IMAGE PROCESSING AND ANALYSIS TECHNIQUES FOR ESTIMATING WEIGHT OF MANGOES

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2021

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A report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Mechatronics Engineering with Honours

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this thesis entitled "IMAGE PROCESSING AND ANALYSIS TECHNIQUES FOR ESTIMATING WEIGHT OF MANGOES" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : NUR AZREEN AZWA BINTI NGAHADI

Date : 05.07.2021

APPROVAL

I hereby declare that I have checked this report entitled “title of the project” and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

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Date : 05.07.2021

DEDICATIONS

To my beloved mother and father, my respected supervisor and my fellow friends.

Thank you for giving me endless supports, encouragement, moral supports and motivation given to me to finish up this thesis.

May Allah bless and protect all the people around me.

ACKNOWLEDGEMENTS

All thanks to Allah SWT. Alhamdulillah! I wish all of those who have contributed to the success of our project to convey my profound thanks. They have helped me to comprehend and think. I would first of all want to offer my heartfelt thanks for support, advice, understanding and inspiration to my project supervisor, Dr Hairol Nizam bin Mohd Shah. It can be hard for me to refer to anything that I did not know without its continual and eternal support and patience from the start till the end of this undertaking.

I am highly thankful to my panel, Assoc. Prof. Dr. Muhammad Herman bin Jamaluddin for his honest evaluation on my idea of this project. During the seminar, he also gives his thoughts on idea to improve for my project.

Finally, I want to thank my loving parent, relatives and friends and encourage me to achieve my ambitions constantly and without division. Without them this adventure was not feasible. My gratitude also goes to the participants who directly or indirectly participate in this project's accomplishment. You have been so graciously appreciated for your desire to guide me.

ABSTRACT

In today's scenario, image processing has played a major role which frequently implemented in applications such as image sharpening and restoration, colour processing, quality grading and inspections. This project was focused on image sharpening and restoration which is referred to as process images that been captured from the image acquisition setup. For quality grading, it is widely used in agriculture applications such as fruit quality in terms of weight, volume, colour, size and shape. The problem of quality grading on the farm is the grading process being carried out manually. The results of the manual grading procedure are typically unreliable, time-consuming and prone to mistakes, given the different skill levels and experience of human workers. The project planned to carry out an image processing algorithm and analysis techniques for measuring the weight of mangoes. Depending on the applications of the image processing algorithm, several criteria had to be taken into consideration such as the size of the mango image in terms of high resolution or the speed of the performance in processing the image. Used for processing and analysis of pictures taken from the image capture equipment is Matrix Laboratory (MATLAB) software. The image processing algorithm was including image enhancement, image adjustment, image thresholding and features extraction. The number of pixels from the image was then tallied in the mango region. In order to analyse the relationship between actual mango and mango pixels, the linear regression model was built. The correlation coefficient, R^2 value for the method developed is 0.98. The performance of the method was evaluated in terms of accuracy and error to know the method is valid to use or not. The weight estimation method obtained the Root Mean Square Error (RMSE) value of 2.29 % and the accuracy is 97.71%. For the size classification, the accuracy is 100% by using the Gaussian Naive Bayes classifier learner with the training time is 0.1 second.

