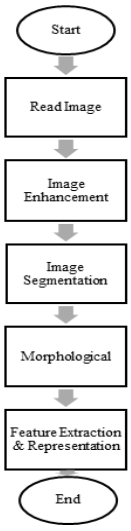

Figure II: Image Processing Algorithm Flow Chart

i. Read Image

First, an image is called from memory in the computer. The selected image is basically used for image processing, analysis, visualization, and algorithm development. The Figure 2 shows the image that been called from memory.

Figure 2: Original Image

ii. Image Enhancement

Image enhancement is an important process to improve the visual appearance of image from a camera so that the output result is able to match with the certain specific application [5]. Image enhancement includes variety of algorithms such gamma correction, contrast improvements, histogram equalization, noise reduction and image sharpening.

In this project, histogram equalization algorithm is used to improve the input images. This method is basically used for the contrast adjustment so that the intensity contrast value can be shown in better distributed on histogram. In short, histogram equalization may be able to lead an image to better views. The Figure 3 shows the image enhancement by using histogram equalization.

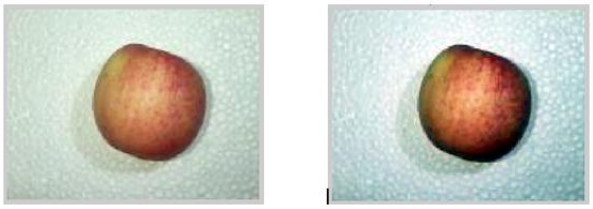

Figure 3: Images Before and After Image Enhancement Process

iii. Image Segmentation

Image segmentation is defined as a process of partitioning a digital image into multiple segments [6]. Segmentation in computer vision is used to eliminate the unwanted information. Once an image has been segmented, the resulting objects can be represented, analyzed and classified with the feature extraction techniques. In this session, thresholding and holes filling technique are applied before undergoing image feature extraction. The Figure 4 and Figure 5 show the methods of thresholding and image complement.

Figure 4: Images Before and After Thresholding

Figure 5: Images Before and After Complement of Image

iv. Morphological Processing

Morphological image processing is an operation that is relevant to the shape or morphology of features in an image [7]. Morphological operation is basically applied to grayscale images. In particular, the binary regions produced by simple thresholding are distorted by noise

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vi. Morphological Processing

Morphological image processing is an operation that is relevant to the shape or morphology of features in an image [7]. Morphological operation is basically applied to grayscale images. In particular, the binary regions produced by simple thresholding are distorted by noise and texture. Noise may contain numbers of imperfections that may influence the analysis result. Thus, morphological technique is able to remove the imperfections by probing the structure of an image. The Figure 6 shows the image that undergoes the morphological image processing technique.

Figure 6: Images Before and After Morphological Processing

vii. Feature Extraction

Feature extraction is the process by which certain features of interest within an image are detected and represented for further processing [8]. This process is the indicator that shows the transition data from pictorial to non-pictorial. The results can be subsequently functioned as an input to a number of pattern recognition and classification techniques. However, the method also had been applied in various applications such as traffic sign [9-12].

B. Experiment

This experiment is to evaluate the performance of the designed image processing algorithm. In this session, different image processing technique such as image enhancement, image segmentation and image extraction are used.

i. Equipments Required

1. CMOS Digital Camera
2. Polystyrene foam board
3. Cardboard
4. Laptop with a software of MATLAB
5. Measuring Tape
6. 2 types with different size of apples
7. 2 LED torch lights

