

CLARIFICATION OF MUSK LIME BASE ON COLOR

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A thesis submitted in partially fulfillment of the requirements for the award of degree of
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DECLARATION

I declare that this thesis entitled “Clarification of Musk Lime Base on Color” is the result of my own research except as cited references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : Jun 11th, 2012

SUPERVISOR'S DECLARATION

“I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Computer Science (Software Engineering)”

Signature :.....
Supervisor : Mr. Wan Muhammad Syahrir Bin Wan Hussin
Date : Jun 11th , 2012

DEDICATION

Special dedication to my beloved parent,

Sinnasamy s/o Poniah,

Kohela d/o Govindasamy,

To all my lectures especially my PSM Supervisor,

Mr. Wan Muhammad Syahrir Bin Wan Hussin,

ACKNOWLEDGEMENT

I am deeply indebted to many people who, directly or indirectly, are responsible for this project coming into being. I am most grateful to Mr. Wan Muhammad Syahrir Bin Wan Hussin as my supervisor for his constructive criticism of my research in this project, and most of all his guidance and support for the whole project.

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I am indebted to Mr. Mohd Ashik bin Abdul Rahman, general manager of Hessa Creative SDN BHD whom teaches me a lot about post harvest process in tomato industry in completing this project.

And finally, thanks to parents, and numerous friends who endured this long process with me, always offering guidance and supports.

ABSTRACT

Clarification of musk lime base on color can directly gain to marketing company because grading process must when it comes to exporting such materials. In the Malaysia, this type method of grading for musk lime is not used which cause imbalance in marketing as the price of the musk lime varies with the grade. Therefore, this system carried out to develop a prototype judging the musk lime maturity and to estimate the expiry date of musk lime by their color. Software development life cycle methodology was implemented in this system design by using several image processing techniques including image acquisition, image enhancement and feature extraction. Seventy four sample data of musk limes were collected during image acquisition phase in the format of RGB color image. The grading systems use a computer and capture the image of musk lime using web cam. Then, it the background of the image removed by using averaging filtering techniques. Next, RGB color information is changed to HSV color information. The values are then being used as information for determining the maturity and estimate expiry date of musk lime.

ABSTRAK

Pengagihan limau kasturi mengikut warna boleh mendapat manfaat secara langsung kepada syarikat pemasaran kerana proses pengedaran ketika mengeksport limau kasturi. Di Malaysia, kaedah jenis ini tidak digunakan untuk penjualan limau kasturi yang menyebabkan ketidakseimbangan dalam pemasaran sebagai harga limau kasturi berbeza dengan gred. Oleh itu, sistem ini dijalankan untuk membangunkan prototaip menilai kematangan limau kasturi dan untuk menganggarkan tarikh luput limau kasturi dengan warna. Kaedah kitar hayat pembangunan perisian telah dilaksanakan dalam reka bentuk system ini dengan menggunakan teknik pemprosesan imej beberapa termasuk pemerolehan imej, peningkatan imej dan penyarian sifat. Tujuh puluh empat data sampel limau kasturi dikumpul semasa fasa pengambilan imej dalam format imej warna RGB. Sistem penggredan menggunakan computer dan menangkap imej limau kasturi menggunakan camera. Kemudian, latar belakang imej yang dikeluarkan dengan menggunakan purata menapis teknik. Seterusnya, maklumat warna RGB ditukar kepada maklumat warna HSV. Nilai-nilai ini kemudiannya digunakan sebagai maklumat untuk menentukan tarikh matang dan anggaran lupusan limau kasturi.

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CHAPTER I

INTRODUCTION

This chapter briefly describes the clarification of musk lime base on color that will be developed later. This chapter comprises six sections: The first section describes the background of the project. Second section describes defines the word commonly use in this project. The third section describes the problem statement and motivation of the project. The fourth section describes the objectives for the project. The fifth section describes the scopes for the project. The sixth section explained the outcome of the project. Finally the thesis organization is described in section six.

1.1 Background

Malaysia is one of the leading economies of the ten ASEAN Countries, and is achieving steady growth. The main contributions are from Agriculture sector. Agriculture in this country has been strongly supporting the economy by specifically on plantation crops, to which Malaysia has put the heaviest weight compared to its Asian neighbors. From the observation, application of information and technology in agriculture has help to improve this sector. More specifically, e-Agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use information and communication technologies (ICT) in the rural domain, with a primary focus on agriculture. ICT help this sector by providing system must be in user-friendly form, easy to access, cost-effective and well protected from unauthorized accesses. This research focus on musk lime in agriculture sector.

In Malaysia musk lime which is known as ‘limau kasturi’ is used mostly as refreshments and beverage because of its distinctive flavor. It is classified in the Rutacea family which includes several other important fruits such as oranges, mandarins, limes, Clementine, lemons and grapes. Musk lime plants are characterized by a spiny or thorny stem, green and leathery leave, and clusters of small and aromatic white flowers. The fruit, which is similar to the lemon, is juicy, acidic, and typically green or yellowish green even when mature (but will turn yellow like the lemon if exposed to a cool winter environmental conditions). The lime fruit tends to be smaller and rounder (globular) than the lemon, and with a sweeter and more acidic pulp and a thinner rind. It also has discovered that this beneficial effect derived from the quantities of vitamin C the fruit contains. The products of musk lime in industries are perfumes, iced tea or a soft drink, cleaning products, and aromatherapy.

In current industry, musk lime is not classified into grad it delivers to market and factory to process. Indirectly, it causes loss to the musk lime industry and farmers. Other than that, the absence of classifying system causes the limes not to be exported to foreign country. Musk lime can be classify using manual method by human power but will leads to error. By using, ICT application (Image processing method) can develop a user friendly system to categorize the musk lime. The classified musk lime can sell with different prices in market and may export to the foreign country.

In computer science, image processing is any form of signal processing for which the input is an image, such as a photograph or video frame, the output of image processing may be either an image or, a set of characteristics or parameters related to the image. There are several steps involves to develop system by using this method: - Image acquisition, Image enhancement and Feature extraction. This system can help to gain marketing company and exported to foreign countries.

1.2 Definition of terms

- I. ICT - Information and communication technologies
- II. Agriculture - the cultivation of animals, plants, fungi and other life forms for food, fiber, and other products used to sustain life.
- III. Musk lime – type of lime
- IV. UMP – University Malaysia Pahang
- V. Judgment – decision making
- VI. RGB – Red Green Blue
- VII. HSI – Hue, Saturation, intensity

1.3 Problem Statement

In the industrial scale, this type method of grading is not used either manually or using sophisticated system. Directly or indirectly it will cause imbalance in marketing, as the price of the musk lime varies with the grade. Furthermore, the absence of classifying system causes the limes not to be exported to foreign country. Grading is a must when it comes to exporting such materials. As the result, it will cause gain to marketing company.

Comparing the manual and automatic process of categorizing the limes, manual process requires a lot of human power. The problem faced if the manual process carries out to categorized musk lime is a lot human power needed to identity each of the fruit. Since, the musk lime small in size it will take time and fruits will delay to market. Other than that, judgment of musk lime color grading by human eye can leads to error. Sometime, the tiredness, stress of the worker can cause this problem. Furthermore, the classification of musk lime by human eye also not standard accusation. Human vision has limited ability in differentiating similar colors like dark green, light green, yellowish and yellow.

1.4 Objectives

There are several objectives to be achieved in this project:

- I. To develop a prototype for judging the musk lime maturity base on their color.

II. To estimate the expired date of musk lime by their color.

1.5 Scopes

There are some restrictions in this project. First of all, the maturity musk lime is judged by color. The size of musk lime should be small within (3-6 centimeters in diameter). During image capturing process there should be a fixed length between the camera and the musk lime (~50mm). This process includes seventy four samples of musk lime. This project will be completed by using Matlab R2010a as the development platform. The healthy musk limes without injured will be the outcome of this project.

1.6 Significance of the study

Basically, this project helps agriculture industry to increase product where musk lime companies earn more by classification the fruit into grad. The classified musk lime can sell with different prices in market and may export to the foreign country. Directly or indirectly, the present of this system in agriculture industry farmer get more benefit. This is because farmer can reduce human power in the musk lime farm for the clarification process.

1.7 Thesis Organization

Chapter 1 included background of the study, definition of term, problem statement, and objective, scope of study and significance of the study. The background of the study explains general information on musk lime. The subchapter 'definition of terms' defines the term commonly used in this documentation. While the problem statement discusses the possible problems that need to be overcome throughout this project, the problem faced by musk lime industry explains in problem statement subtitle. The main purpose and aim of this project is elaborated under objective. Scope of the study explains the characteristic of musk lime that will be required for this project. At lastly, significance of the study explained outcome and benefit of the project.

CHAPTER II

LITERATURE REVIEW

This chapter briefly describes the review on existing techniques related with clarification of musk lime base on color. This chapter comprises five sections: The first section explained more briefly about musk lime. In the second section, describes details on color separation. The third section describes the comprehensive review on existing related systems. The fourth section explained current flow system in industry. Next, fifth section describes new system that will proposed to the industry. Finally, conclusion gives a summary on this chapter.

2.1 Introduction

In the Malaysia, there are certain limes that can found in Malaysia: - lime (Citrus Aurantifolia), musk lime (Citrus Microcarpa), kaffir lime (Citrus Hystrix)

and pomelo (*Citrus Gradis*) [3]. Calamondin or culomansi (scientific name : *citrus microcarpa*) is a fruit tree in the family Rutaceae that was developed in and is very popular throughout Southeast Asia, especially the Philippines, where it is most commonly used for cooking [1]. Musk lime consists of vitamin C which good for health. The usages of musk lime in daily life are [4]:-

- a) To avoid dandruff
- b) To wash silver things
- c) Beauty of skin and body
- d) To clean leg from bad smell
- e) To wash rust on the cloths

Basically, computer vision system can recognize the fruits base on four features textures, color, intensity and size. Normally, by increasing the features used, the performance of the methods proposed can be increased. Moreover, both surface information (color and texture) and geometry information (size and shape) of food products in images play a significant part in defect detection and class discrimination [14]. Color features have been extensively applied for apple quality evaluation mostly for defect detection. For instance, color features of each pixel in images obtained in three components of RGB spaces could be successfully used to segment defects on 'Jonagold' apples [6][7].

Nowadays the market need high quality products within a short time, automated grading of agricultural products is getting special priority among many farmer associations. In order, to solve this problem the system (detector of musk lime) plays an important role of quality control for agricultural products. Regarding there is some journal has been taken from seniors and internet. There are development of a lemon sorting system based on color and size, color grading in tomato maturity estimator using image processing technique, Automated oil palm fruit grading system using artificial intelligence, Fruit recognition using color and texture features and Eggshell crack detection system. In this chapter, there are two related systems selected to do some research:-

- a) Color grading in tomato maturity estimator using image processing technique [8].
- b) Automated oil palm fruit grading system using artificial intelligence [9].
- c) Objective color measurement of tomatoes and limes [10].

2.2 Overview

Color provides valuable information in estimating the maturity and examining the freshness of fruits & vegetables. Color is one of the most significant criteria related to fruit quality. It indicates the parameters like ripeness. The adaptation of human eye to small changes in color and the effect of the background on the perceived color, type of illumination, viewing angle are some of the main sources of error. Hence it is hard to provide precise guideline for visual inspection of fruits based on color. The system can offer the solution for these problems [15 – 18].

Limes turn yellow when ripe. While limes grow as a green skinned fruit, they will actually turn yellow when fully ripe. Their sugars increase and they are quite delicious [2].

Limes start out are green. They turn yellow when first ripe (Extremely ripe Meyer limes actually take on an arrange hue. Once mature, most varieties will hang on the tree of several months slowly growing larger on developing thicker skins [2].

