UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FRUIT SIZE AND COLOR MATURITY IDENTIFICATION USING RASPBERRY PI

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Telecommunications) With Honours

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree Bachelor of Electronics Engineering Technology (Telecommunications) With Honours. The member of the supervisory is as follow:

.....

(**IZADORA BINTI MUSTAFFA**)

ABSTRAK

Warna dan saiz adalah ciri-ciri yang digunakan untuk mengklasifikasikan kematangan buah dengan tepat. Proses ini kebiasaannya dibuat secara manual. Proses ini dibuat secara berulang, memenatkan dan oleh sebab itu, kesilapan akan berlaku. Lembaga Pemasaran Pertanian Persekutuan (FAMA) telah menyediakan enam indeks untuk mengklasifikasikan kematangan buah. Satu 'machine vision system' menggunakan Raspberry Pi dihasilkan untuk menentukan saiz dan warna kematangan buah. Sistem ini mampu mengukur saiz buah. Sistem ini juga mampu mengenal kematangan buah melalui warna yang dominan dengan menggunakan K-means clustering untuk proses penggredan yang selanjutnya.

ABSTRACT

Color and size are features used to accurately classify fruits according to its maturity. The process is normally done manually. The process is repetitive, tiresome and therefore prone to human error. The Malaysian Federal Agricultural Marketing Authority (FAMA) has set six indexes to classify fruit maturity. A machine vision system using Raspberry Pi is developed to determine the size of the fruit and color maturity. The system is able to calculate the approximate size of the fruit. The system is also able to detect the maturity of the fruit through color by using K-means clustering for further grading process.

DEDICATION

To my beloved parents, Mohd Khairul bin Abdullah and Maimunah binti Seman for the support and encouragement.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

FAMA	-	Federal Agriculture Marketing Authority
DOA	-	Department of Agriculture
LPP	-	*Lembaga Pertubuhan Peladang*
MPIB	-	Malaysian Pineapple Industry Board
MARDI	-	Malaysian Agriculture Research and Development Institute
FFB	-	Fresh Fruit Bunches
HIS	-	Hue, saturation, and intensity
CCD	-	Charge Coupled Device
OpenCV	-	Open Source Computer Vision
VNC	-	Virtual Network Computing

CHAPTER 1

INTRODUCTION

1.1 Introduction

Color and size is the most important aspect of agricultural and food products because high-quality products are significant for success in today's highly competitive market. In agricultural applications, the quality of a product especially fruits. Which are often classified by their texture, shape, and color. These elements utilize human's vision especially as a part of deciding the quality or ripeness of fruits. The process of evaluating is done manually, repetitive and prone to human error.

In recent years, image processing techniques have been discovered progressively helpful in the fruit industry, especially for applications in grading or ripeness of fruits. Studies show that, utilizing image processing able to improve the product quality while helping people from traditional evaluation for fruits.

1.2 Problem Statement

During harvesting season, farmers just used his/her knowledge only using vision to select the fruits by assuming the color and size. The process of evaluating the fruit maturity is tiring and time-consuming. So, a lot of error can occur in evaluating of the fruit. Therefore, this project will give a concept of idea to find the fruit size and the maturity of the fruit.

1.3 Objective

1. To study fruit maturity grading system applied by FAMA
2. To study existing fruit grading systems
3. To develop a fruit size and color maturity identification algorithm using Python and OpenCV and implement it using Raspberry Pi.

1.4 Work Scope

The scope of this project is to study on how to develop an algorithm for fruit identification using Raspberry Pi with using Python and OpenCV. Equally important, to study the maturity system by Official Portal of Federal Agricultural Marketing Authority - Standard and Grade Specifications. This scope will conduct regarding Raspberry Pi, Python, OpenCV.

- Fruit maturity grading system by FAMA.
- The existing fruit grading system.
- Implementation of Python and OpenCV in Raspberry Pi.