ABSTRAK

Dalam senario hari ini, pemprosesan gambar telah memainkan peranan utama yang sering dilaksanakan dalam aplikasi seperti penajaman dan pemulihan gambar, pemprosesan warna, penilaian kualiti dan pemeriksaan. Projek ini difokuskan pada penajaman dan pemulihan gambar yang disebut sebagai proses gambar yang diambil dari penyediaan pemerolehan gambar. Untuk penilaian kualiti, banyak digunakan dalam aplikasi pertanian seperti kualiti buah dari segi berat, isipadu, warna, ukuran dan bentuk. Masalah penggredan kualiti di ladang adalah proses penggredan dilakukan secara manual. Hasil prosedur penilaian manual biasanya tidak boleh dipercayai, memakan masa dan terdedah kepada kesilapan, memandangkan tahap kemahiran dan pengalaman pekerja manusia yang berbeza. Projek ini merancang untuk menjalankan algoritma pemprosesan gambar dan teknik analisis untuk mengukur berat buah mangga. Bergantung pada aplikasi algoritma pemrosesan gambar, beberapa kriteria harus dipertimbangkan seperti ukuran gambar mangga dari segi resolusi tinggi atau kecepatan kinerja dalam memproses gambar. Digunakan untuk memproses dan menganalisis gambar yang diambil dari peralatan menangkap gambar adalah perisian Matrix Laboratory (MATLAB). Algoritma pemprosesan gambar merangkumi peningkatan gambar, penyesuaian gambar, ambang gambar dan pengekstrakan fitur. Jumlah piksel dari gambar kemudian dihitung di wilayah mangga. Untuk menganalisis hubungan antara mangga dan mangga piksel sebenar, model regresi linear dibina. Pekali Korelasi, nilai R^2 untuk kaedah yang dikembangkan adalah 0.98. Prestasi kaedah ini dinilai dari segi ketepatan dan kesilapan untuk mengetahui kaedah itu sah digunakan atau tidak. Kaedah anggaran berat memperoleh nilai Ralat Kuadrat Punca Min (RMSE) sebanyak 2.29% dan ketepatannya adalah 97.71%. Untuk klasifikasi ukuran, ketepatannya adalah 100% dengan menggunakan pelajar pengkelasan Gaussian Naive Bayes dengan masa latihan adalah 0.1 saat.

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LIST OF SYMBOLS AND ABBREVIATIONS

2D	-	2-Dimensional
3D	-	3-Dimensional
PPI	-	Pixels Per Inch
RGB	-	Red, Green and Blue
HSV	-	Hue, Saturation and Value
OpenCV	-	Open Source Computer Vision
MATLAB	-	Matrix Laboratory
SVM	-	Support Vector Machine
LabVIEW	-	Laboratory Virtual Instrument Engineering Workbench
CCD	-	Charged-Couple Device
RMSE	-	Root Mean Square Root
R^2	-	Correlation Coefficient Value
g	-	gram
s	-	second

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CHAPTER 1

INTRODUCTION

1.1 Motivation

National fruit mango contributes a major part to national growth. For increment in the profitability of the agriculture industry the proper detection, grading and packaging of fruit are very important. Mango is one of the fruits grown in Malaysia with an export value of 2 million tons in 2019. Malaysia can grow a significant quantity of mango of high quality in order to raise the value of mango exported to the world market. An important step in the fruit processing is post-harvest handling, such as washing, grading and packing, to ensure the consistency of the fruit. Sorting is one of the main processes for assessing fruit consistency and pricing. High graded fruit is calculated on the basis of height, maturity index and external fruit defects.

Image processing is a method of executing such image operations to produce an enhanced image or to obtain useful information from it. It is a type of signal processing where an image is entered, and the image or features associated with this image can be generated. In recent years, image processing methods have gradually been applied to the evaluation of food quality. The paper addresses recent progress in imaging methods for food quality measurement such as charge-coupling cameras, ultrasound, magnetic resonance imaging, computed tomography and electric tomography for picture acquisition, pixel and local method of pre-processing. For the pre-processing of images, such as threshold, gradient, region-based and image classification; size, form, color and texture functionality. For calculating artifacts and math, fuzzy logic and classification approaches for neural networks.

For ensure the quality of the mango with high graded, image processing techniques is used to determining the weight. The estimation of the mango weight in this project is to measure the mango weight using the illustration of the mango. Image processing techniques are dedicated to allowing fast and precise field fruit crop yield

forecasts. The key goal of the project is to measure the approximate weight of the mango using the techniques of image processing and analysis.

1.2 Problem Statement

Agriculture is one of the important aspects that contribute to the economics of many Asian countries, including Malaysia. From that, the quality of agricultural products like mangoes is important to achieve customers' demand. The ISO standard also defines product quality as the entirety of features and characteristics of a product or service that has the potential to satisfy explicit or tacit requirements, whereas the quality of agriculture is defined as a metric of perfection or a state of being free from flaws, shortcomings and major variations.

In order to ensure good fruit quality, the important step in the processing of mango is the post-harvest method of washing, grading and packing. Grading is a key step in assessing the consistency of mango and then pricing. The size of mango is the main parameter to identify the quality of mango. The size of the mango is determined by weight. The grading process is being carried out manually. Owing to the various skill levels and expertise of human workers, the outcome of the manual grading process is often unreliable, time-consuming and prone to cause errors. The advancement of image processing methods and computer vision technologies allows this tedious procedure to be streamlined in order to generate bias-free and realistic images [1].