Table 2.1 Musk lime color descriptions

Category	Description
Dark green	Unripe musk lime, 90% green, 10% black
Green	Start ripe , musk lime ready to plug, 100% green
Yellowish	50% Green, 50% yellow
Yellow	Ripe musk lime, 100 % yellow

The musk lime that export to market and factory must have some specification:-

- I. Size
- II. Skin color
- III. Clean
- IV. Free from injury or disease
- V. Texture of musk lime free damages

2.3 Exiting case study

2.3.1 Color grading in tomato maturity estimator using image processing technique [8]

This study conducted by W. Md. Syahrir, A. Suryanti, C. Connsynn on 2008. They are form Faculty of Computer Science and Software Engineering, University Malaysia Pahang. This study is carried out to helping the growth of Malaysia's tomato industry by enhancing the process of manpower color grading into the era of machine vision color grading in order to compete with the same industry globally. This related study will describe the techniques that have been used.

2.3.1.1 Method

This system develops using image processing techniques which is image acquisition, image enhancement and feature extraction. The flow chart of the process is shown in figure 2.1.

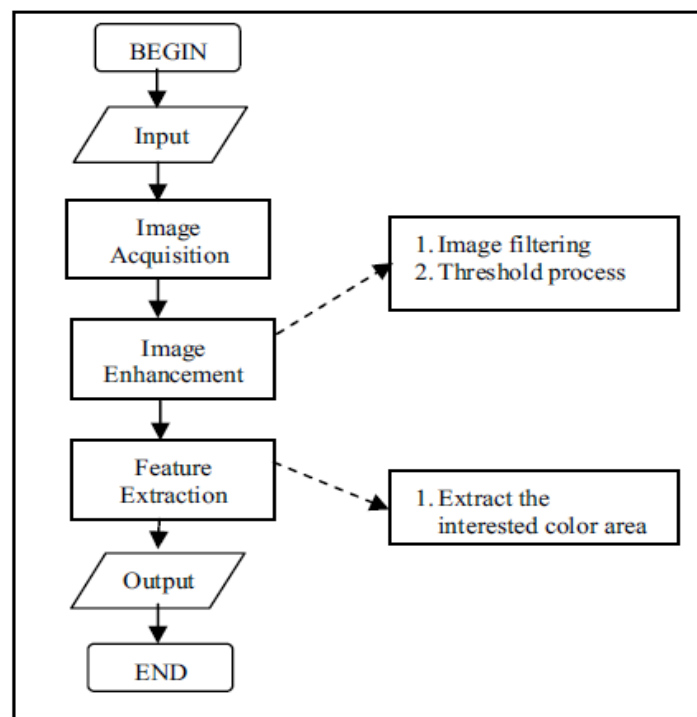


Figure 2.1 Overall processes in tomato maturity estimator

In the first phase, 50 tomatoes were used as sample data in the testing phase of this project development. All tomato samples had gone through the phases of the prototype of that system that has produced output, mainly image acquisition, convert an image into grayscale image, filtering, threshold and features extraction.

Image acquisition is the first process in the system development. The images were captured by placing a PC camera at approximately 100mm on the top of the tomato, by using same background and same visible light condition. Next step is Image Enhancement. The purpose of image enhancement is to highlight certain features of interest in an image. The background of the image considered as noise in this system, thus removing the influences of background is necessary. Two types of image enhancement technique in Spatial Domain methods had been implemented which are image filtering and threshold process in order to remove the influence of image background.

Features extraction is to extract the information of the interested area in the image for further usage in processing the image. a^* values of the tomato color is the interested area in this process. After the influence of the image background has been removed, the total of a^* values are collected and sum up. The sum of total a^* values will then be used to get the mean of a^* values. In details, several processes under feature extraction are to be undergo by the image which including boundaries tracing, removing background and obtaining a^* values. The expired date of tomato is determined base on the storage life shown in figure 2.2.

Storage life:	
Breakers (10 – 20% of full maturity).....	21 to 28 days
Turning (30 – 40% of full maturity).....	15 to 20 days
Pink (50 – 60% of full maturity).....	7 to 14 days
Light red (70 – 80% of full maturity).....	5 to 6 days
Red (full maturity).....	2 to 4 days

Figure 2.2 show the tomato storage life time.

2.3.1.2 Advantages and disadvantages of the system

By using this system, the prototype was able to estimate the expiry date of the tomatoes which is not even available yet in the Export Market Process, where this can increase the product of tomato in market with different size. Furthermore, the prototype provide a better alternative compared to using manpower in determining tomato maturity, the machine will not prone error due to tiredness or bias.

The disadvantage of the system is the prototype can only process one tomato for each process. The worker has to scan the tomato one by one where it will take time. The packaging process will be late and local market will late receive the product. Next, the prototype was not able to differentiate tomato with other fruits or vegetable.

2.3.2 Automated oil palm fruit grading system using artificial intelligence [9]

This study conducted by Z. May, M. H. Amaranon 2011. They are from Electrical and Electronic Engineering Department, University Teknologi Petronas. This related study will describe the techniques that have been used.

2.3.2.1 Method

This system is developing by using artificial intelligence techniques. The steps taken for latter approach includes image acquisition, color feature extraction and finally classification using fuzzy logic algorithm as shown in figure 2.3.

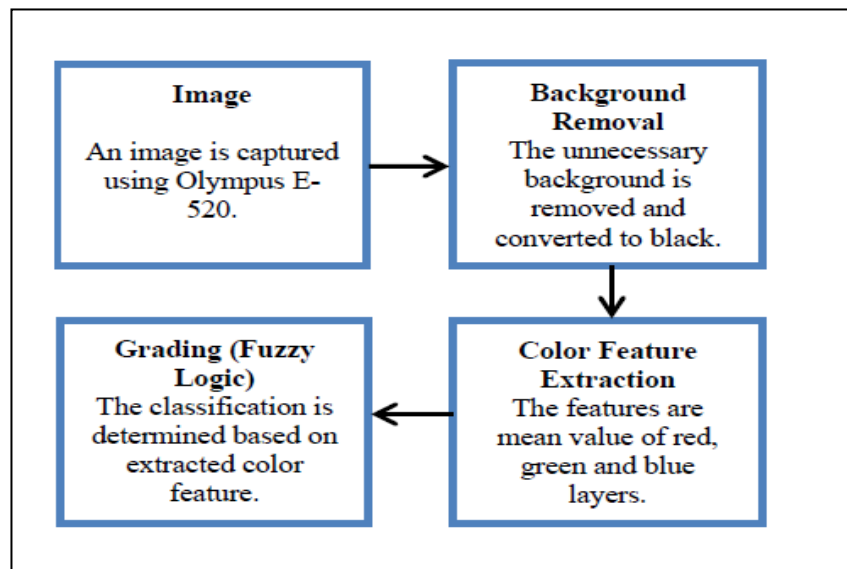


Figure 2.3 the flowchart of grading method

In the first phase (image acquisition), the oil palm fruits are collected from a plantation. The oil palm fruits are graded manually by human grader as soon as he collects the fruits. The images that taken converted into JPEG format and resized to 640x480 pixel dimensions. Even though the best lighting is using direct sunlight but we are using the controlled lighting condition because this system is planned to use in the building.

Next step is background removal. The region of interest is the fruit itself without the background. The background is the noise to the image and it has to be

removed. The background subtraction method is used to remove the white background.

In the feature extraction step, the color features of the oil palm fruit are analyzed based on the RGB color model. To classify the fruit into under ripe, ripe and overripe categories, we need to obtain a range of mean value of red, green and blue layer for each fruit. The mean values of red, green and blue layers are calculated using the equations as shown in figure 2.4.

	$\text{MeanR} = R / \text{No. of pixels}$
	$\text{MeanG} = G / \text{No. of pixels}$
	$\text{MeanB} = B / \text{No. of pixels}$
Where:	
MeanR =	Mean value of Red layer
MeanG =	Mean value of Green layer
MeanB =	Mean value of Blue layer
R =	Red pixel
G =	Green pixel
B =	Blue pixel

Figure 2.4 the flowchart of grading process

Finally, grading stage where fuzzy logic process will determine the grade of oil palm. Figure 2.5 shows the complete process of developing a fuzzy inference system (FIS) for the grading process using MATLAB.

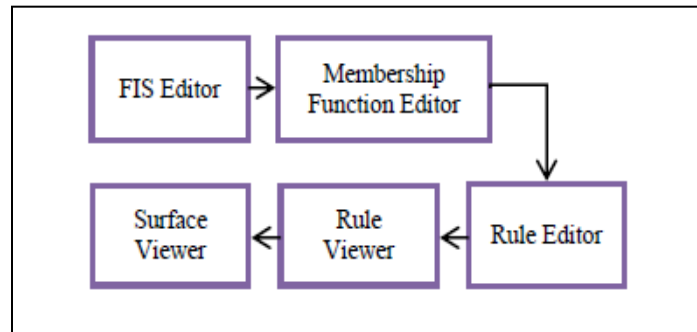


Figure 2.5 Fuzzy inference systems

There are four important step involved fuzzification, rule evaluation, aggregation and defuzzification.

2.3.2.2 Advantages and disadvantages

The advantage of the system is to distinguish between the three different classes of oil palm fruit which are underripe, ripe and overripe which can save time of separating process. Furthermore, the prototype also provide a better alternative compared to using manpower in determining oil palm maturity, the machine will not prone error due to tiredness or bias.

Next, the disadvantage of the system is the prototype can only process one oil palm for each process. The separating process will be late and local market will late receive the product. Next, the prototype was not able to differentiate oil palm with other fruits or vegetable.

2.3.3 Objective color measurement of tomatoes and limes [10]

This study conducted by H.M.W. Bunnik, D.G. Bailey and A.J. Mawson from Farm Technology Group, Wageningen University and Research Centre.

2.3.3.1 Method

This system is developing using image processing method. For the first step, the image of lime and tomato is capture. Capturing the images of the object (lime or tomato), a charge coupled device (CCD) camera is used (Sony DFW-SX900, resolution 960 x 1280 pixels). The camera is linked by fire wire to a PC on which the processing software is installed. Next high quality of lighting will be fixed to obtain accurate measurements of the color specular reflections from the surface of the object must be avoided. This may be achieved using indirect, diffuse illumination. For this purpose the halogen lamp is fitted into a tube. When considering the color change of limes and tomatoes, they both start as green objects. Whereas the tomatoes progresses until it is red, the lime stops changing 'halfway', when it is yellow. This means that a similar algorithm can be used for both cases. The color correction requires that the background pixels are not saturated in any of the channels, as this would distort the average obtained. The black level is estimated empirically. A linear expansion is applied to each of the RGB channels to set the black level to 0, and the white level to 255. Figure 2.6 show a sketch of the measuring device.

