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Fruit Grading of Garcinia Binucao (Batuan) using Image Processing

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Abstract*: Digital image processing, along with computer vision techniques, can be applied for automatic gradation of batuan fruits based on the quality of the fruit. It can increase the commercial value of the production. This paper presents an automated approach for fruit grading of Batuan fruits. First, it detects the batuan fruit and then after detection, it classifies the grade of the batuan fruit - Immature (light green), Mature (green) or Ripe (yellow). For gradation, we have used the color features and area of the fruit. The average accuracy for batuan fruit grading is up to 98%.

***Index Terms*: Fruit Grading, Image Processing, Classification, OpenCV**

I. INTRODUCTION

Garcinia Binucao, locally known as batwan or batuan is an endemic Philippine tree usually found in the Visayas region of the Philippines. The batuan tree grows with an average of 20-meter height in the lowland areas. The batuan fruit shape is round and its diameter is around 4cm. Its fruit contains up to 10 seeds that is very sour pulp taste. The color of outer covering is greenish and turns into yellowish when it becomes ripe, its outer covering. This batuan tree grows abundantly as a backyard garden tree and usually mixed with local vegetable dishes. The fruit may be eaten raw or it is mixed with other dishes as flavoring for its sour taste.

In the last decades, researchers applied several techniques and interest in computer vision in fruit detection [1], [2] and [3]. The general goal of these studies are the robotic fruit/vegetable harvesting system which can automatically detect fruit/vegetable in various environment condition. But there are several problems encountered in detecting fruit/vegetable in the uncontrolled environment conditions. In order to overcome these problems, computer vision plays a very crucial role for the success of fruit harvesting.

There are some difficulties with digital systems usage for fruit detection. Occlusions because of the leaves and branches cause obstacles on the image. The other important effect is outdoor conditions, especially illumination and shadow conditions because of sunshine. Also, different objects which have different forms, sizes, and structures can affect image analysis. In light of this information, it can be said that to get reach the best result on fruit detection, data is very important. In recent years, application of machine vision in agriculture has increased significantly. In the past, a lot of research work has been carried for automated grading of fruits. The size gradation technique using mechanical roller belt for distinguishing large and small sized fruits are modeled [4], [5] and [6]. Several models are proposed for weight-based fruits gradation [8] and [9]. A manually operated onion grader system was designed to evaluate uniformity, capacity, accuracy, damage, and size are used for gradation of rose onion [10]. They have used three methods of sorting; one by manual selection; another by using semi-automatic sorting and an automatic sorting. In [11] they have presented an online fruit grading using machine vision based on their external quality. Using the European standards, apples are graded into four. Few other researchers [13], [14] and [15] have proposed several methods using machine vision techniques for fruit grading. The overall review of these techniques is discussed in [7]. The main contribution of our proposed system is the development of an automated system for grading of harvested batuan fruit. In this study, light green for immature, green for mature and light yellow color for ripe batuan fruits were selected for comparing detection success rates of fruits in different colors and under various lighting conditions. The applied algorithm codes were written and run in OpenCV.

II. RELATED WORKS

In recent years, a bunch of proposals have been introduced in the field of an automated system for grading and classifying the fruits. All the proposed papers commonly discussed the identification of fruits based on external testing of the fruit (i.e.., by color changes and skin disorders).

A method to detect and classify the quality of apples defect has been proposed by Unay [5] using multilayered perceptron-neural networks, in which the authors performs tests on a single-layer and multilayer perceptron by focusing on the defects of the varieties of apples and analyzing the quality of apples by taking color, texture and wavelet features of an outer skin of the fruits A grading system for apple fruits has been proposed by V. Leemans [6] focusing on the external features of the fruit. He used more than a 1000 images of apple fruits consisting of 528 Golden Delicious apple varieties and 642 Jonagold apple varieties. These images have three acceptable categories, the Extra, I and II and the reject for each class represents 60, 10 and 20% of the sample size.

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The grading of apple fruit images was performed in six different steps: acquisition of images; classification of colors; segmentation of apple defects; recognition of calyx and stem; characterization of fruit defects and lastly the apple fruit classification.

Their study achieved a highest classification rate of 78% and a lowest classification rate of 72% for grading the Golden Delicious and Jonagold apple fruit varieties.

