Image Processing Techniques for *Harumanis* Disease Severity and Weighting Estimation for Automatic Grading System Application

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***Abstract*—Harumanis Mango is known as the king of Mangoes. It is very nutritious and rich with carotenes. However, many of the farmers and agriculture experts reported that they have problems in grading and inspecting the Harumanis Mango. Sometimes, Mango production loses its quality due to diseases that are not even visible to the naked eyes. Traditionally, farmers and agriculture experts will estimate the severity of the disease using their experiences. While for weight estimation, manual inspection was done by using a weight scale. This traditional method has its own drawbacks as it can lead to some errors due to inconsistencies made by human inspection. Furthermore, they are less efficient and very time-consuming. Therefore, an automated procedure that able to classify the disease severities and weight estimations would be much appreciated. With the aid of image processing techniques, diseases can be classified according to its scale, and its weight can be estimated. A number of pixels of Harumanis Mango will be used for classification. The analysis will be done by using the statistical method of regression. It shows that the accuracy of weight estimation is 72.25%.**

***Index Terms*—Image Processing; Disease Severity; Harumanis; Weight Estimation.**

I. Introduction

Mango is one of the world's most popular tropical fruits with a rising production trend every year [1]. In Peninsular Malaysia, Mango is grown in a limited, mixed property or orchard. According to "Fruit Crops Statistics" report produced by Department of Agriculture Putrajaya, Malaysia in 2015 the area of Mango orchard in Peninsular Malaysia is 5772.7 hectareage [2]. Today, there are over 300 cultivars with fruits considerably in different size, shape colour, flavour and fibre contents. A good Mango is juicy and sweet and may also have its own attractiveness and variation.

One of the well-known Mango cultivars is Harumanis [3]. This cultivar is distinctive to Perlis and known in the national agenda as a speciality fruit from Perlis for the world.

Harumanis is famous because of its great taste and smell. However, due to radical climate changes from hot to humid, the Mango is exposed towards some diseases which will affect its production if not being monitored and inspected correctly.

According to Federal Agricultural Marketing Authority (FAMA) Malaysia, the Harumanis mango quality is determined by its size and weight [4]. Besides that, disease spreading is another one of the factors that influence the Harumanis mango quality decision making. The process of classifying mangoes generally depends on its physical characteristics. This process is done by using manual labour and is incredibly dependent on the human visual system. Uniformity in the classification process is essential so that its output is guaranteed to satisfy the requirements of the buyer. Figure 1 shows the manual sorting for Mango that has been done by the orchard workers [5].

Figure 1: The manual sorting for Mango that has been done in a local rural industry [5].

In recent years, machine vision technology has become possible and more important in many areas including in the agricultural industry application. The conventional inspection process which is subject in nature is gradually being replaced by computer vision techniques [6]. Examples of application of machine vision technology in agriculture-based are for quality inspection, classification, sorting, and grading. By implementing the automated vision techniques, it does not only speed up the processing time but also reducing errors. Many companies are moving to machine vision technology in many crops such as on peaches and oranges [1].

II. Literature Review

A. Elements of Machine Vision System

The fundamental of machine vision workstation includes one Personal Computer (PC), a webcam, cables and a container to fit all of the tools as shown in Figure 2, while Figure 3 shows the basic element that is essential of in a machine vision system [7].

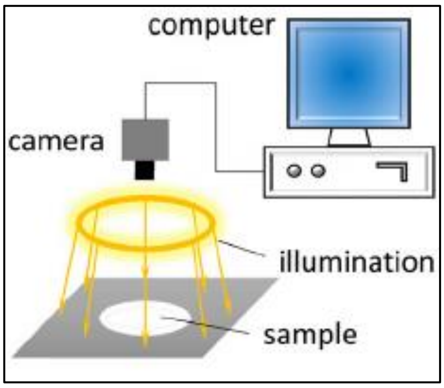

Figure 2: The fundamental of machine vision workstation

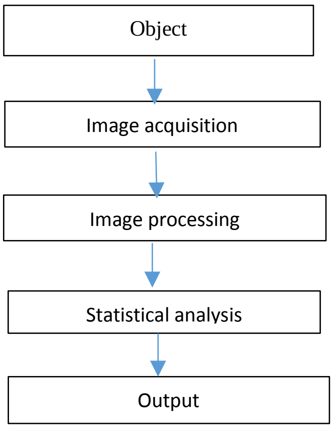

Figure 3: The basic element of machine vision workstation

Image analysis and processing development comprise three level which includes low-level processing, intermediate level processing and high-level processing. The low-level processing includes image acquisition and pre-processing such as extraction, image enhancement and restoration. The intermediate level processing is focusing on the image transformation such as RGB transformation, segmentation and filtering. Finally, the high-level processing involved recognition and interpretation.