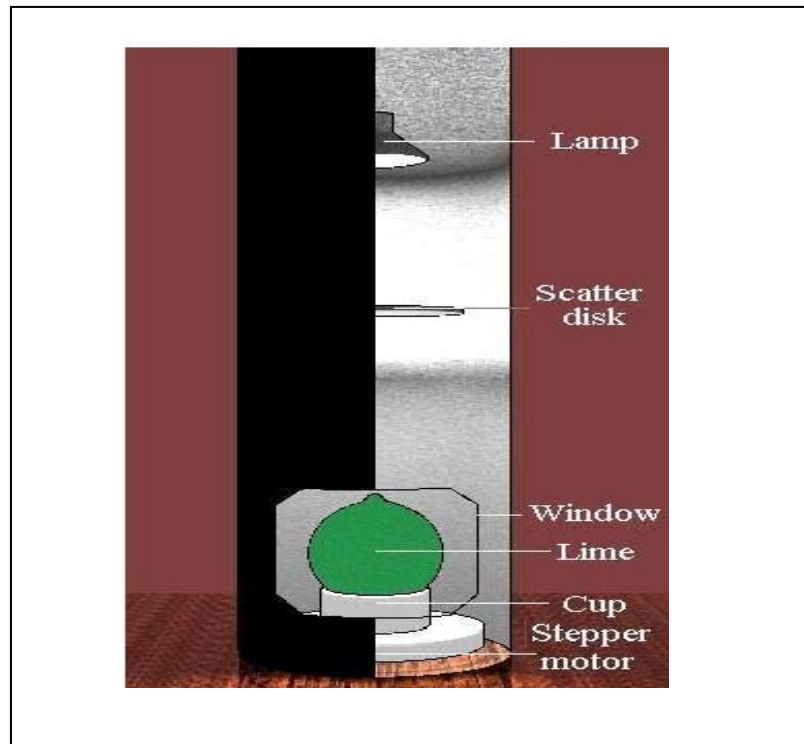


Figure 2.6 Lemon measuring device

The next step is to determine which pixels belong to the object being imaged. The blue channel stays approximately constant during the ‘degreening’ and is of a similar low level for both limes and tomatoes. Morphological filtering removes isolated areas that have been mis-thresholded to give a clear silhouette of the object. Dividing the red by the green gives a usable numerical ratio.

$$pixel_colour_index_0 = \frac{Red}{Green}$$

This algorithm shows calculating of pixel of color index.

Once the pixel color index of the object is known a histogram is obtained of the pixel color index value. From the histogram four index numbers are generated: Mean, standard deviation, skew and Kurtosis as shown in the figure 2.7.

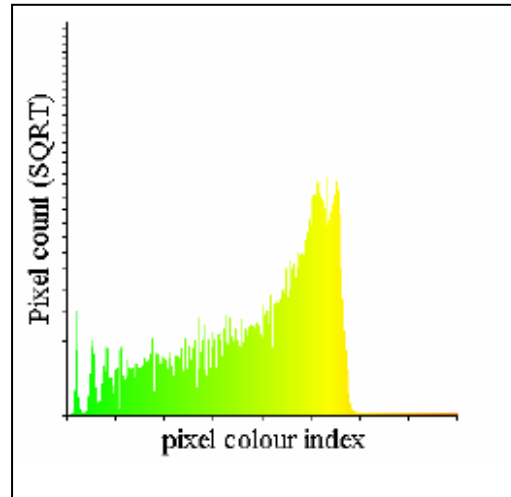


Figure 2.7 Histogram of the lime

Due to the large amount of data produced when making the measurements over a large number of objects and over an extended time, there is need for an automated processing system. This program is written in visual Basic Excel and allows the input of large quantities of data in random order, producing the sorted data in a number of charts. Finally, for the testing process 100 separate which time the index numbers should remain constant.

2.3.3.2 Advantages and disadvantages

The advantages of the system is can grade two fruit (tomatoes and limes) using a system. Other than that, this system also can develop a low cost objective technique that will measure the color of limes and tomatoes. The disadvantages of the system is only one fruit each time can scanned where it will longer time to deliver to the market.

2.4 Manual flow of musk lime

According to Mr. MohdAshik b. Abdul Rahman, KampungJerengkang, general manager of Hessa Creative SDN BHD, 71900 labu, Negeri Sembilan who have musk lime farm have shared his opinion on this industry. He was conducting this business for past 4 years and using his own modal. There are around 10 workers works in his farm, where the worker have to take care of the musk lime tree. After the musk lime collected, it will deliver to markets and shops. First of all, the musk lime tree will started to produce flower which will become green color musk lime after 2 months and it can plug from tree. The musk lime which plug can sell in market for 4 days.

Basically, in industry the musk limes not separating using the color or size. After it plug, will send to market and they will start to sell it. The musk lime only deliver in Malaysia, it does not export to foreign countries. It causes big loss to the industry because of selling grad A, B, C and D musk lime with same price without separating. The figure 2.8 shows current flow chart of musk lime process where it

start from worker plug the musk lime from tree and it collected. Then, the collected musk lime may send to market for sell or factory for process musk lime juice.

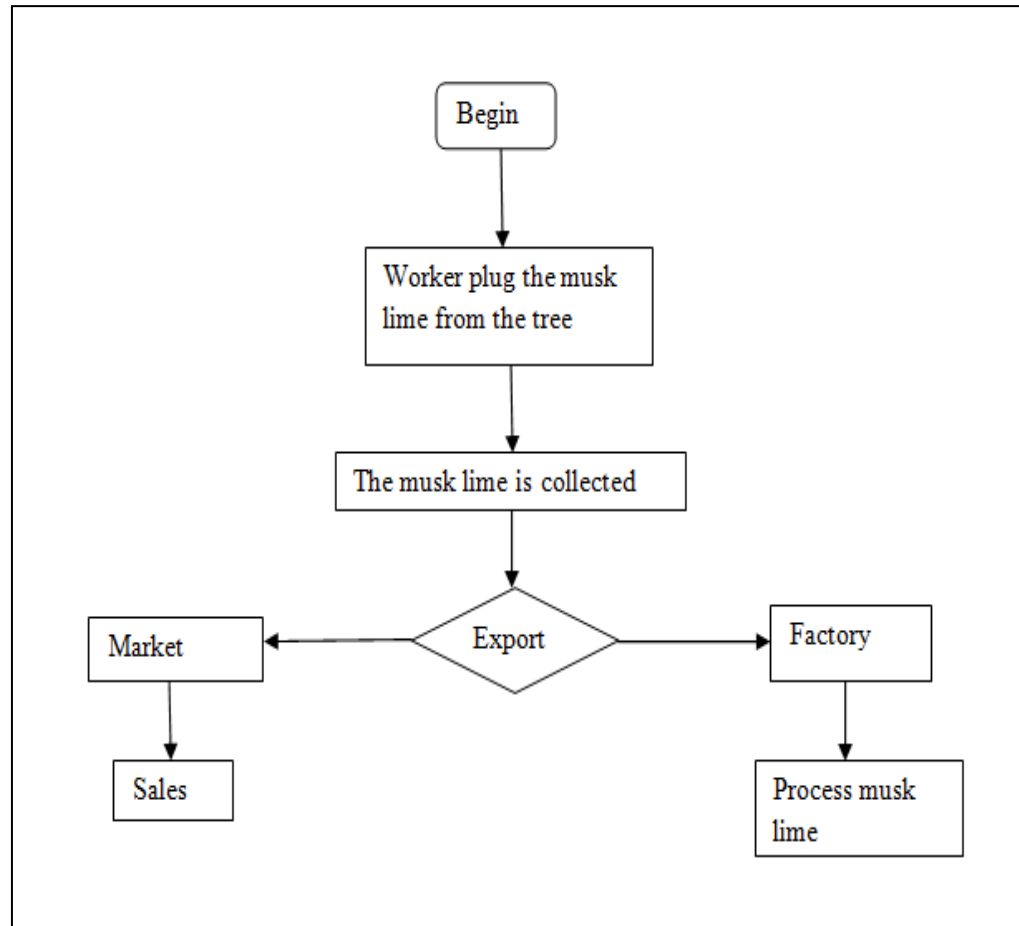


Figure 2.8 Flow chart of the manual method

2.5 Proposed new system

Musk lime detection system is system that developed to improve the current system use in industry. The computerize system just convert the manual system to computerize system where there are much easier to be use. Figure 2.9 flow chart of

musk lime process after the system apply in agriculture industry where it begins with plugging musk lime from the tree by the worker. Then, all the musk limes are collected into large basket before grad it. Next, the machine vision system will clarify musk lime into grad A, B, C and D as shown in the figure 2.10. Furthermore, the limes are exported to local markets, foreign countries and factory. Most probably, grad A and B will be exported to local market and foreign countries but grad C and D will be delivering to factories to make juice. This is because grad C and D fruits are more ripe musk lime compare to grad A and B. This is because the percentage of color and life storage each musk lime is different according to grad as shown in table 2.2. The life storage of musk lime is fixed by doing testing with the musk limes. Some of the testing result is shown in figure 2.11 and 2.12. Figure 2.11 and 2.12 show the musk lime that plug from tree categorize into grad A, B, C and D where as figure 2.13 shows grad D musk lime after 2days.

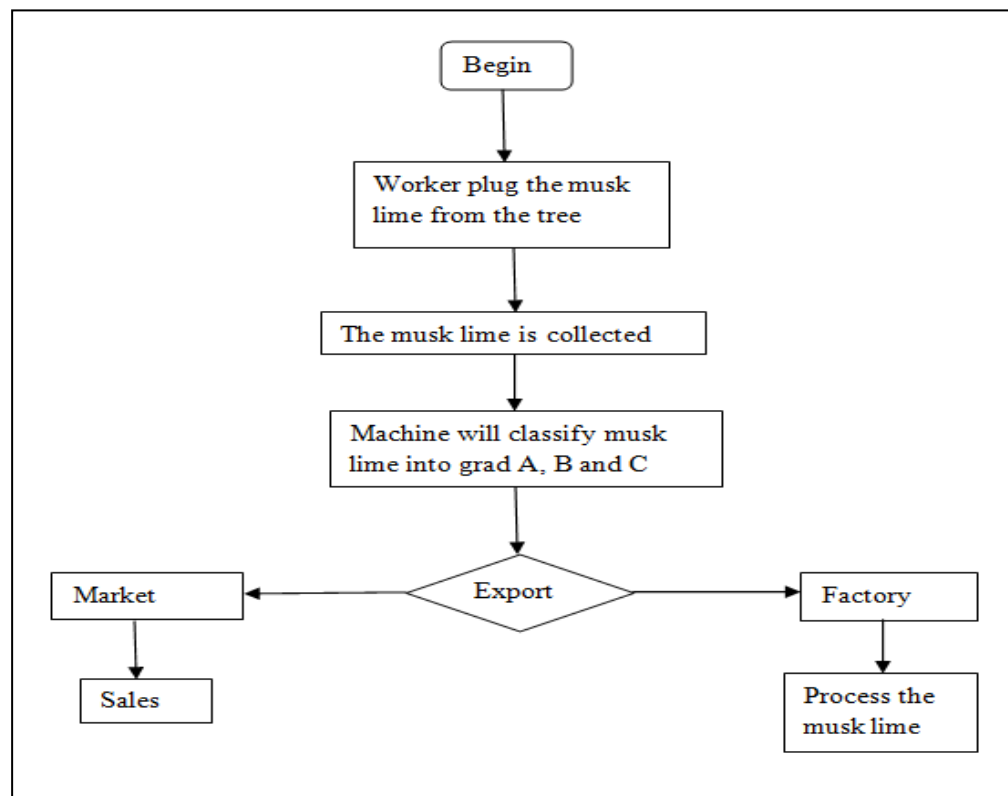


Figure 2.9 Flow chart of the machine vision method



Figure 2.10 Musk lime that arrange from grad A to D

Table 2.2 Clarification of musk lime

	Maturity (%)	Color Balance (%)	Life Storage (days)	Grad
Dark Green	20 -40	90 – Green 10 – Black	6 - 7	C
Green	40 – 60	100 – Green	4 - 5	A
Yellowish	60 – 80	50 – Green 50 – Yellow	2 - 3	B
Yellow	80 - 100	100 - Yellow	1 - 2	D



Figure 2.11 Musk lime with label separated according to grad



Figure 2.12 Grad A Musk Lime with label



Figure 2.13 Grad D musk lime after 2 days

2.6 Conclusion

The related journals are color grading in tomato maturity estimator using image processing technique, automated oil palm fruit grading system using artificial intelligence and Objective color measurement of tomatoes and limes. Tomato color grading and Objective color measurement of tomatoes and limes has use image processing techniques whereas oil palm fruit has use artificial intelligence technique. For clarification of musk lime base on color used image processing technique suggested for this title.