In this research, we create an alternative way to identify mangoes based on weight automatically by using image processing and visualization techniques via a computer vision system. The mango pixels counted have a high relationship to the mango weights with a low correlation coefficient value. Several collections of mango samples will be evaluated by constructing a linear regression model based on the precision of the mango weight estimate. The mango is classify based on the size range which is large, medium and small size.

1.3 Project Objectives

This project will be conducted based on the following objectives:

1) To develop an image processing algorithm and analysis techniques based on mango weight estimation.
2) To determine the relationship between mango pixels and actual weight by using a linear regression analysis.
3) To evaluate the performance of the method developed by calculate the accuracy and to classify the size of mango.

1.4 Project Scopes

The scopes of this study are as below:

For this project, 15 random mangoes with average weight 200 – 500 grams will be used as a sample. The actual weight of the mango will be recorded by using a digital kitchen scale. The mangoes will be exposed to an image acquisition system which is consist of a webcam, a computer with an image board and lighting system. The setup of the experiment is indoor due to power supply needed. The images will be captured with the black background, lighting and height of camera with background is 27 cm. The coding is generating in the MATLAB to process the image. The Red, Green and Blue (RGB) image will be converted to the grey scale image. The adjusting and thresholding processes will be performed with using a MATLAB software. The number of pixels of the mango is recorded. The histogram of the image will be observed. The graph of linear regression analysis will be plotted to describes the relationship between the weight of mango and the pixels counted. The estimation weight of the mango will be calculated by using the formula formed from linear regression model by using MATLAB software. The performance of the method will be evaluated by calculating the RMSE and accuracy for estimating a mango weight. In the result, the table of actual weight, estimation weight and error will be performed to show difference value. The size of the mango will be classified according to the size range decided which is large, medium and small size using classification learner.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents on the discussion of the weight estimation method and concepts, previous studies on weight estimation, previous research on techniques to process the image of object, analysis techniques used to estimate weight of object and applications of the system.

2.2 Overview of Research Field

Mango is cultivated in most frost-free tropical and hot subtropical climatic areas, such as Malaysia, and there is still a good demand for this fruit from both local and international markets. Rapid and reliable grading is thus crucial for increasing production and achieving levels of export efficiency. The grading process is manually carried out nowadays. Due to varying skill levels and experience of human labor, the result of the manual grading process is always inconsistent, time-consuming, and likely to introduce errors. To automate mango grading, an image acquisition and processing system has been developed for the extraction of the predicted area, perimeter, and roundness (geometry and shape). To classify mangos into one of three mass groups, such as big, medium and small, an image processing algorithm based on a regionally based global color binarization threshold, combined with a median filter and morphological analysis, was developed. [2].

Creation of an integrated mango classification system using image processing technology that utilizes artificial intelligence in order to track and determine the quality of mangoes prior to packaging and for export to the market. Through the use of Charged-Couple System (CCD) cameras, C-language programming, computer vision and artificial neural networks, the classification scheme for image recognition requires artificial intelligence[3]. To determine the mass, volume and defect of the mango fruit base, the computer utilizes the captured mango image to process the split sheet.