The study K.Vijaya Rekha [7] employed multispectral imaging techniques to analyze the apple quality. It works with the images of the apples in different infrared regions of the electromagnetic spectrum. The techniques used in this study are image processing; image segmentation and multivariate image analysis. The system was able to classify defects on several varieties of apple.

The study of Kazuhiro Nakano [14] integrate a neural network to classify and grade a San-Fuji variety of apples into five quality classes. Apple fruit image color values is acquired and saved in the database. This images were feed to the neural network. The output is done with the computation of fruit variability, mean color and the ration of red color of the fruit apple A 95% accuracy has been obtained based on global classification rate of 70%.

A study that combines size, color, and shape of the fruit has been conducted in order to increase the accuracy rate of fruit recognition [15]. The system uses a nearest neighbor's classification algorithm to classify and recognize fruit images based on the feature values obtained. The system was able to recognize and classifies fruits up to 90% accurately.

In [16], obtained a highest accuracy rate in sorting and grading fruits based of the fruit shapes and fruit size using Fuzzy Logic and Support Vector Machines. An Image processing technique based on the fruit size achieved a highest rate in detecting and grading the fruits [17]. Embedded system for grading fruits is used to implement the algorithm which are low cost and high in accuracy of grading fruits.

In [18], uses color, shape and size in grading the Coffee-Excelso beans. It helps the authors to find a high quality green bean from a small amount of samples. The study achieves a high quality rate of grading.

In [19], presented a novel approach for grading lemon based on color and size. The volume and color of the lemon are determined and images are saved in the database during the calibration stage. Fruit images are then compared with the images stored in the database based on their color features and sizes. Then, these images will be determined for the final grade of the lemon. The accuracy achieved was 94.04% in determining the overall fruit grade.

III. METHODOLOGY

In this study, two sections will be presented. First, we have to identify and recognize the batuan fruit, then we have to grade the harvested batuan fruit. Therefore, the first phase is fruit identification. Information such as color, texture or surface information, shape and size is included in the fruit identification. We only focusing on the surface information to characterize the fruit so that it will be able to combine color and texture features for batuan fruit recognition.

The recognition consists of two parts:

1) Training

2) Classification

For training, we first have to pre-process the image. In a real situation, it is necessary to cope with variation of illuminations, background image clutter, image-shading, and image shadows. We will perform background subtraction in order to reduce the complexity of the scene and it will allow the focus on the description of the object.

For grading, the captured batuan fruit images are sent to the computer for the purpose of analyzing (using OpenCV). Then, it computes the size and area of captured fruit image. The captured fruit image is compared with the images that stored in the database. If matched is found in the database, it will be selected for further processing and sort the grade of the fruit wise (light green for immature, green for mature and light yellow color for ripe), otherwise, it will not select.

Algorithm of the proposed system:

1) Read the image – both for training and testing.

2) Then Pre-process the fruit image for further feature extraction.

3) After detecting the fruit, we have to measure the quality; this module calculates area and color of batuan fruit.

5) Gradation is done after matching with database and result in grade light green for immature, green for mature and light yellow color for ripe.

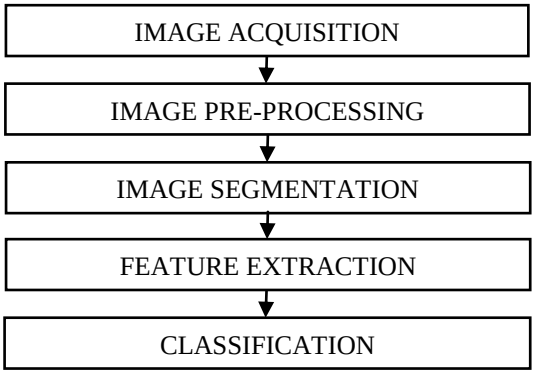

Fig. 1. Block diagram of the proposed methodology

The process of fruit grading is divided into two parts, image processing, and machine learning. The fruit images are captured from the field. These images are further processed using image processing operations and at the end, machine learning model classifies the fruit based on the image features. Various steps of image processing include image background removal, noise removal, image resizing, image segmentation, image feature extraction, while machine learning includes feature selection and classification. For different image dataset, techniques at each intermediate step might vary. For example, image resizing is not necessary every time, some image database contains images with low resolution. The evaluation of the system is carried out by the machine learning evaluation metrics such as accuracy, precision, recall, and confusion matrix.OpenCV is used to process the image processing algorithms in the study. Open Source Computer Vision Library (OpenCV) is an open library that has several hundreds of source computer vision algorithms. API of OpenCV allows for automatic memory allocation and deallocation.