CHAPTER III

METHODOLOGY

This chapter will be discussing the methodology and the framework of the clarification of musk lime base on color. This project will be conducted based on the Software Development Life Cycle (SDLC).

3.1. Introduction

Methodology is a codified set of recommended practices, sometimes accompanied by training materials, formal educational programs, worksheets and diagramming tools. Generally it can be defined a guideline for solving a problem, with specific components such as phases, tasks, methods, techniques and tools [18]. It documented a set of procedures and guidelines for one or more phases of the

software life cycle, such as analysis and design. Many methodologies include a diagramming notation for documenting the result of the procedure and an objective (ideally quantified) set of criteria for determining whether the result of the procedure is acceptable quality.

This chapter will discuss about the software process and methodology to be implemented in the classification of the musk lime. Other than that, system concept, requirement specification, design, coding and then finally, via compilation and assembly, to the stored program form also will discuss in this chapter. Besides that, this chapter will be describing about the software and hardware requirements for this project. This project will be completed by using Matlab R2010a as the development platform.

3.2. Software Development Life Cycle (SDLC)

Software development life cycle is a frame work that describes the activities performed at each stage of software development project. It also can be defined as process of developing information system through investigation, analysis, design, implementation and maintenance. Various SDLC methodologies have been developed to guide the processes involved including the waterfall model, rapid application development (RAD), joint application development (JAD), agile development, iterative and incremental development and spiral model.

The SDLC methodology will help to achieve these goals by:

- Documenting requirements and maintaining trace ability of those requirements throughout the development and implementation process.
- Ensuring that projects are developed within the current and planned information technology infrastructure.

- Identifying project risks early.

This project will develop by referring water fall model introduced by Royce 1970 which organized the phases in linear order [19]. Water fall model include requirements, design, implementation, verification and maintenance phases. It is called waterfall because of the way it falls down. This visual aspect is what affects people's perceptions of what it does and hence how it is implemented. The earliest paper which describes the waterfall is "Managing the Development of Large Software Systems" by Dr. Winston W. Royce published in 1970. However he did not call it the waterfall model and he had several criticisms in using it if it was naively implemented. Instead he was championing the concepts of a sequence of development stages and crucially iterating back to previous stages as more evidence emerged during development [20].

According to a Version One survey (2007), nearly 70% of software development organizations are still using the Waterfall Method in other words, not only is it the oldest and most well tested methodology [21].

- a) Advantages of waterfall model

This model easy to explain to the user the concept of the system and stages are well defined. Besides that, it also helps to plan and schedule the project properly. The project requires the fulfillment of one phase, before proceeding to the next. Therefore if there is a fault in this software it will be detected during one of the initial phases and will be sealed off for correction.

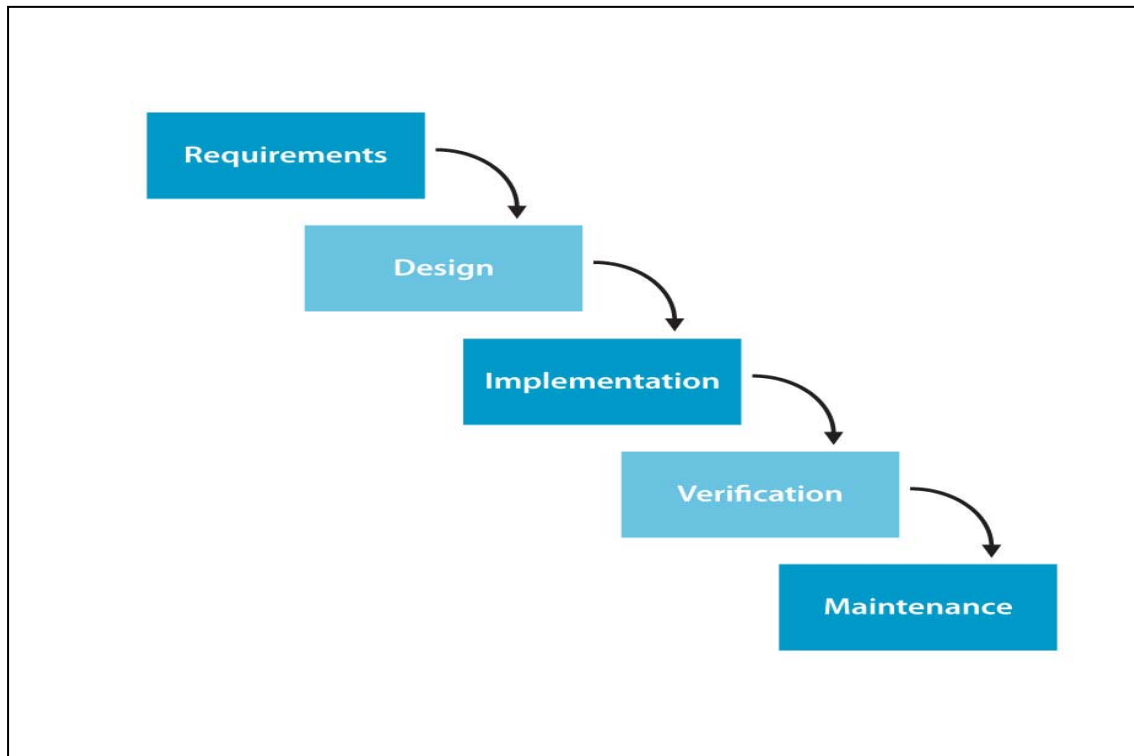


Figure 3.1[22]

Figure 3.1 shows the steps that involve in water fall model for classification of musk lime base on color. The steps are requirements analysis planning, system design, implementation, verification / testing and maintenance. The first phase requirements are set of functionalities and constraints that the end-user (who will be using the system) expects from the system. Next, system design helps in specifying hardware and system requirements and also helps in defining overall system architecture. Besides that, in next step the system is first developed in small programs called units, which are integrated in the next phase. In next step, the system will be tested to check error of the system. Generally, problems with the system developed (which are not found during the development life cycle) come up after its practical use starts, so the issues related to the system are solved after deployment of the system. Not all the problems come in picture directly but they arise time to time and needs to be solved; hence this process is referred as Maintenance [23].

Each phase in the software methodology (water fall model) will be divided into several sub process whereas each of them plays unique role in order to achieve the objectives of the system to be develop.

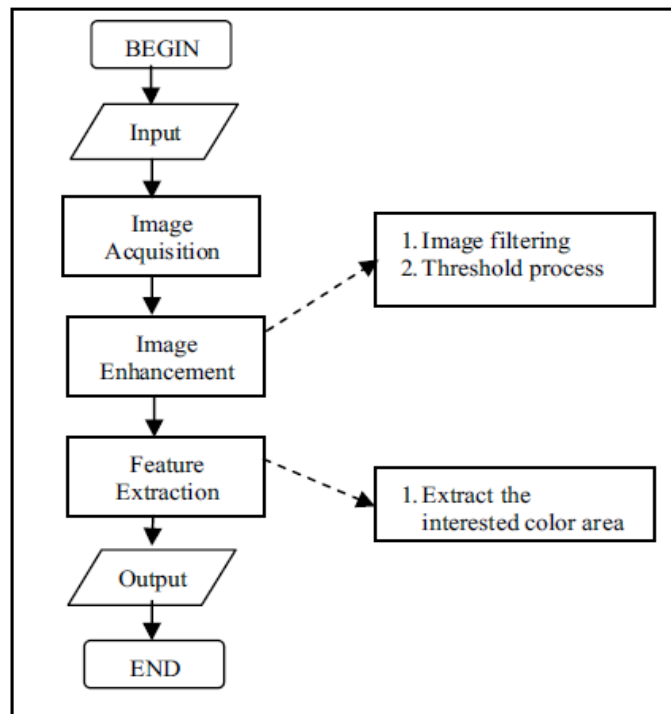


Figure 3.2 Overall process of classification of musk lime base on color

Figure 3.2 shows general process in image processing that will implement in this project. The input of the system will be an image and the output will be in mathematics variable form. The process and techniques of image acquisition, image enhancement and feature extraction will be applied in the water fall methodology.

3.2.1. Requirement Phase

The planning of the system began with the writing proposal of this system and approved by final year project coordinator and supervisor. After that, a schedule has been made to guide along the software development to make sure it can be finished at the time given. Then, meet the supervisor to get guidelines, advices and ideas about this project. All the project planning is being done in Gantt chart which use to schedule or plan the activity that will be involved in project development.

Furthermore, in this phase the officer of agriculture department will give the entire requirement for the project. The information is gathered through an interview with general manager of Hessa Creative House SDN SHD who conducts musk lime business in Nilai, Negeri Sembilan. Some information has been collected during the discussion and problem statement of the project is identified. Requirements elicited were then reviewed by supervisor and the details will be explained in following sub-chapter.

3.2.1.1. Image Acquisition

According to the general manager, musk lime maturity can be determined base on the color. Image acquisition is the first process in the system development to get the image. The images were captured by placing a PC camera at approximately 50mm on the top of the musk lime, by using same background and same visible light condition.



Figure 3.3 Setup for image acquisition

Figure 3.3 shows illustration of setup for image acquisition where images were captured approximately 50mm on the top of the musk lime. The images were captured is in JPEG format JPEG format is use because JPEG image are best used for the representation of natural scene. Figure 3.4, 3.5, 3.6 and 3.7 image show captured during image acquisition process.



Figure 3.4 Grad A musk lime



Figure 3.5 Grad B musk lime



Figure 3.6 Grad C musk lime



Figure 3.7 Grad D musk lime

3.2.2. User Design

After the requirements have been determined, discussion about a prototype in designing the system will be carried. The design of the system will be developed

using Graphical User Interface (GUI). Figure 3.8 shows the interface of the system which created using 'GUIDE' function in MATLAB. The following sub-chapters will explain about the image processing techniques that have to be implemented in the system.

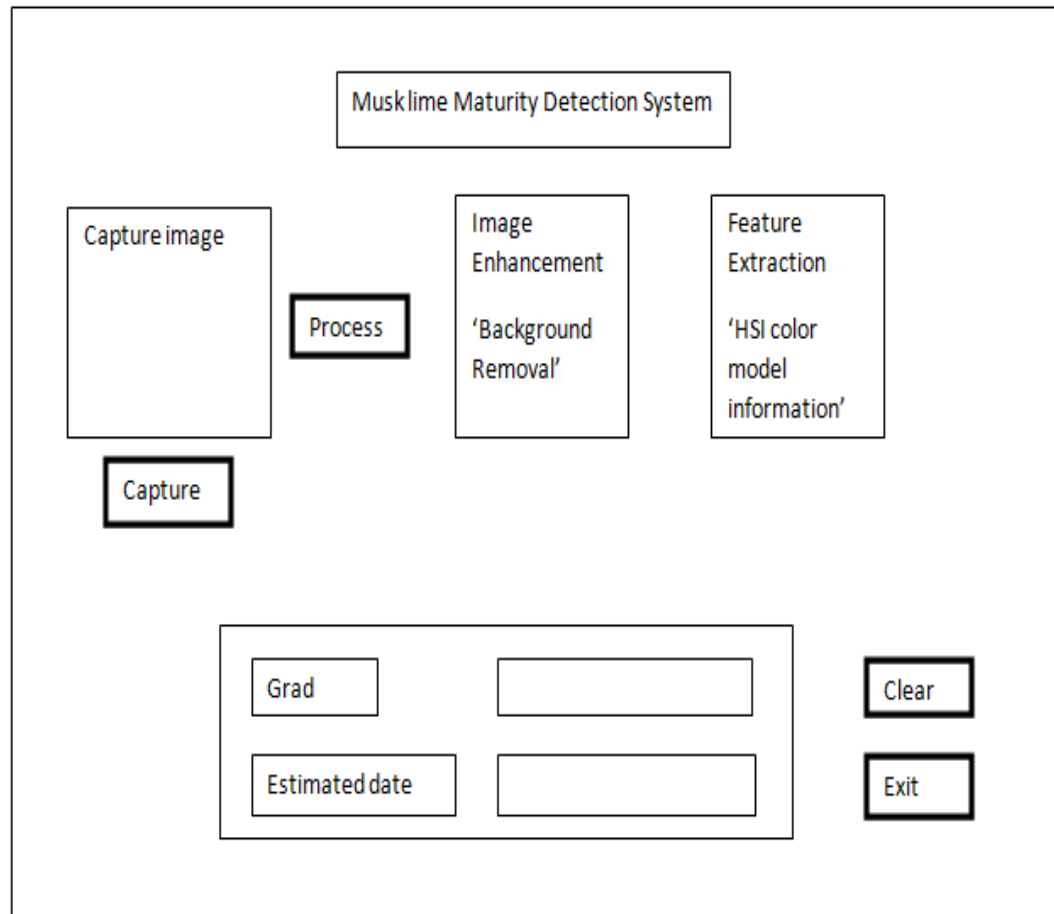


Figure 3.8 Draft interface of the system

3.2.2.1. Image Enhancement

Image enhancement means is a process to improve quality of an image for human viewing and also for a specific application. Since, RGB color model sensitive to lighting or other conditions. HSV (Hue, Saturation and Value) prefer for this project. The capture image is in RGB format. So, the image will converted to HSV (hue, saturation, value) format by calling the function.