1.5 Conclusion

Fruits can be classified by texture, shape, and color. The problem is that, these elements utilize human's vision especially as a part of deciding the quality or ripeness of fruits. So, the process of evaluating the fruit maturity is tiring and time consuming when harvesting the fruit. Hence, the objective is to help the farmers to determine the condition of the fruit based on size and color maturity. Therefore, in this project will focus on the maturity grading system by FAMA and study the existing grading system. Lastly, using Python and OpenCV software to identify the size and the maturity of a fruit and implement it using Raspberry Pi.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will explain about the involvement of agricultural sector for fruit industry in Malaysia. Also, the existing system for grading fruits and the importance of fruit grading. Likewise, methods for grading fruits.

2.2 Malaysia Fruit Industry

Malaysia delivers a wide assortment of tropical organic products, for example, pineapples, durians, watermelons, starfruits, bananas, papayas and mangoes. Malaysian tropical atmosphere is exceptionally ideal for the generation of different fascinating organic products, particularly since Peninsular Malaysia occasional encounters sea tempests or dry spells and expand the ability to support tropical natural product sends out. Malaysian natural product industry is essential socio-financially, as it is assessed that at the very least 135,000 little holders are included in organic product development in Peninsular Malaysia, extending from one to two hectares each in size. Natural product crops use around 375,000 hectares (5.4%) of an area in Malaysia.

Malaysia imported about RM 193.80 Mil worth of natural products in 2011 while its fare adds up to RM 269.07 Mil. Malaysian tropical organic products are principally traded to business sectors in Singapore, Thailand, Hong Kong and Indonesia while for the most part transported in from China, USA, South Africa and Thailand. Per capita utilization of tropical natural

products in Malaysia was 44.88 kg in 2011. There are 18 products of tropical natural products which been exhorted by FAMA to be developed by the cultivators taking into account the interest and showcasing potential prerequisites.

In Malaysia, agriculture division is administered by Ministry of Agriculture and Agro-Based Industry (MOA). There is four department who are directly linked to fruits sector. There are DOA, FAMA, LPP, and MPIB. The first stage is call 'Agronomy' when a farmer wanted to crop any fruit. Then, FAMA will give advice to them about the current statistic, suitable service and suitable time to do the crop in order to fulfill current demand. DOA plays the role in advising on the type of land, seeds, and fertilizers suitable to be used. *Lembaga Pertubuhan Peladang* (LPP) or Board of Farmer's Organization will register these farmers under the regulatory body and responsible in giving engineering assistance such as tractors and irrigation system. For research development, Malaysian Agriculture Research and Development Institute (MARDI) provided consultancy and technical services to the farmers, such as disease control and how to optimize the harvesting output. MPIB or Malaysian Pineapple Industry Board is one of the bodies under MOA to coordinate activities and process research related to pineapple as it is the highest type of fruit produced in Malaysia.

Aside from those organizations mentioned above, there are one financial institution namely AGROBANK specially in giving credit assistance to the farmers for agriculture's cultivation. The second part of the fruit's cultivation, DOA, FAMA, MARDI as well as MPIB for pineapple will have a scheduled visit to ensure the successful of cultivation. Finally, FAMA would purchase the fruits upon requested after fruits harvested (Zakaria 2014).

2.2.1 Federal Agriculture Marketing Authority (FAMA)

FAMA is on the second level of the chain as a direct purchaser nevertheless independent or contract farmers. For independent farmers, FAMA would gather the fruits at the farm upon asked for, while contract farmers will have a suitable harvesting plan as a guideline. Table 2.1 demonstrates the obtaining sort offered by FAMA to the agriculturists.

No.	Type of purchasing by FAMA	Type of farmers	Description
1	Direct purchasing	Non-contract (independent) and contract farmers	FAMA would buy and collect the fruits at the farm or collection centers upon request from the farmers.
2	Purchasing contract according to percentage	Contract farmers	50% from the harvested fruits purchased by FAMA and the rest up to the farmers
3	Purchasing contract according to seasonal lease	Contract farmers	- Advances given by FAMA maximum 20% of production value - Advances calculated as a debt and will be deducted from the sales proceed with FAMA

Table 2.1: Type of fruits purchasing offered by FAMA (Source: Zakaria, 2014)

2.2.2 Wholesalers

Wholesalers include in the fruit supply chain. Wholesalers like to buy at the collection centers because of different choices of fruits. Some of them ready to specifically offer the fruits to the customer as they possess the retail shops or vendors. Some of them would likewise buy from FAMA as a second source.