ii. Experiment Procedure

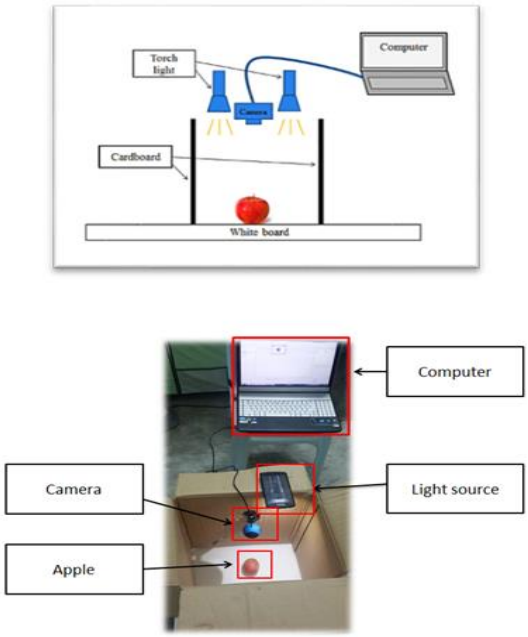

Figure 7: Experiment Setup

1. Figure 7 shows the experiment setup of acquiring images of apples.
2. The position of camera is set to 25cm above from apple.
3. The camera is connected and synchronized with computer.
4. The LED torch lights are switched on and fixed at the positions beside the camera.
5. The surrounding light is switched off in order to minimize external parameters such as surrounding lighting condition that may influence the final result.
6. 3 different samples of each type of apple are used as materials for image acquisition process.
7. Each sample of apple is taken photo for 5 times.
8. The best photo of sample is selected for analysis session.
9. The steps of 6-8 are repeated by using the different type of apple.
10. The performance of each sample are measured and tested by using MATLAB.
11. The results of apple features are recorded in a table.

III. Results And Discussion

A. Image Processing Algorithm Result

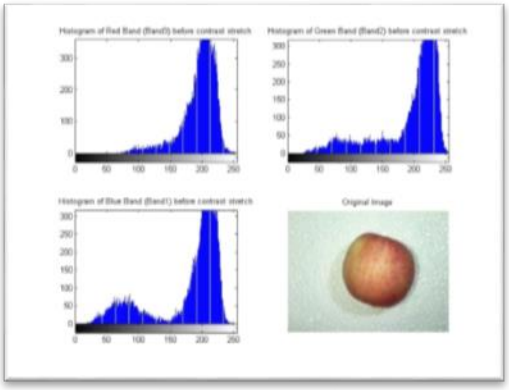

Figure 8: Histogram results of three color components

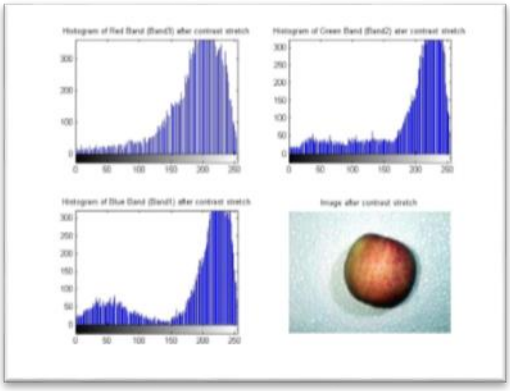

Figure 9: Histogram results of three color components after image enhancement

Figure 8 and Figure 9 show the image contrast change by undergoing the image enhancement technique (Histogram Equalization). Figure 4.1 shows the original image, and plotted histogram of RGB. Obviously, the original image shows a bit improvement after image equalization. The color of apple (Figure 9) becomes brighter compared to the original image. In additions, uniform (flat) histogram results are obtained after histogram equalization.