Averaging filter is implemented in this process. The average filter computes the mean (average) of the gray-level values within a rectangular filter window surrounding each pixel. This has the effect of smoothing the image (eliminating noise). The default filter size is 3x3 as shown in Figure 3.9. The filtered pixel will be calculated by:

$$r = (a1 + a2 + \dots + a9) / 9$$

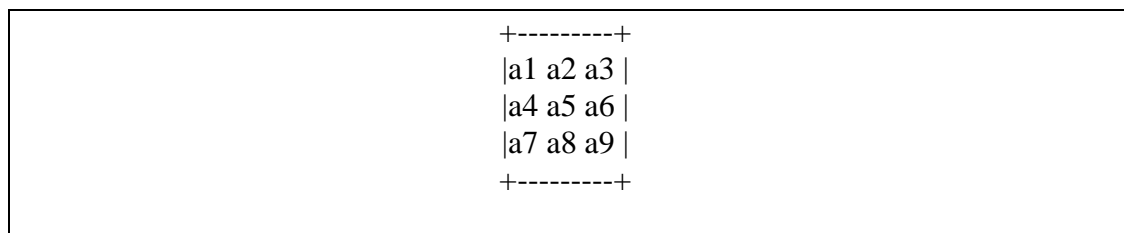


Figure 3.9 Filter window 3x3

The background of the image considered as noise in this system, thus removing the influences of background is necessary. The filtered image will be converted to threshold image to target the interested area where at next step the

background of the object will be removed. The result will be display at interface of the system.

3.2.2.2. Feature Extraction

The idea of features extraction is to extract the information of the interested area in the image for further usage in processing the image. From HSV image, the exterior boundary of the object is traced. Whereas from the threshold image some function is apply to remove background of the object. The color changes of limes consider it start with green and end yellow. Where, from HSI image three values can be calculated but this project just required 'H' value. This is because Hue (H) describes a pure color of the image whereas saturation (s) gives a measure of the degree to which a pure color is diluted by white light and Value (V) gives effectiveness of the color. So, to identify the color changes from green to yellow average of H is calculated to estimate the maturity of musk lime. The accurate color classification is possible with only hue parameter (0-20). Table 3.0 hue range that used determines grad of musk lime using matlab.

Table 3.0 Average hue for musk lime according to grad

Grad	Percentage of color balance (%)	Hue range
C	20 - 40	0.002 – 0.005
A	40 - 60	< 0.0125
B	60 - 80	< 0.0326
D	80 - 100	<0.0428

3.2.3. Implementation

In this phase, the designs and ideas that collected regarding the project will translate into code using MATLAB. The implementation stage of software development is the process of converting a system specification into an executable system. MATLAB was chosen as the programming language in this system development because MATLAB is support the image processing coding. Codes and function is implemented using MATLAB in converting techniques described in user design phase into executable program. This stage also to make sure the technique the applied is successful implement.

3.2.4. Testing or verification

After the completion of executable program manufacture, a test has to be carried out to examine if the system meet its requirement and the system meets expectation of the supervisor. The system makes sure that it can run well and achieve their objective. This system tested determine if there is any error occur when the system in running mode. The test case has included hardware integration of all components in the system. There are hundred musk limes as the testing samples at this stage. After the musk lime tested using machine, the lime will be cut to test the result manually.

3.3. Software and Hardware Requirement

This subchapter will identify resources needed in developing classification of musk lime base on color. Hardware and software should be considered to make sure the project can enhance successfully during the development phase. Software is a general term for the various kinds of program used to operate computers and related devices, while hardware is physical aspect of computer.

3.3.1. Software Requirement

The software requirement for this system has been identified as shown in table 3.1 below:-

Table 3.1 Software that used to develop the system

Item	Name	Purpose
Operating System	Microsoft Windows 7 Ultimate	As the operating system
Software	MATLAB R2010a	As a platform in developing and running the system
	Microsoft Office Word 2007	To document the system's document
	Microsoft Office	To produce system

	Project 2007	Gantt Chart
	Microsoft Power Point 2007	To do system presentation
	Microsoft Visio 2007	To design UML diagram and flow chart
	Kaspersky Anti Virus 2010	Protection from virus
	Adobe Acrobat Reader 9.0	To read internet resources
	Adobe Photoshop 7.0.1	To edit the images To design the system's poster
	Logitech HD Pro webcam (driver)	To capture images

a) MATLAB R2010a

MATLAB is the main development tool to develop the system which has high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation. Furthermore, MATLAB also can be in a wide range of applications, including signal and image processing, communications, control design, test and measurement, financial modeling and analysis, and computational biology. MATLAB allows easy matrix manipulation, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs in other languages.

3.3.2. Hardware Requirement

The hardware requirement for musk lime detection system development has been identified as below:-

Table 3.2 Hardware that used to develop the system

Item	Minimum Requirement
Processor	Intel™ Core™ 2 Duo CPU T6400
RAM	2 GB
Logitech HD Pro webcam C910	10 mega pixels
Light Source	LED usb lamp as shown in figure 3.10
Thumb drive	2 GB
Printer	HP F4250
Others	A black colored box 74 musk lime samples

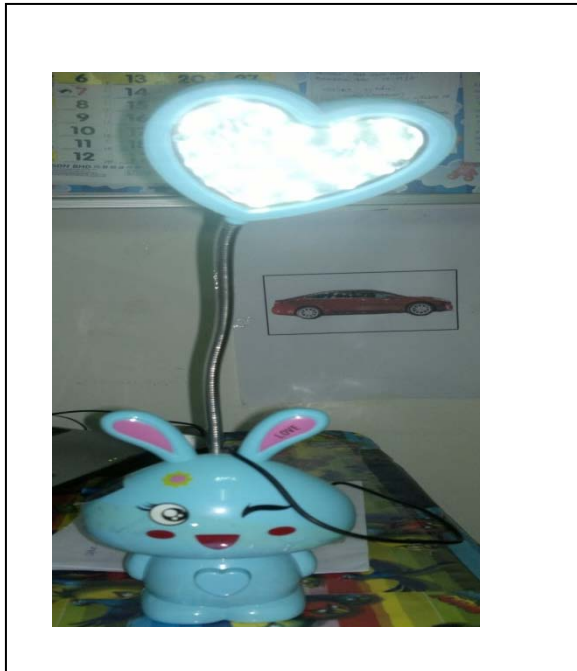


Figure 3.10 LED usb lamp

a) Logitech HD Pro webcam

In this project, web cam is used to capture the image of musk lime to process using Matlab function as shown in the figure 3.11.



Figure 3.11 Logitech webcam

3.4. Conclusion

Classification Musk lime system software development is used waterfall model methodology approach as it tracks from the starting point of the development and as the main guideline the makes the final release software becomes the successful. Planning is very important in developing a system.

CHAPTER IV

IMPLEMENTATION

4.1. Introduction

In this chapter the design are translated into code and the right programming language chosen. As the software progresses, implementation will need to test the software for proper implementation.

4.2. Image Acquisition

Image acquisition is the first process in the system development to get the image. Image acquisition means to acquire an image to be proceeding in the following steps

of image processing. Web camera is used to capture the image of musk lime. After that, the image is process using image processing techniques. The setup for capture musk lime image shown in figure 4.1.

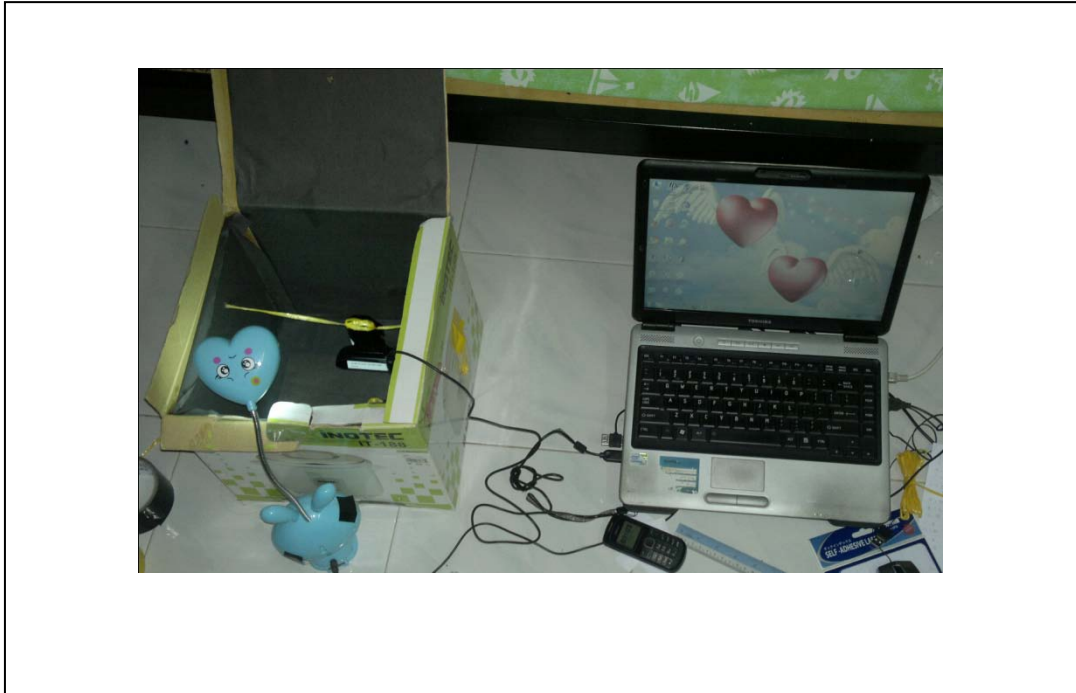


Figure 4.1 Setup for image acquisition process

Figure 4.2 describe function code required to capture an image using setup in figure 4.1. When user click on the *Capture* button, the system start creating one image object with `vidobj = videoinput('winvideo', 1)`. The data acquired are stored as array `lime`. In this case, `lime` is a three-dimensional (M-by-N-by-3) array which representing a color image. `imresize(lime,0.2)` used to resize the image (`lime`) size where 0.0 describe the scale times of size `lime`. Since, the scale is greater than 1.0, so the output of `lime1` will be larger than `lime`. `imshow` function will display the output `lime1` at axes 1.

The Matlab workspace should be cleaned up each time after creating a new object.