2.2.3 *Pasar Tani* (Farmers market)

In Malaysia, the farmer's market is known as *Pasar Tani*. In 1985, to allow consumers to buy directly from the farmers, its operation usually start in the morning on a designated day of the week. It can reach up to 100 stalls in every area offering assortments of fruits, vegetables, and other agriculture from the farmers. Farmers would either bring the fruits independent from anyone else to *Pasar Tani* in the event that they had their own particular transport, or generally took care of by authorities or wholesalers. FAMA itself at times would supply the fruits to the entrepreneurs to increase their product varieties. There are 52 areas of *Pasar Tani* in Johor, with 1,865 entrepreneurs people included. In addition, infrastructure and easy payment scheme for the amenities for markets such as canopies, tables, and basket will be provided by FAMA. This is one of the exceptionally effective projects from MOA for agriculturists

in Malaysia. The reason is that customers like to buy at the *Pasar Tani* because its cheaper and have a lot of choices of fruits than in supermarkets.

2.3 Malaysia Fruit Grading System

Grading of fruits and vegetables after harvesting is an essential step in post-harvest management. Grading of fruits and vegetables on the basis of physical characteristics like weight, size, color, shape, specific gravity, and freedom from diseases depending upon agroclimatic conditions. The known methods of grading of fruits and vegetables are manual grading, size grading.

Grading of fruits and vegetables in the fresh form for quality is essential, as the people are becoming quality conscious day by day. Further, upon arrival of fruits and vegetables at the processing centers, they should be graded strictly for quality. From immature, mature and over mature fruits and vegetable should be sorted out for the best attributes.

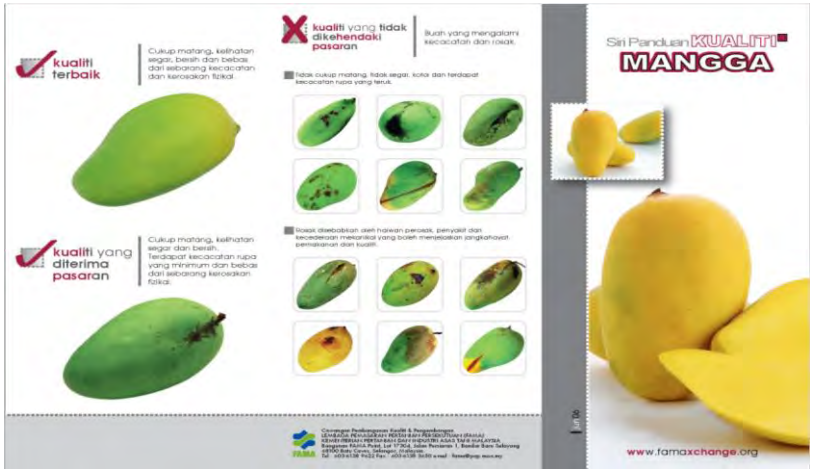
2.3.2 The Fruits Grading Classification

Grading is sorting of vegetables and fruits into different grades according to the size, shape, color, and volume to fetch a high price in the market. The fruit grading can be categories into three class.

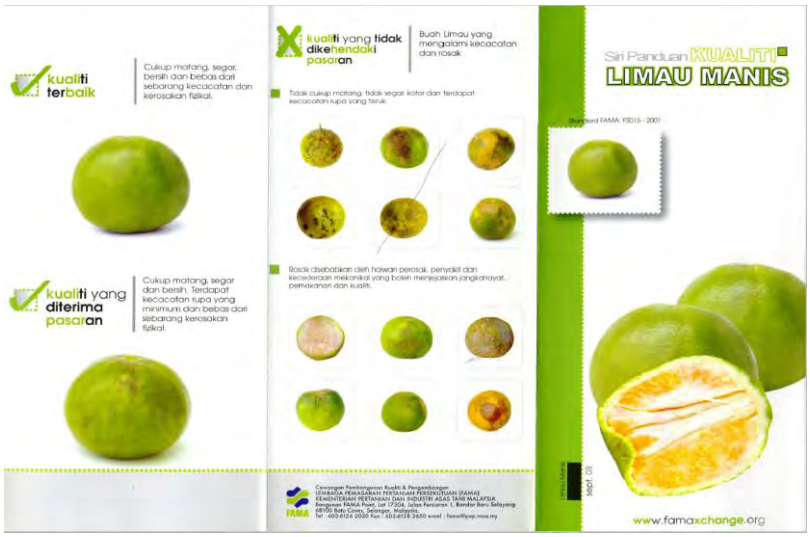
Firstly, the extra class is of superior quality possess the shapes and color of the variety and without internal defect likely to affect the inherent texture and flavor. A 5% tolerance is allowed for errors. It must be carefully presented taking into accounts the uniformity of the produces in size color, condition arrangement of the produce in the package quality and appearances of the packing or pre-packing material. Next is the class 1st, which is almost having the same quality is like the extra class except that a 10% tolerance is allowed. Individual fruit is allowed a slight defect in shape, color, and