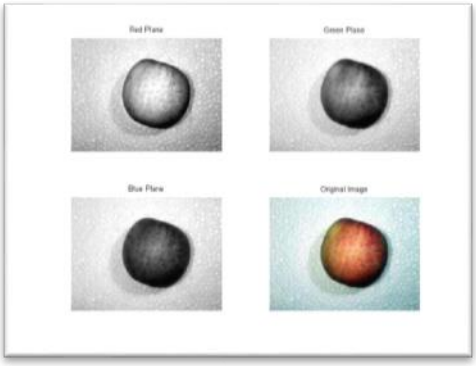

Figure 10: RGB image and its three color components

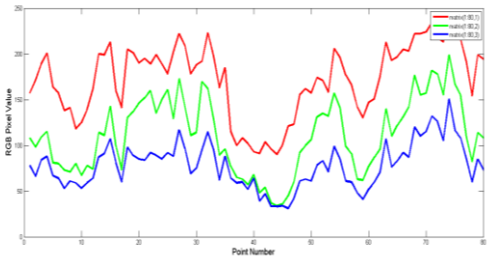

Figure 11: RGB pixel value versus point number

The Figure 10 shows the RGB image and its three different color components that show in grayscale. Comparing the three color components, the image of apple in Red Plane is brighter while the Blue Plane shows the darkest image result of apple. The Red Plane image have been eliminate the color components of blue and green while the Blue Plane image have been eliminate the color components of red and blue. Since the apple in the original image shows the highest Red pixel value (Figure 11), the image of apple in Red Plane displays brighter grayscale result. Besides, original image contains low RGB pixel value of Blue color that consequently causes the apple image in the Blue Plane become the darkest.

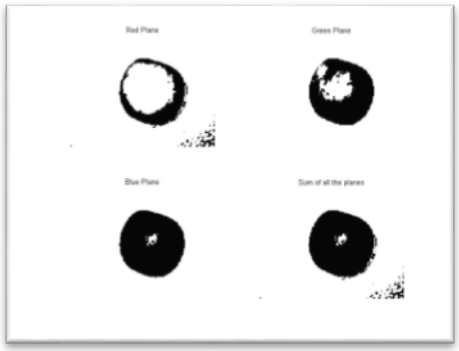

Figure 12**:** Images after thresholding process

Image segmentation is used as an algorithm before extracting the features of image. The Figure 12 shows how the operation of image segmentation ran in different color components.

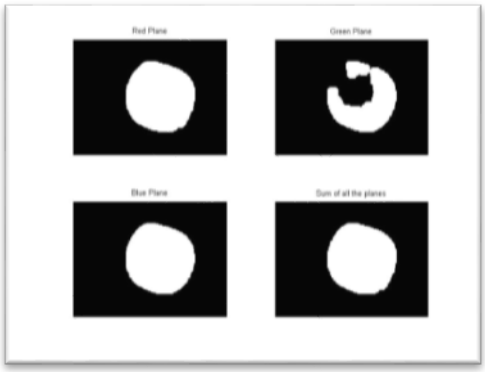

Figure 13: Images after morphological process

Image morphological is the technique used to 'grow' or 'thicken' object in binary image. According to the changes from image segmentation (Figure 12) to image morphological process (Figure 13), it can be noticed that the small points of in RGB plane disappear. Finally, the image processing is done and the RGB plane image is ready for feature extraction.

B. Experiment Result

Table 1
Area pixel results of apples

Pixel Value	Types of Apple					
	Type A			Type B		
	1	2	3	1	2	3
Red Component	6890	6229	6431	error	2206	2064
Green Component	6879	6010	6406	4050	4164	4078
Blue Component	6869	6191	6442	4250	4339	4350
RGB Component	6897	6269	6464	error	4349	4352

Table 1 shows the area pixel of apples. The RGB component amount two types of apple present the highest number of pixel. The pixel values of red component for Type B apples are highly differences compared to other color components. This is because the apple image that shows in only red component value in grayscale does not have enough of information for extracting. The proper method must be choose wisely to produce and accurate reliable and acceptable result [13]. Besides that, the type B first apple shows errors in the red component image and RGB component image. The errors are due to the incomplete of segmentation process. The incomplete of image segmentation causes the image features cannot be extracted.

IV. Conclusion And Future Work

In conclusion, the objective of designing an image processing algorithm for fruit classification is achieved. The experiment of detecting the size of apple is successfully carried out and the image processing algorithm is successfully used to analyze the size of different types of apples. From the experiment, light intensity is an important parameter for image processing. The shadow formed under an apple with low intensity of light is the factor that influences the accuracy of result. In additions, large image sizes require long unacceptable processing time. Thus, using low resolution and suitable camera is better used in designing a fruit sorting system.

In this paper, it only focuses the research on the image processing but the architecture system still has not completely been designed. For future work, the algorithm will be used with the simulation software V-REP. Besides, the designed algorithm is still not fully perfect. Therefore, we shall extend this work to more complex image processing technique and design a more complete algorithm that can be able to extract the features of maturity, defect and quality of apple.

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