`delete(vidobj)` was used to delete the graphics object with handle `vidobj` while `clear vidobj` was used to clear `vidobj` from the Matlab workspace.

```
vidobj = videoinput('winvideo', 1);%create the object
lime = getsnapshot(vidobj);%Get acquired data
lime1 = imresize(lime,0.2);

%To show image at axes1
axes(handles.axes1);
imshow(lime1);

%To clean up
delete(vidobj)
clear vidobj
```

Figure 4.2 Source code for image acquisition

4.3. Image Enhancement

4.3.1. Conversion of RGB to HSV

In this project, HSV color model are used to determine maturity of musk lime. So, the RGB image has to convert to HSV image as shown in figure 4.3.

```
%Convert to hsv
lime_hsv = rgb2hsv(lime1); %create color transformation structure
```

Figure 4.3 Source code for converting of RGB to HSV

4.3.2. Filtering

Average filter used in this system. Filter `h = fspecial('average')` is applied to the image by function `imfilter(lime_hsv,h,'symmetric')`. This is to smoothes image data and eliminating noise. `Symmetric` means input array values outside the bounds of the array are computed by mirror-reflecting the array across the array border. `imshow` function will display the output `lime_hsv1` at axes 2. These source codes are shown in Figure 4.4.

```
%Filter
h = fspecial('average');
lime_hsv1 = imfilter(lime_hsv,h,'symmetric'); %symmetric show the
parameter

%Show filtered lab image
axes(handles.axes2);
imshow(lime_hsv1);
```

Figure 4.4 Source code for filtering

4.3.3. Threshold

Threshold image is consist only with binary pixels where an object pixel is given a value '1' (remarked by white color) while background pixel is given value of '0' (remarked by black color). First of all, RGB image converted grayscale image with function `rgb2gray(lime_hsv1)`. Then, the intensity of image is adjusted by calling function `imadjust(IG,stretchlim(IG),[])` that specify lower (bottom 1% of all pixel values) and upper limits (top 1% of all pixel values) that are used for contrast stretching the grayscale image. The grayscale image is converted to binary image by function `im2bw(lime_hsv2,level)` as shown in figure 4.5.

```

%Convert to bw
IG = rgb2gray(lime_hsv1);
lime_hsv2 = imadjust(IG,stretchlim(IG),[]);%adjust contrast of an
image
level = graythresh(lime_hsv2);%threshold image
BW = im2bw(lime_hsv2,level);%bw = binary image

```

Figure 4.5 Source code for threshold

4.3.4. Create Histogram

This histogram shows the hue graph of the HSV image. Hue image is extract out from HSV image by function `lHSV(:, :, 1)`. `imhist` is the function to create histogram of the image and axis x and y is on with label as shown in figure 4.6.

```

hImage = lHSV(:, :, 1);

%creating the hue graph
% Compute and plot the histogram of the "hue" band.
axes(handles.axes4);
[hueCounts, hueBinValues] = imhist(hImage);
bar(hueBinValues, hueCounts, 'r');
axis ([0 0.5 0 1000]);
grid on;
xlabel('Hue Value');
ylabel('Pixel Count');
title('Histogram of Hue Image');

```

Figure 4.6 Source code for create histogram

4.4. Feature Extraction

4.4.1. Trace Boundaries

The trace boundary image is shown in axes 3. The boundary of the musk lime was traced by implementing function `bwboundaries (BW, 'noholes')` into the binary image as shown in Figure 4.6. This function traces the exterior boundaries of objects where nonzero pixels belong to the musk lime and 0 pixels constitute the background as shown in figure 4.7.

```
%traced boundary
axes(handles.axes3);
imshow(lime_hsv);
hold on;
[B,L] = bwboundaries (BW, 'noholes');
for k=1:length(B)
    boundary = B{k};
    plot(boundary(:,2),boundary(:,1), 'w', 'LineWidth', 2);
end
```

Figure 4.7 Source code for trace boundary

4.4.2. Removing Background

The background of the image was then remove by function code `KM2 = imfill(KM, 'holes')`. `KM` was an empty array with the size of `BW`. The cell which is located within the boundary was being assigned pixel value of 1's as shown in Figure 4.8.


```

%To remove background
dim = size(BW);
nn=size(boundary);
KM=zeros(dim(1),dim(2));
ii=0;
while ii<nn(1)
    ii=ii+1;
    KM(boundary(ii,1),boundary(ii,2))=1;
end
KM2 = imfill(KM,'holes');
lhsv = rangefilt(lime_hsv);
no = 0;
for i=1:dim(1)
    for j=1:dim(2)
        if (KM2(i,j)) == 1
            no = no + 1;
        end
    end
end

```

Figure 4.8 Source code for removing background

4.4.3. Obtain Value of Hue

In this process, `no` has been used to determine the number of cells containing pixel value of 1's in array `KM2`. While function code `h = lhsv(i, j, 1)` was used to retrieve specifies H value in location (i, j) of the image.

The H value is then being stored in an array by function code `MeanHue(nu,1) = hue`. Finally, the average of H values that contains in `MeanHue` are being returned by function code `mean(MeanHue)` as shown in Figure 4.9.

```

%To obtain hue value
range = zeros(no,1);
nu = 0;
for i=1:dim(1)
    for j=1:dim(2)
        if (KM2(i,j)) == 1
            nu = nu +1;
            h = lhsv(i, j, 1);
            range(nu,1) = h;
            %Hue (nPoint, 1) = HSV (j, k, 1);
            %array(nu,1)=a;
        end
    end
end

hue = mean(range);

```

Figure 4.9 Source code for obtain value of Hue

4.4.4. Estimate Maturity of Musk Lime

Musk lime maturity was determined by classifying average of Hue value obtained into four classes. The source code for estimate tomato maturity is shown in Figure 4.10. The `mday = 2` is the maximum storage days. Function code `day = round(diff*0.023)` compute the days left towards `mday` in a round number. Expiry date was computed by function code `expiry_date = datestr(now + (mday-day), 'm d, yy')` by summation of current date and `(mday-day)`.

```
%Estimate maturity
if (hue < 0.002 && hue > 0.005)
    percent = 'C,10-20%';
    diff = hue -(0.044);
    day = round(diff*0.023);
    mday = 7; %max day
    expiry_date = datestr(now + (mday-day), 'm d,
YYYY');

elseif (hue < 0.0125)
    percent = 'A,40-60%';
    diff = hue -(0.0122);
    day = round(diff*0.031);
    mday = 5; %max day
    expiry_date = datestr(now + (mday-day), 'm d,
YYYY');

elseif (hue < 0.0326)
    percent = 'B,70-80%';
    diff = hue -(0.0545);
    day = round(diff*0.040);
    mday = 3; %max day
    expiry_date = datestr(now + (mday-day), 'm d,
YYYY');

elseif (hue < 0.0428)
    percent = 'D,100%';
    diff = hue -(0.0825);
    day = round(diff*0.055);
    mday = 2; %max day
    expiry_date = datestr(now + (mday-day), 'm d,
YYYY');
```

Figure 4.10 Source code for clarification of musk lime

CHAPTER V

RESULT, DISCUSSION AND CONCLUSION

5.1. Introduction

There are 74 musk lime used as sample data in the testing phase of this development. The musk lime samples had gone through the phases as discuss in the chapter 3 and 4. This chapter will describe about the output result of each phases mainly, image acquisition, image enhancement and feature extraction. Please refer to appendix B for full details on testing results.

5.2. Image Acquisition

All the musk limes for testing phases are collected from Hessa Creative SDN BHD farm which located in Negeri Sembilan. The samples are taken with various color musk lime to get accurate testing result for each grade. Each of the musk lime image captured under the same environment as discuss in the chapter 4. Figure 5.1 show the sample captured image for testing phase.



Figure 5.1 Original image

5.3. Image Enhancement

After the musk lime image captured, it will process under certain processes. The captured image will converted to HSV, filtered with average filter, threshold and histogram is created for hue value.

5.3.1. Conversion of RGB to HSV

The captured image which is in the RGB format was converted to HSV format as shown in figure 5.2. The output of HSV image also display in the interface of the system.

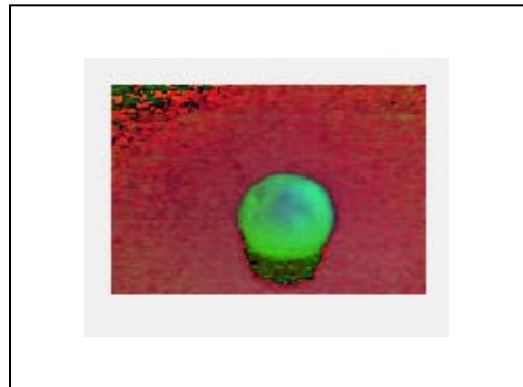


Figure 5.2 HSV image

5.3.2. Filtering

After the image converted to HSV format, it filtered using average to remove noise as shown in the figure 5.3. The noise of the image cannot be seen by naked eye.



Figure 5.3 Filtered image

5.3.3. Threshold

The filtered image converted to grayscale image which is two dimensional images as shown in figure 5.4. Then, the grayscale image was converted to a binary image as shown in Figure 5.5.

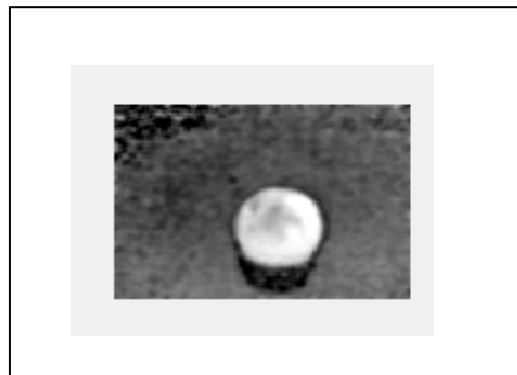


Figure 5.4 Grayscale image

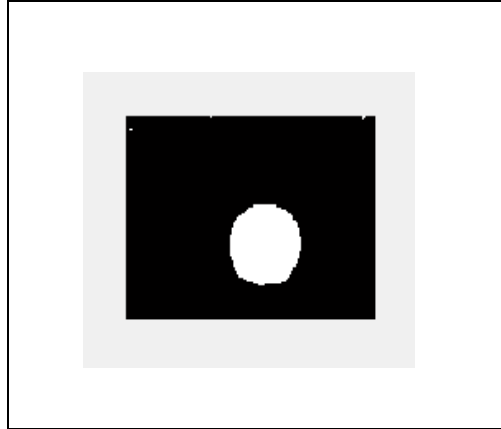


Figure 5.5 Binary image

5.3.4. Create histogram of the Hue value

Since, only hue value is use determine the maturity of musk lime. The hue value has illustrated in histogram form as shown in figure 5.6.

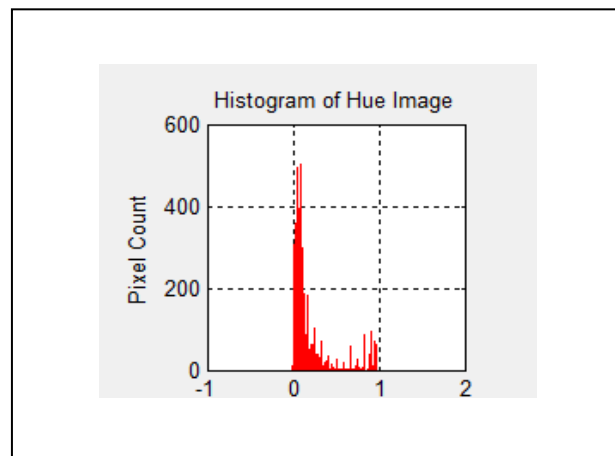


Figure 5.6 Hue value histogram

5.4. Feature Extraction

In this phase, the system traced musk lime boundary in the threshold image and then background is removed which considered noisy. Using hue (H) value, the maturity of the musk lime is obtained.

5.4.1. Trace Boundaries

The boundary of the musk lime is traced as shown in the figure 5.7 which plotted on the HSV image.