B. Role of Image Processing in Agriculture Application

Image processing can be used in agricultural applications for many purposes like disease detection on leaves, stem and fruit like in apples and grapes, as well as monitoring disease spreading and computing weight of fruits. In mango grading, biochemical parameter like Total Solid Soluble (TSS) and physical parameters like sizes and shapes can be used.

Apart from that, disease severity and mango weight can also be utilised to grade a Mango. Statistical analysis has proved that the Mango pixels have a very high correlation with the Mango weight [4]. Therefore, through these two methods, grading of Mango can be done. If the fruit is large and heavy that does not mean its quality is good, there can be some diseases on the fruit. Therefore, based on weight and the spreading of the disease it can finally show the quality of the fruit, and through this quality, grading of fruit can be done quickly. Figure 4 below shows the Harumanis mango that was sold in different weight and has several diseases on it.

Figure 4: Harumanis mango that was sold in different weight and has several diseases on it.

III. METHODOLOGY

300 samples of Harumanis mangos was taken in random and categorised into three different grades which are grade A, B and C based on its size. Agriculture experts inspected the sample of each fruit in Ladang Harumanis, Santan Kangar, Perlis. Table 1 shows the details about the number of samples for each grade. To avoid the degradation, all image of the fruits were taken after 12 hours of inspection. They were stored at room temperature.

Table 1
Details about the Number of Samples for Each Grade

Grade	Number of Samples
A	100
B	100
C	100

Images of the Harumanis mangoes are taken from a digital camera at a fixed distance of 22cm. For disease severity test, image acquisition by the digital camera is made in RGB format. For a better quality resolution, the images are saved in the BMP format [8]. Next, the RGB images are converted into grey-scale by eliminating the hue and saturation information.

For the disease evaluation parameters, the dark spot pixels area or infected tissue area that occurred on Harumanis mango are counted as well as the healthy part too. The infection was identified by symptoms such as cankers, oozing, rotting and blackening [9]. Therefore, disease incidences can be calculated as shown in Equation 1 while Table 2 shows the details about the disease scoring scale for Mango in general[10].

$$\%Percent\ \text{infection} = \frac{A_d}{A_t} \times 100\% \qquad (1)$$

where A_d = Total number of pixels in the disease area
A_t = Total number of pixels

Table 2
Disease Scoring Scale for Mango

Percentage Severity	Scale
0-1	1
2-5	2
6-10	3
11-49	4
50-100	5

For the weight analysis, we need to find the total pixel values of infected tissue area as well as healthy tissues. The statistical technique was used to analyse the data. The analysis was done for severity estimation and weight estimation by using the number of pixels information. To calculate the estimated weight, Equation (2) was used [4]. The statistical regression method was used to analyse the data.

$$weight = 0.0029 \times Pixel - 17.084 \qquad (2)$$

where Pixel must be the total number of healthy tissue and infected tissue.

IV. Results and Discussion

A. Disease severity analysis

Figure 5 shows the example of RGB image for Harumanis mango while Figure 6 to 8 shows the Harumanis Mango with different level of disease severity categorised by human inspection in grey-scale.

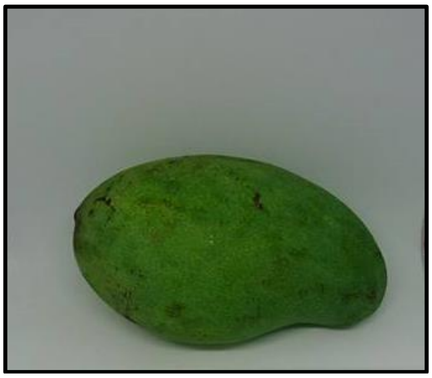

Figure 5: Harumanis Mango in RGB

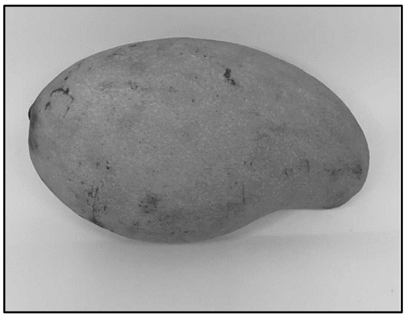

Figure 6: Harumanis Mango with low disease severity in grey-scale

Figure 7: Harumanis Mango with moderate disease severity in grey-scale.