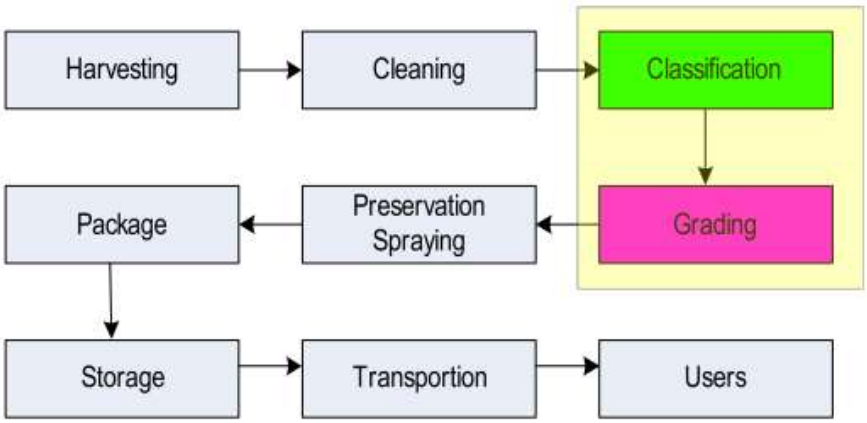

Figure 2.1 Mango sorting process **[3]**

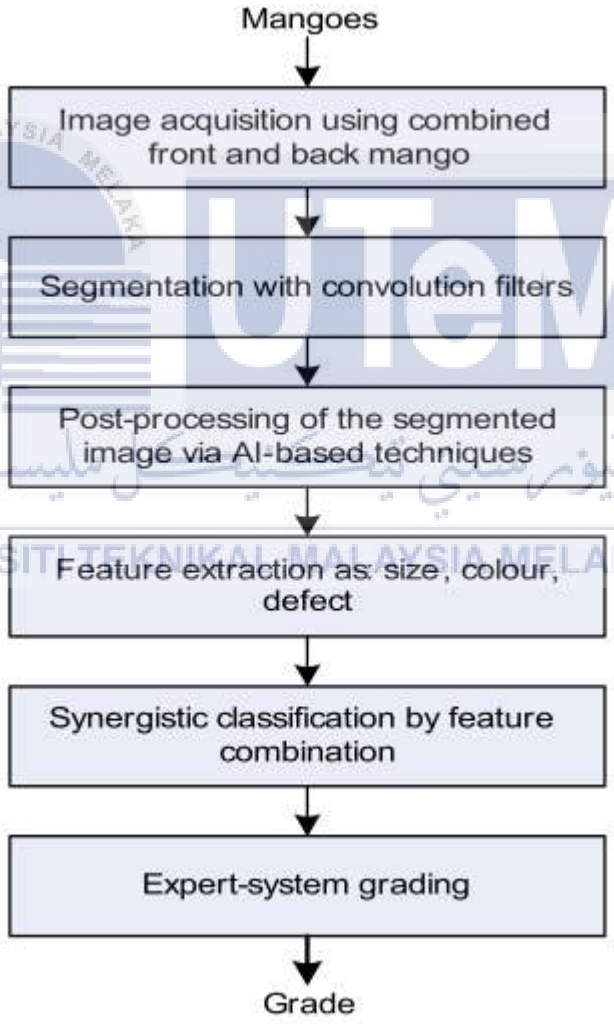

Figure 2.2 Development system fo mango grading

For this research, the grade of the mangoes size is identified by using digital image processing method and analysis through the computer vision system. Digital

image processing is described as subjecting a numerical representation of an object to a number of operations in order to achieve the desired output where it can identify the size of the mango and evaluate the mango features statistically [4]. Digital image processing consists of transforming a physical image into a matching digital image and obtaining useful information from the digital image via different algorithms. Digital image processing flow can generally be categorized into image collection, image enhancement, and image analysis. For image collection, the image of the mango is obtained from the dataset of mango size from the internet. Image enhancement is the method of enhancing digital images to make the after-effects more conducive to monitoring or further analyzing the image.

The MATLAB software is used for the simulation analysis of an image processing algorithm. The image processing toolbox was used for this analysis in the MATLAB software. A complete set of reference-standard algorithm and workflow applications are provided in the image processing toolbox for image processing, developing algorithms, visualization and analysis. It can produce segmentation, enhancement of image, geometric transformation, noise reduction, image recording, and image processing. The final method for image processing is image analysis, where significant information is extracted from mango images. The proposed algorithm for this research paper builds on previous studies on size classification, as well as on recent developments in deep learning, neural network and machine learning for object recognition. This chapter discusses the related research studies.

The complex problems which require a great deal of human expertise in the agriculture industries is fruit grading and sorting. Considering some of the grading issues, a suggested grading scheme is introduced, showing the possibility of applying the approach of image processing and the computer vision system for the classification of mango fruits.

2.3 Grading Features

The quality of the fruit is essential to customers, and suppliers are expected to supply high-quality fruit. In recent years, therefore, systems for fruit grading have been built to meet the needs of the inspection in the fruit processing industry. In addition, the fruiting process consists of a variety of steps which can usually be separated into grouping, processing, packing, transport and storage. Grading is considered to be a crucial step in the attainment of high-quality standards.