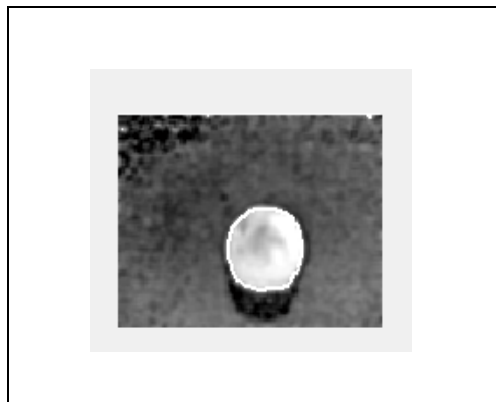


Figure 5.7 Trace boundary image

5.4.2. Removing Background

Next stage is removing the background of the image from threshold image. The influence of the image background was being removed by taking the size of the boundary area drawn at previous stage and filling the area with pixel 1s. Figure 5.8 shows result obtained from threshold image to image that background removed.

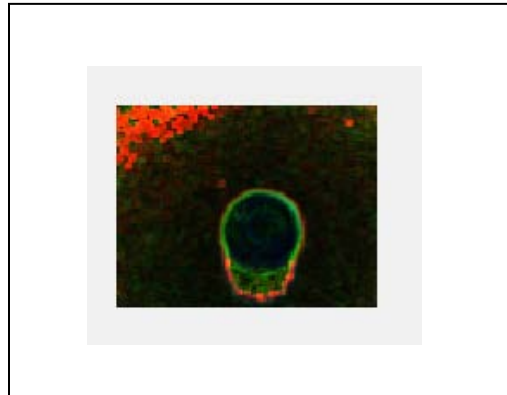


Figure 5.8 Remove background image

5.4.3. Estimate Maturity of Musk Lime

By obtaining Hue value, the maturity of the musk lime is calculated. The estimated expiry date also calculated based on the Hue values. The grad and estimated expiry date is shown in the interface which will discuss in 5.5.

5.5. Interface of the System

Figure 5.9 shows GUI that help user to check the output of the prototype.

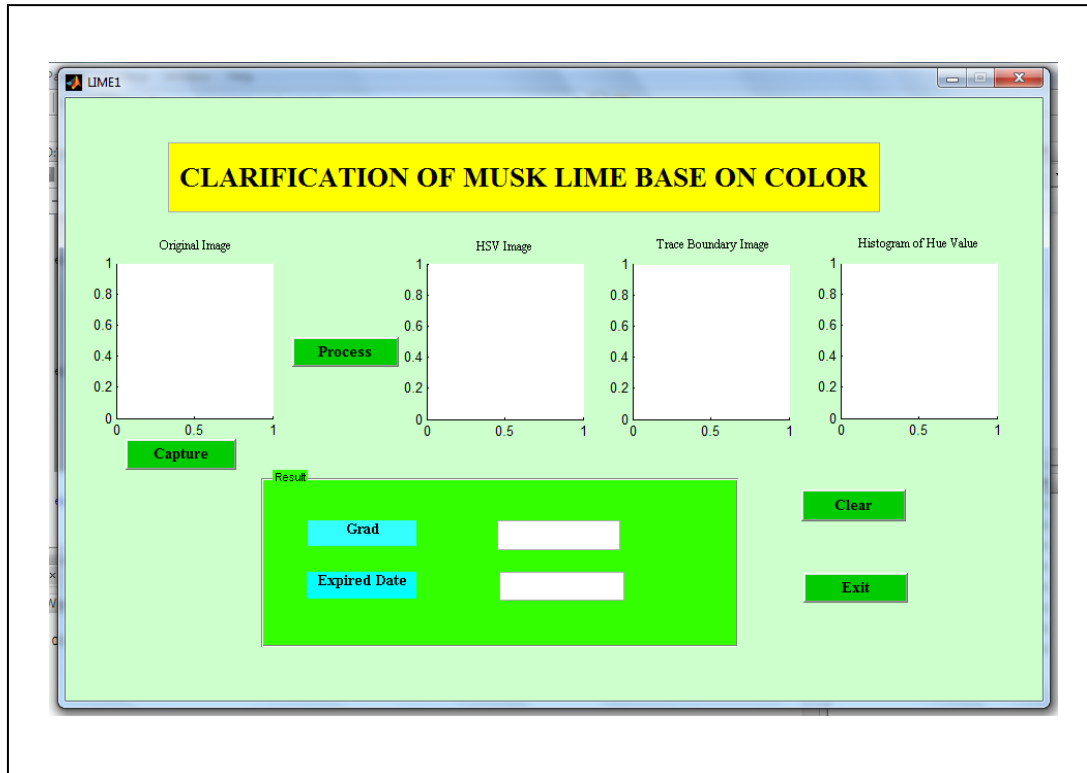


Figure 5.9 Main interface of the system

5.6. Test Results

As mention in the scope of the system, 74 musk limes has been tested with different maturity. The result of testing process is shown in the table 5.0. According to the table, seventy four musk limes have been tested on 20/5/2012 according to

the grad. The overall result show 100% pass for grad A , 92 % pass for grad B, 93% pass for grad C and 100% pass for grad D after the musk lime tested using manual process (cut session). During the testing process some musk limes fail to detect grad using the system due to lighting effect.

Table 5.0 Result from testing

Maturity of musk lime	Tested Limes	Tested day	Expired date	Percentage of pass (%)
A	20/74	20/5/2012	23/5/2012	100
B	28/74	20/5/2012	21/5/2012	92
C	15/74	20/5/2012	24/5/2012	93
D	11/74	20/5/2012	20/5/2012	100
Average percentages of pass result (%)				96

5.7. Advantages and disadvantages

The system provides some advantages and disadvantages which can enhance in the future use.

5.7.1. Advantages

The advantages of this system are:

- I. The system able to judge the grad and estimate the expiry date of musk lime which is not available in current export market.

- II. The system also provide a better alternative compared to using manpower in determining musk lime maturity where the machine vision system will not prone error due to tiredness or bias.

5.7.2. Disadvantages

The disadvantages of this system are:

- I. The system can only process one musk lime for each process.
- II. The prototype was not able to differentiate musk lime with other fruits or vegetables which have same color intensity rather than different shape.

5.8. Achieved Objective

The objectives for this project are:-

- I. To develop a prototype for judging the musk lime maturity base on their color.
- II. To estimate the expired date of musk lime by their color.

All the objectives stated above are achieved. The system for classification of musk lime base on color was developed to achieve the first objective. Then, the system was run to provide the outputs which is expired date and grad of the musk

lime. The functions in this system running properly and user can use to judge the grad of musk lime.

5.9. Constraints

There are some constraints that effect the system when it running. First of all, the distance between camera and musk lime. The changes of the distance between cameras and musk lime will affect the quality of the image captured where sometimes the image will blur not able to process.

Other than that, the environment effect where mainly focus on lighting effects. The lighting effects that cause shadows and reduce the clear of the object. During image acquisition process, the image captured may cause reflection on musk lime. Furthermore, the system only can detect single image of the musk lime. The system unable to process many musk limes once, it have to process one by one.

5.10. Assumptions and Further Research

The system should be published into agricultural sector especially in musk lime industry to help the farmer and offices to estimate maturity of musk lime. Therefore, some assumptions have to be considered along with the development of this system. In the view for the disadvantages stated, further research should be carried out to enhance the current research.

5.10.1. Assumptions

There are several assumptions that were taken in consideration during the system development. First of all, the lighting condition should not too bright because it will change the color of the HSV value. So, suggested the image acquisition process should carry out in room condition with normal lightning.

Furthermore, the musk lime for the testing phase should store in room temperature condition, it were not being chilled in refrigerator or being stored near heater. This is because to get proper result during testing phase. The musk lime also should not be exposed to direct sunlight during the testing phase because it will decrease the quality of musk lime.

5.10.2. Further Research

There are some suggestion and recommendation for further research to publish the system in agriculture industry for estimate maturity musk lime.

The developed system not able to processed more than one image. By using latest equipment the system can be enhance to process more images. Segmentation process can be use to process larger amount of musk lime.

Furthermore, during image acquisition process the musk lime should be in static conditions to capture the image which is not suitable for industry used. The system should be enhancing so that the image of musk lime can captured in motion way, which make the process faster.

The latest technology provides many techniques and processes in image processing field. Further research could take alternative techniques and approaches in order to enhance this prototype to producing better results. The observations on techniques used must be accurate so the problem to get results is achieved successfully.

5.11. Conclusion

For the conclusion, the development of classification of musk lime base color using image processing techniques used has successfully achieve the objective of this study. The main objective of this project is judge the maturity of musk lime base on color and expiry date. The system developed based on image processing techniques which include image acquisition, image enhancement and feature analysis.

The testing process has carried out with 74 musk lime as mention in scope of the project to check whether the prototype can give correct output with correct input. According to the testing result, 74 musk limes have been tested. It found in market grad B musk lime sells more than grad A musk limes.

However, the usability of this system was being restricted due to the disadvantages, constraints and assumptions as discussed in chapter 5. Hence, further research in adapting alternative approaches in processing the image for enhancement to current prototype is very much encouraging. As conclusion, the enhancement in the system can published in agriculture industry to improve the technology and help the farmer to grad the musk lime. As to support Malaysian government goals, the system helps to enhance and improve the use of technology in agricultural field.

REFERENCES

- [1] Saarin Osman.(n.d).LimeCastury.Retrieved April 6, 2011, from <http://limecastury.blogspot.com/2011/04/limau-kasturi.html>
- [2]The Nibble, lifestyle Direct (2005), from <http://www.thenibble.com/reviews/main/fruits/types-of-lime.asp>
- [3]Asmidanasia.(n.d). Pertanian. Retrieved January 12, 2009, from <http://ladangvirtual.wordpress.com/2009/01/>
- [4] MaklumatPertanian – ternakan, tanaman, perikananandanagrotourism (2007), from <http://kebunwarisan.blogspot.com/2010/07/khasiat-limau-nipis.html>
- [5] “A real-time grading method of apple based on features extracted from defects”
Journal of Food Engineering, vol.61, pp.83-89, 2004
- [6] Leemans, V., Magein, H. and Destain M.-F, “Defects segmentation on ‘Golden Delicious’ apples by using colour machine vision” Computers and Electronics in Agriculture, vol.20, pp.117-130,1999
- [7] Sarkar, N, and Wolfe, R. R, “Feature extraction techniques for sorting tomatoes by computer vision” Transactions of the ASAE, vol.28, pp.970-979, 1985
- [8] Syahrir, W. Md., Suryanti,A.,&Connsynn, C. (2008). Color Grading in Tomato Maturity Estimator using Image Processing Technique. Malaysia: University Malaysia Pahang, (276 - 280)

[9]May,Z., &Amaran, M. H. (2011). Automated Oil Palm Fruit Grading System using

Artificial Intelligence: Vol.3. Malaysia: University Petronas Malaysia

[10]Bunnik, H.M.W., Bailey,D.G., &Mawson,AJ.Netherlands : Waneningen University and Reseach Centre, Farm Technology Group, (263-268)

[11] Paliwal, J., Visen, N. S., Jayas, D. S. and White, N. D. G., “Cereal grain and dockage identification using machine vision” Biosystems Engineering, Vol.85, pp. 51-57, 2003

[12] On encoding of arbitrary geometric configurations - Freeman.H, IEEE Trans. Elect. Computers EL-10, 260-268, 1961

[13]Visual Pattern recognition by moment invariants, HU.MK, IRE, Trans. Info. Theory IT-8, 179-187, 1962

[14] Automated Machine vision inspection of potatoes - Tao, Morrow, Heineman P.H. ASAE, No. 90-3531, 1990