This is reducing the amount of programming complexities for programmers. OpenCV-Python is an integration of OpenCV with the Python programming language.

Python syntax is simple and easy to use. It emphasis on readability and uses standard keywords.

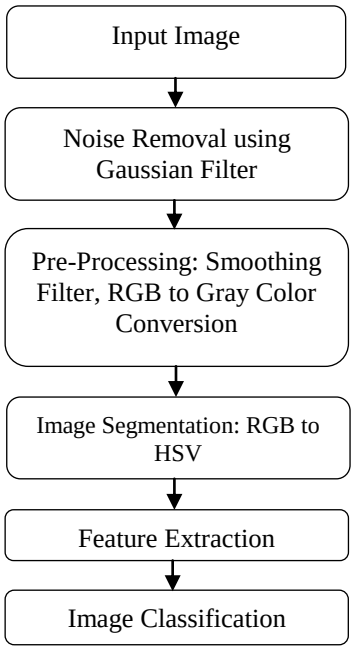

Fig. 2. Batuan fruit grading block diagram

A. Image Acquisition

The images of the batuan fruit are captured through the camera in a controlled background and are stored in the JPEG or PNG format. This image is in RGB (Red, Green, and Blue) form. Color transformation structure for the RGB batuan fruit image is created, and then, a device-independent color space transformation for the color transformation structure is applied.

B. Image Preprocessing

To remove noise in the fruit image or another object removal, several pre-processing techniques are considered. Image cropping of the fruit image to get the interested image region. Smoothing of fruit image is done using the smoothing filter. Increasing the contrast of the fruit image is done using Image enhancement.

C. Image segmentation

Segmentation means partitioning of an image into various part of same features or having some similarity. Image segmentation can play a vital and important role in batuan fruit detection. Image segmentation means to divide the image into particular regions or objects. The primary goal of segmentation is to analyze the fruit image data so one can extract the useful features from the data. There are two ways to carry out the image segmentation: (1) based on discontinuities and (2) based on similarities. In a first way, an image is partitioned based on sudden changes in intensity values, e.g., done via edge detection. While in a second way, images are partition based on the specific predefined criteria, e.g., thresholding is done using Otsu's method.

D. Feature Extraction

The feature extraction aspect of image analysis focuses on identifying inherent characteristics or features of objects present within an image. The features are used to describe the object. Generally, features under the following three categories are extracted: color, shape, and texture. The color is an important feature because it can differentiate one ripeness of the fruit from another. Texture means how color patterns are scattered in the image.

E. Color Detection

The color is detected using RGB values. So for e.g., three colors are considered, say ripe batuan fruit having a yellow color, mature batuan fruit having a light green color and immature batuan fruit having a green color. An algorithm for color detection [16] is used to determine the color of the batuan fruit. Here are the steps for determine the color.

1) Read and store the image of batuan fruit. Determine the color of input pixel in RGB and store it into three variable ri1, ma1, and im1.
2) Read them from a different location (pixels) of image and then Calculate the mean of ri1, ma1, im1 and store into variable ripe, matr, imma.
3) We can store these values in the database for each class of batuan fruits and later it can be matched with our batuan test fruit.

F. Classification

Classification maps the image data to a specific groups or classes. Classification is usually called a supervised learning approach. Classification is a two-step process: First, the classifier model is generated which describes the predefined set of classes. This step is called a learning phase (Training step), where classification algorithm develops the classifier by "learning from" the data with their specific class labels. In the second step, the model, which is generated in first step, is used for classification. In other words, test data is used to estimate the accuracy of the trained model by evaluating how good it performs on the test data. In the fruit classification, the ripeness of batuan fruit is classified according to the features extracted from the images. Different classification models are support vector machine, neural network, nearest neighbor, and rule-based classifier.

IV. RESULT AND DISCUSSION

All the image pre-processing, feature extraction and classification techniques in our proposed method are simulated in OpenCV and run on an Intel(R) Core(TM) i5 8th generation processor with 12GB memory and 2GB video card. Listed below are the number of trained and tested batuan fruit images with entries from each category. Table 1 shows the number of batuan fruit images for immature, mature and ripe in training and testing case.