The quality of the fruits usually depends on external parameters or characteristics like size, intensity of colour, shape, appearance of the surface and internal parameters such as sugar content, acid content, color and size is the important factor for fruit grading and sorting [5]. The fruit grading method is currently being applied on the basis of weight, volume and scale that are accessible in all fruit processing industries. Fruit grading system methods using computer machine vision and image processing play an important role in the quality management of fruit processing industries.

2.4 Image Processing Method

Hossain *et al.* acknowledge that image processing and computer vision give us new knowledge that can be used to track the quality of highly accurate food and agricultural products [6]. As a consequence, an image processing algorithm is implemented with an online rating scheme, and samples must be taken at once. Nguyen *et al.* use image processing technology to construct an integrated mango classification system that uses artificial intelligence to track and analyze the quality of mango through the creation of a system that can identify mangoes in terms of colour, weight, size, shape and fruit density [3]. Via the use of CCD cameras, C-language scripting, machine vision, and artificial neural networks, the image recognition classification system combines artificial intelligence. The unit uses the captured mango image to calculate mass, volume, and defects on the surface of the mango fruit, processing the split sheet.

Dameshwari *et al.* are designing an automated method that can be used to distinguish and classify mango by image, size and color characteristics through image analysis [4]. MATLAB software has been used as a programming framework for the recognition and classification of fruit using the Image Processing toolbox. The proposed method can be used to identify visible defects, leaves, size and shape of the mango and to recognize the mango at high speed and precision. Next, Minh Thanh et al. categorized mango using image processing and support for Vector Machine (SVM). Image processing algorithms and the SVM model have been programmed using the Python language and open-source libraries, such as OpenCV and scikit-learn, which can also be enhanced to provide greater results for realistic applications. [7].

F.S.A. Sa'ad *et al.* also developed a vision strategy to identify the mangoes by their shape and weight using image processing and classifying the mango using mathematical classification, and then apply it to post-harvest handling. [8]. The image analysis and processing developed in this study consisted of three levels which is pre-processing, intermediate processing and post-level processing. All programming was applied directly using the Laboratory Virtual Instrument Engineering Workbench (LabVIEW) 2013 perception acquisition and creation toolkit tools.

2.4.1 Image Acquisition

In order to start the experiment, this is the main step that needs to be emphasized. To get the input which is the image, the quality of the image play a role. By taking the side view and the top view of the mango in an image acquisition chamber, another technique was created to estimate the volume of the mango. By positioning a mirror at an angle beside the mango from which the side profile of the mango was reflected within the frame, the use of two cameras was avoided [1]. A single low-cost web camera is used to capture the top-view image of the mango instead of using multiple image acquisition devices, which will later be processed to extract the necessary geometric features.

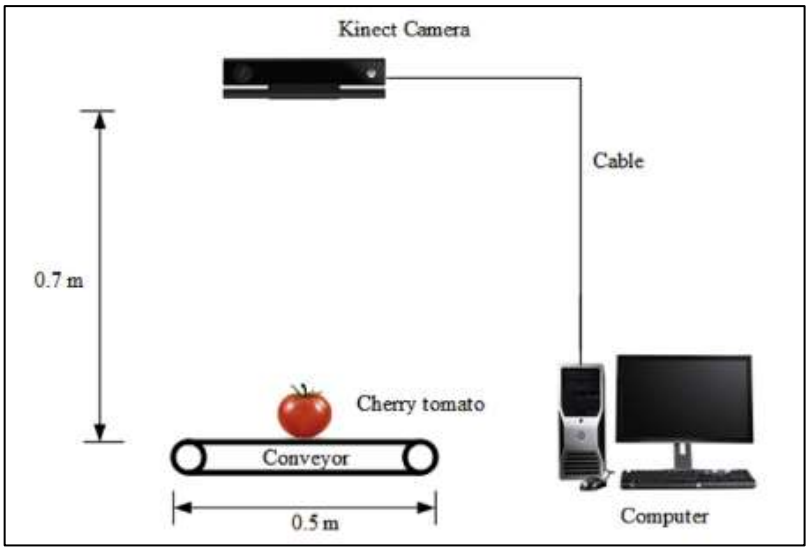

Figure 2.3: Example 1 for image acquisition setup [9]

Figure 2.4: Example 2 for image acquisition setup [10]