[15]An instrument system for cereal grain classification using digital image analysis -Sapirstein, H.D, Neuman, M, Wright E.H. - J Cereal Sci, 6, 3-4, 1987

[16] Corn quality evaluation with computer vision - Ding et, al. ASAE No. 90-3532, 1990

[17] Wikipedia the free Encyclopedia, Conversion of a color image to a binary image. Retrieved Jun, 11, 2008, from, http://en.wikipedia.org/wiki/Binary_image

[18] <http://en.wikipedia.org/wiki/Methodology/> Retrieved 2001

[19] KarlM(n.d), prutt05_lec6, from

http://www.nada.kth.se/~karlm/prutt05/lectures/prutt05_lec6.pdf

[20] Coley Consulting, Information and Advice for Software Testing, from

<http://www.coleyconsulting.co.uk/waterfall-model.htm>

[21] Skysigal(n.d). Waterfall SDLC Methodology (2007), [http://skysigal.xact-](http://skysigal.xact-solutions.com/Resources/SoftwareDevLifeCycle/WaterfallMethodSDLC/tabid/600/Default.aspx)

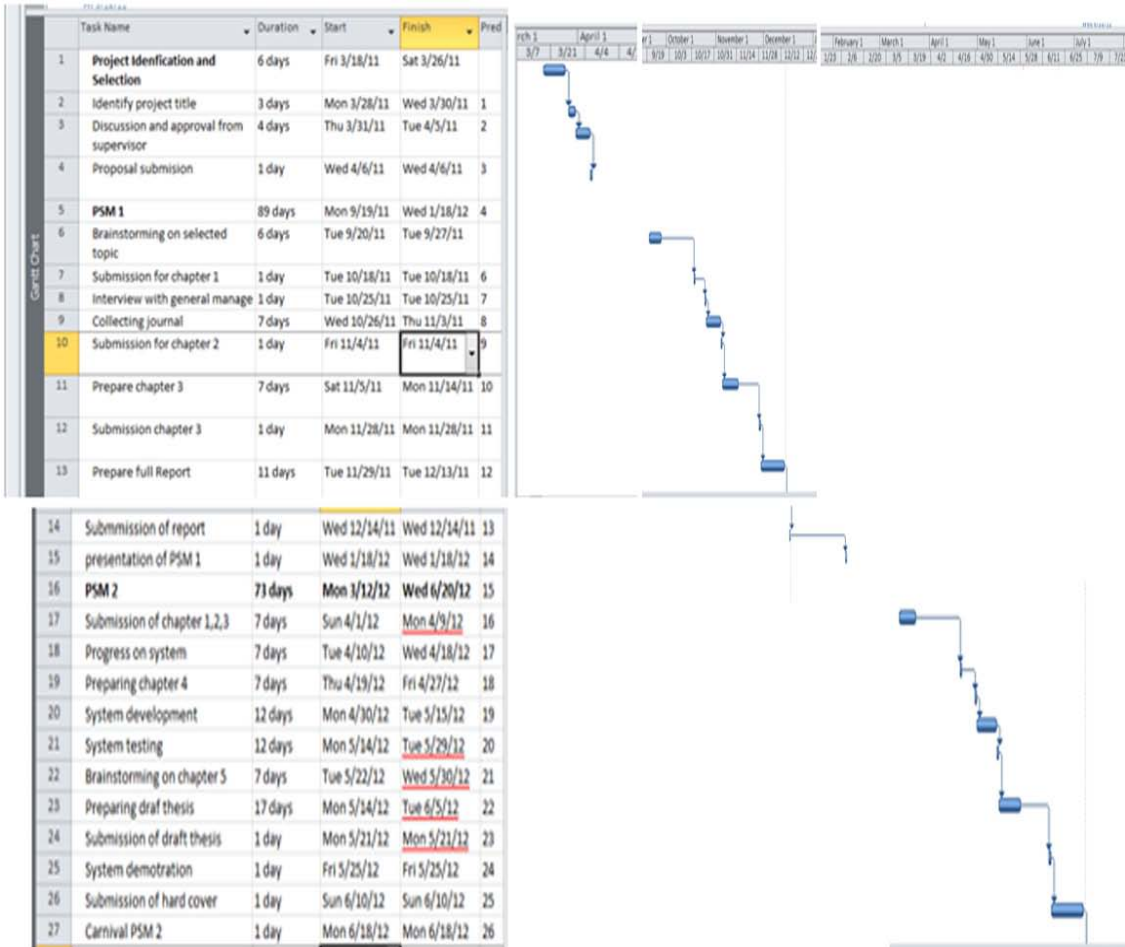
[solutions.com/Resources/SoftwareDevLifeCycle/WaterfallMethodSDLC/tabid/600/Default.aspx](http://skysigal.xact-solutions.com/Resources/SoftwareDevLifeCycle/WaterfallMethodSDLC/tabid/600/Default.aspx)

[22] Waterfall Model, <http://www.waterfall-model.com/> Retrieved 2011

[23] One Stop Testing,<http://www.onestoptesting.com/risk-analysis/> Retrieved 2011

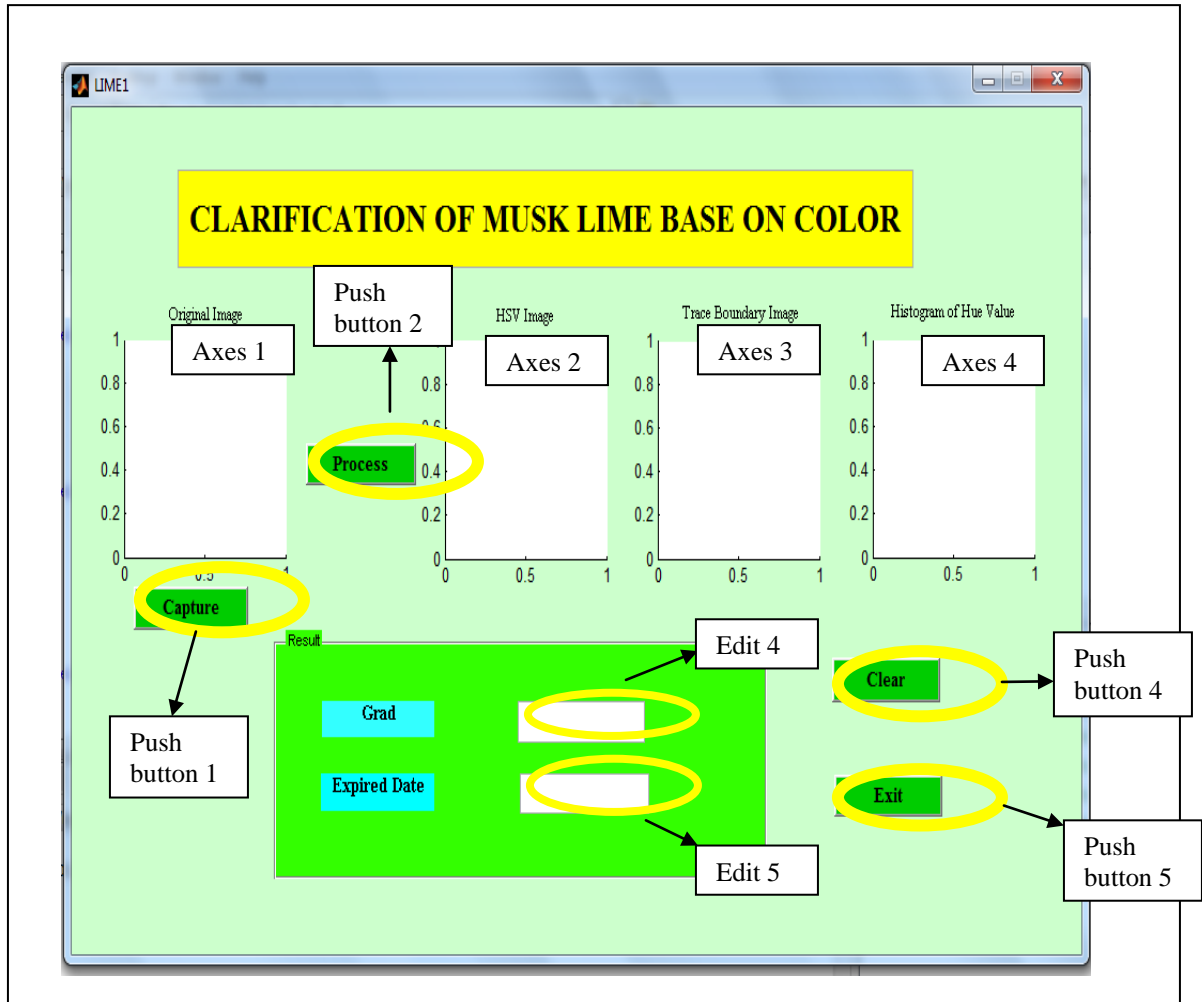
APPENDIX A

Gantt chart



APPENDIX B

Guidance to Use the Interface



The main interface of system

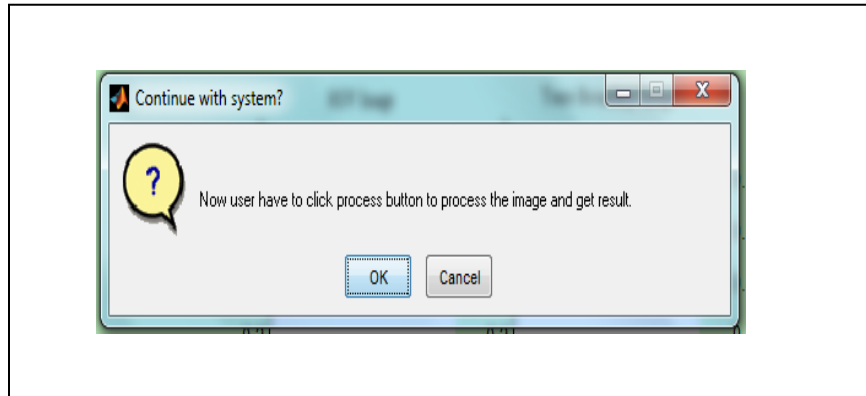
Push button 1(Capture): When user clicks this button, musk lime image will be captured.

Push button 2(Process): When user clicks this button, the captured image will be process and the result will display at edit 4 and edit5.

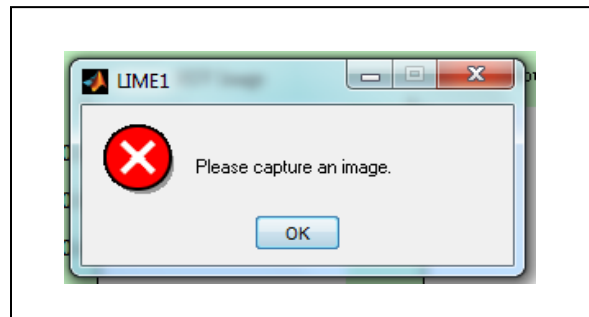
Push button 4(Clear): When user clicks this button, the data will clear and take new snap.

Push button 5(Exit): When user clicks this button, user can exit from the system.

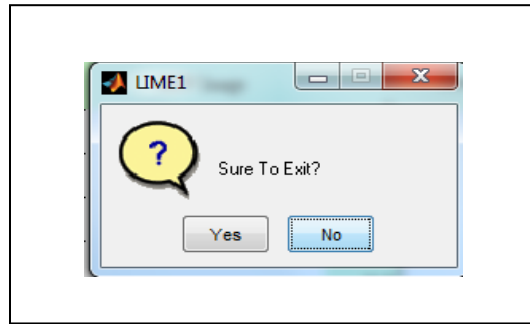
After user click the capture button, pop message to guide the user will appear to whether the user want to continue process the image or exit from system as shown below :-



If the user directly clicks, process button pop message below will appear to guide user to click capture button.



When user click, the exit button pop message to ask confirmation from the user will appear as below:-



APPENDIX C

Testing Results