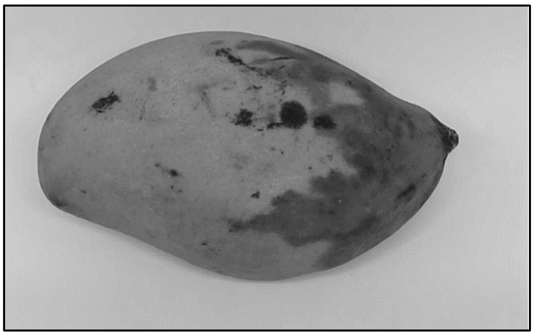

Figure 8: Harumanis Mango with low high disease severity in grey-scale

Based on Figure 6, we can obtain the disease severity as shown in Equation 3. By referring to Table 2, we know that the scale of this disease is 2. The experiment was done for all 300 samples, and the scale automatically produced by using MATLAB. Figure 9 shows the bar chart plot of disease severity scale for each grade with their own frequency in some samples. Even though human says that it is Grade A, for example, it also has some disease on it. Based on the plot, we can say that even though fruit is large and heavy, that does not mean its quality is excellent.

$$\%Percent\ \text{infection} = \frac{7117}{167873} \times 100\% \\ = 4.2395\% \qquad (3)$$

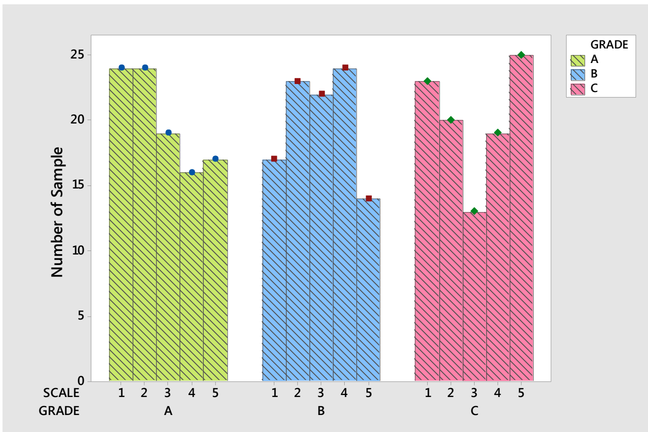

Figure 9: Bar chart of disease severity scale for each grade

B. Analysis of Weight Estimation using Number of Pixels

Normality test has been done to investigate either the data is normally distributed or not. Three methods were conducted in the test; Anderson -Darling, Ryan-Joiner which is similar to Shapiro-Wilk, and Kolmogrov-Smirnov. From the statistical point of view, H-null hypothesis is accepted since the significant value is larger than *p-value* (0.05). The Q-Q plot is produced to investigate the pattern of the normality test for both estimated weight and actual weight. Figure 10, shows the Q-Q plot for the estimated weight. Since the data points lie along the line, it strongly agreed that the data is normally distributed.

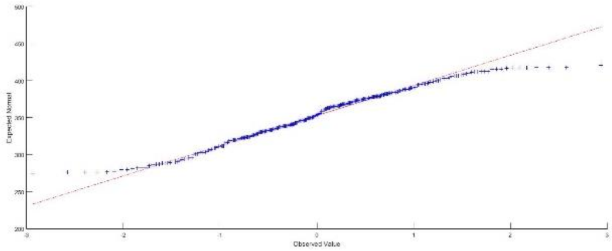

Figure 10: Q-Q plot for weight estimation

Because of all the data consist of a random sample of paired observations of numeric, the Pearson, *r* has been used in this paper. The purpose to used Pearson, *r* is to measure the strength of the relationship between two variables. In this case, the variable between estimated weight and actual weight will be investigated. Figure 11, shows the regression scattered plot between the estimated weight and actual weight.

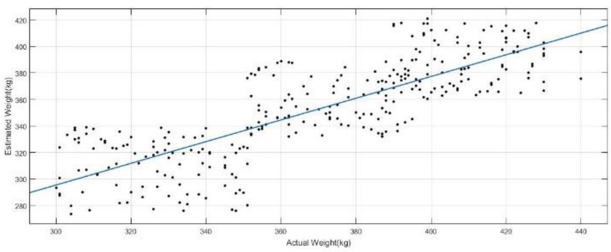

Figure 11: Correlation graph for theoretical and actual weight

The correlation formula derived based on the collected data is shown in Equation (4):

$$w_e = w_a 0.8186 + 49.89 \tag{4}$$

where w_e = estimated weight
w_a = actual weight

A Pearson, *r* correlation test showed that the relationship between estimated weight and actual weight are statistically significant with a value of *r* is 0.85 and *p-value* is 0.00. This means that H-null is rejected and the weight estimation and actual weight are positively related. Based on the value of Pearson, *r*, the accuracy of the estimated weight techniques based on a number of the pixel can be determined. The accuracy of this techniques is 72.25%.