minor skin defect which do not affect the general appearance for keeping qualities. In packing the size range may be wider and product need not always be arranged in the package. Lastly, class 2nd. This class product may exhibit some external or internal defects provided they are fit for consumption while fresh. This class is best fitted for local or short distance market. This category will satisfy the needs of customers who are not too demanding and for whom price is more important than quality (FAMA 2016).

The example of Standard & Grade Specifications: -



(a)



(b)

Figure 2.1: Standard & Grade Specifications of (a) Mango; (b) Lime (Source: FAMA,2016)

2.4 Methods for Fruit Identification and Grading

The effectiveness agricultural industry and process evaluating that is right are critical to enhancing productivity. As of now, the agricultural industry has better advancement, particularly regarding reviewing of natural products, yet the procedure should be revamped. This is on the grounds that evaluating of fruit products is essential to enhance nature of the fruit products. In a roundabout way, great fruit products could be sent out to different nations and create income (Mohd Firdaus 2014).

Analyzing image using computer vision has many potential functions for fruits grading. One of the researchers has a made a fruit grading system using Computer vision. According to Al Ohali (2011), the Kingdom of Saudi Arabia is the world's largest producer of date in Saudi Arabia. Approximately 400 date varieties in bulk. So, during harvesting season the date sorting and grading give problems for date growers. This is because the process to grade and sort is time consuming which can delay the post-harvesting operations.

Therefore, a fast and efficient system to sort the date is needed. So, he designed and implemented a prototypical computer vison-based date and grading and sorting system. The fruit grading sorting system consists of the conveyer, camera control, and helm control systems. The system uses RGB color method to determine dates quality. In addition, the dates are classified categories (grades 1,2 and 3) defined by experts based on extracted features (Al Ohali 2011).

The other researcher has made oil palm fresh fruit bunch ripeness classification based on the color of the fruit. The oil palm fruits are one of the major agricultures goods, particularly in Malaysia. The palm oil is the basic ingredient in manufacturing such as candles, soap domestic frying oil and snack food. Not only that, the ripeness of the oil palm fruits depends on the color of the fruit. So, they designed intelligent color vision system for ripeness classification of oil

palm fresh fruit bunch. So, Ripeness classification of oil palm fresh fruit bunches (FFBs) is used to harvest the palm fruits for maximum oil production.

The application of the color vision is used for automated ripeness classification of oil palm FFB. The digital image processing techniques are used to the images of oil palm FFBs of type DxP Yangambi are collected and analyzed. The intelligent grading system the consisted of a camera for image acquisition and a computer for data storage, image pre-processing and ANN classification.

The system included the Vivotek IP8332 Network Bullet Camera (0 Lux, 1.0 M pixels, F1.8) for image capturing and MATLAB Image Processing Toolbox is used for image processing. In addition, an ANN system was trained and tested using the MATLAB Neural Network Toolbox. The system is illustrated in figure 2.2 (Fadilah et al. 2012).