Fig. 3. Images of Batuan fruit with immature grading from left, mature grading image in the center and ripe grading in the right

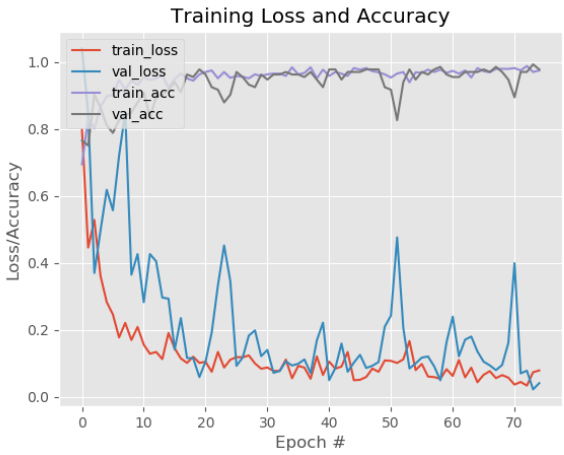

Fig. 4. Result of training accuracy and loss

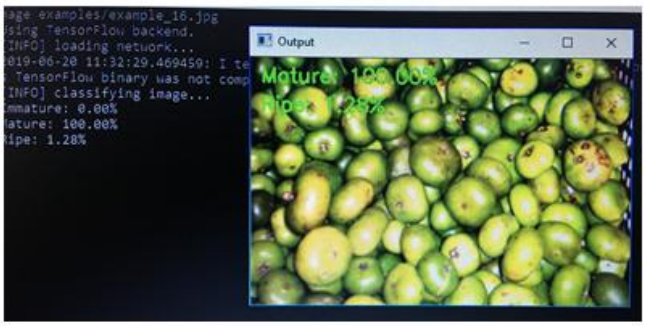

Fig. 5. Result Batuan fruit grading with a classification of 100% mature

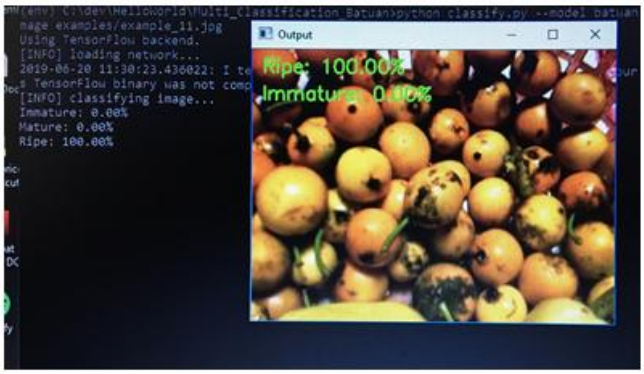

Fig. 6. Result Batuan fruit grading with a classification of 100% ripe

Fig. 7. Result Batuan fruit grading with a classification of 99.99% mature and 63.38% Immature

TABLE I. LIST OF IMAGES USED FOR THE EXPERIMENT

Training			**Testing**		
Immature	Mature	Ripe	Immature	Mature	Ripe
100	100	100	20	20	20

The Performance of all classifiers can be tested and evaluated by the following parameter:

Accuracy rate = correctly classified images / Classified images. (1)

Figure 5 shows the result of grading of batuan fruits with the grade of 100% mature. Figure 6 shows the result of grading of batuan fruits with the grade of 100% ripe. While, figure 7 shows a result 99% mature and 63.38% immature. The average accuracy for batuan fruit grading the accuracy is up to 98%.

V. CONCLUSION

The main advantage of this method is the use of computer vision instead of depending on human expertize. We have obtained an accuracy of 98% for batuan fruit grading. Hence, it can be concluded that our proposed method is efficient for automated batuan fruit grading from images. We can improve the accuracy of grading of batuan fruit up to 100 %. Thus, we need to increase the number of batuan fruit images to be trained. We can also extend this work by incorporating other fruit varieties and enhance the algorithm of our system to include a fruit recognition and detection system and fruit grading. We can incorporate the shape feature to detect more precisely the quality of the fruit. This method is intended to help the agriculturalist and farmers by freeing them from the burden of time-consuming manual gradation.

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