Figure 12 shows both the estimated and actual weights result versus some samples that conduct in this experiment. Based on the graph, we can see the estimated weight does not differ too much from the actual value. Therefore, this has proven that the number of the pixel can be used to estimate the Mango's weight.

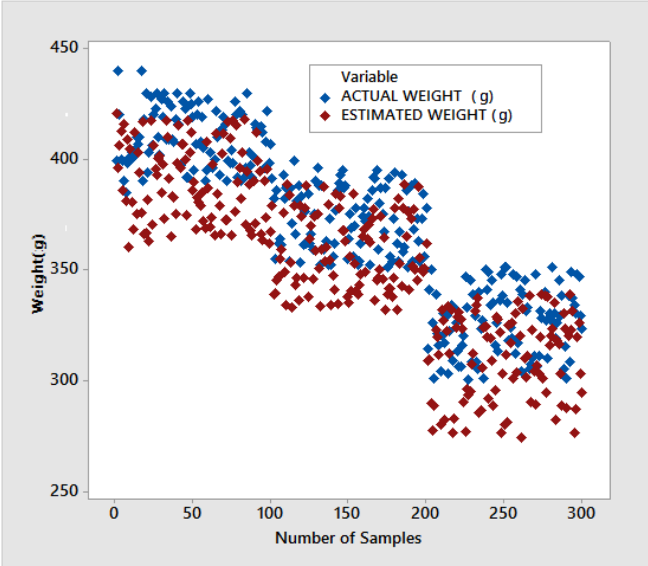

Figure 12: Scatter plot of actual weight and estimated weight versus the number of Harumanis mango samples

V. CONCLUSION

Based on these experiments, the process of disease severity detection and weight inspection can be done automatically, and errors caused by human inspections can be reduced. By developing this project, it will help other agencies like the Department of Agriculture (DOA), Malaysian Agricultural Research and Development Institute (MARDI) and Federal Agricultural and Marketing Authority (FAMA) Malaysia as well as farmers in decision making related to the quality inspection of the Mango. Besides that, the method for this Harumanis may be applied to another type of crops for the detection of diseases and quality inspection purposes elsewhere in the world. It is recommended that for further research, an online system for classification of disease severity fused with weight estimation to classify the grade of the Mango can be developed to help farmers or agriculture experts. To get higher accuracy, a camera with higher resolution might be used in the future.

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REFERENCES

[1] T. U. Ganiron, "Size properties of mangoes using image analysis," *Int. J. Bio-Science Bio-Technology*, vol. 6, no. 2, pp. 31–42, 2014.

[2] F. C. Statistic, "Statistik tanaman buah-buahan," 2015.

[3] H. Faridah, M. Rosidah, and M. Y. Jamaliah, "Quality assessment towards VHT Harumanis mango for commercial trial to Japan," *J. Agribus. Mark.*, vol. Special Ed, pp. 77–90, 2010.

[4] M. Jhuria, A. Kumar, and R. Borse, "Image processing for smart farming: Detection of disease and fruit grading," *2013 IEEE 2nd Int. Conf. Image Inf. Process. IEEE ICIIP 2013*, pp. 521–526, 2013.

[5] M. A. Momin, M. T. Rahman, M. S. Sultana, C. Igathinathane, A. T. M. Ziauddin, and T. E. Grift, "Geometry-based mass grading of mango fruits using image processing," *Inf. Process. Agric.*, vol. 4, no. 2, pp. 150–160, 2016.

[6] V. Ashok and D. S. Vinod, "Automatic quality evaluation of fruits using Probabilistic Neural Network approach," *Proc. 2014 Int. Conf.*

Contemp. Comput. Informatics, IC3I 2014, pp. 308–311, 2014.

[7] H. Hong, X. Yang, Z. You, and F. Cheng, "Visual quality detection of aquatic products using machine vision," *Aquac. Eng.*, vol. 63, no. December, pp. 62–71, 2014.

[8] P. Mitkal, P. Pawar, M. Nagane, P. Bhosale, M. Padwal, and P. Nagane, "Leaf Disease Detection and Prevention Using Image Processing using Matlab," pp. 26–30.

[9] A. Masood, S. Saeed, N. Iqbal, M. T. Malik, and M. R. Kazmi, "Methodology for the evaluation of symptoms severity of mango sudden death syndrome in Pakistan," vol. 42, no. 2, pp. 1289–1299, 2010.

[10] A. Amna Malik, ShaziaIram, "Current status of mango pre and post-harvest diseases with respect to environmental factors," *Int. J. Agron. Agric. Res.*, vol. 8, no. 4, pp. 101–110, 2016.