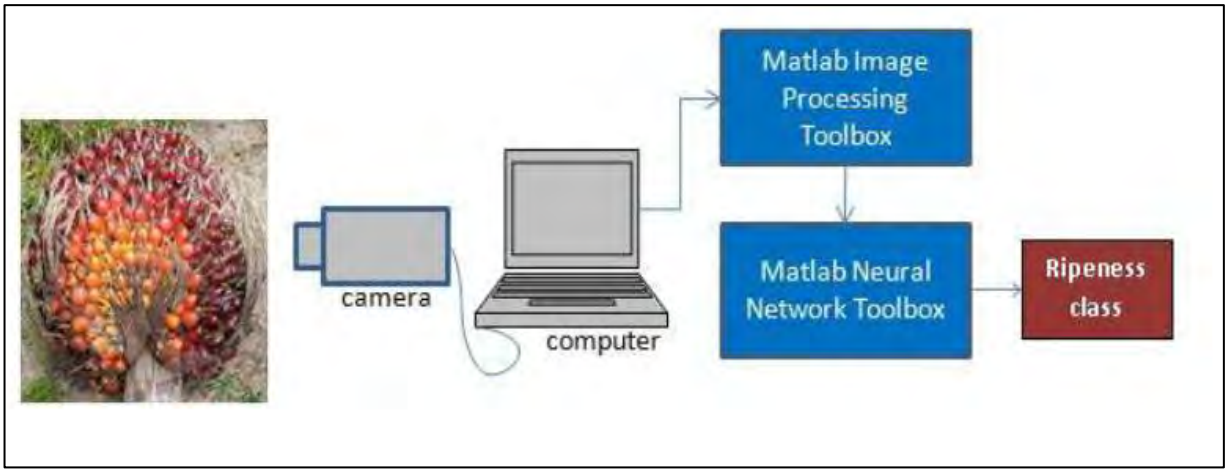


Figure 2.2: Oil palm FFB grading system (Source: Fadilah et al,2012)

For colorization of the oil palm fruits ripeness, four sample that can be shown in Figure 2.3. For unripe fruits are in deep violet to black. The fruits ripen are red and the overripe oil palm FFB shows that most of the outer fruits are gone, and the inner fruits are orange in color.

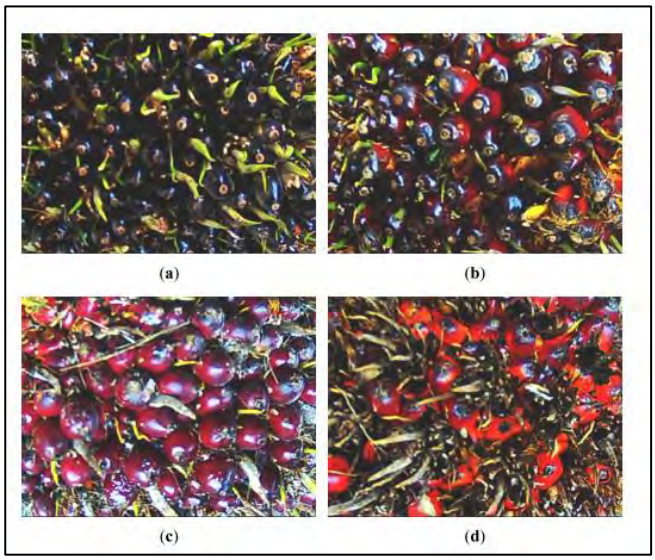


Figure 2.3: Oil palm FFB images for four ripeness category (a) Unripe; (b) under ripe;(c) Ripe; (d) Overripe. (Source: Fadilah et al,2012)

Next researchers have made a lemon sorting system based on color and size using HSI color model technique for color and image processing for size. The size, color, shape, defect and internal quality give many kinds of information for grading systems. The most important features for accurate classification and/or sorting of citrus such as oranges, lemons and tangerines were color and size. The system identified with two inspection stages of the system which are external fruit inspection and internal fruit inspection. In addition, the internal inspection needs a special sensor for moisture, sugar, and acid contents and the former task can be accomplished through processing of color images.

Other than that, in visual basic environment, an efficient algorithm for grading lemon fruits was developed implemented. The systems consist of two CCD cameras, two capture cards, an appropriate lighting system, a personal computer and other mechanical parts. The information of the fruit was extracted on the HSI color values and estimated volumes. The system can be seen in Figure 2.4 which consist of two CCD cameras with 510 x 492 pixels (PROLINE-565 s), two capture cards (WinFast DV2000 with a resolution of 3 H 240 V), an appropriate lighting system and a personal computer (PC). The camera is a CS lens mount, a