BANANA GRADING SYSTEM USING COLOR HISTOGRAM (BGS)

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BACHELOR OF COMPUTER SCIENCE

(GRAPHICS AND MULTIMEDIA TECHNOLOGY)

WITH HONORS

UNIVERSITI MALAYSIA PAHANG

BANANA GRADING SYSTEM USING COLOR HISTOGRAM (BGS)

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Report submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Computer Science (Graphics and Multimedia Technology) with honors

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SUPERVISOR DECLARATION

"I hereby declare that I have checked this project and in my opinion this project is satisfactory in term of scope and quality for the award of degree of Bachelor Computer Science (Graphics and Multimedia Technology)".

Supervisor Signature :
Supervisor Name : Dr. Muhamad Masroor Ahmed
Date : 8 Jun 2012

STUDENT DECLARATION

"I hereby declare that I have written this project with my own words expects fot the quotation and summaries which have been duly acknowledge. This thesis has not been accepted for any degree and it not concurrently submitted for awards of other degree.

Student Signature :
Student Name : Siti Nur Saadah bt Mohd Jali
Date : 8 Jun 2012

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Abstract

Bananas Grading System (BGS) which is one of the system using image processing technique. The purpose of BGS is used to standardize the grading of the banana and distinguish between three differences classes of banana which are unripe, ripe and overripe. This BGS used computer system to analyze and interprets images that correspondent to human eye and mind. This study is taken into account of four types of banana fruits which are ‘Pisang Lemak Manis’, ‘Pisang Mas’, ‘Pisang Putar’ and ‘Pisang Berangan’. It attempts to form the decision by analysing the skin colour and condition. Bananas Grading System (BGS) is been done manually which brings variation of the results for banana grading. Since the colour is one of the most significant criteria related to fruit identification and fruit quality, it is a good indicator for ripeness. Therefore, fruits grading in present study only considers the colour of the skin of the bananas. The method that is used to develop this BGS is image processing method in term of color histogram of RGB. The color histogram method is evaluating the mean value of red, green and blue in order to classify the banana. In this BGS, fifty sample of banana is tested. From the result, the successful rate of grading the banana is 85% percent while the error rate is 15% percent. , based on the objective of this system which is to develop grading system to judge the maturity level and to standardize the banana grading based on maturity level, the objective is successfully achieved the goal. The problem regarding grading system by using Human Visualization System also solved. The cost of manual grading system, the time for grading the bananas and the man power uses is decreased.

Abstrak

Sistem Penggredan Pisang (BGS) yang merupakan salah satu sistem yang menggunakan teknik pemprosesan imej. Tujuan BGS digunakan untuk menyeragamkan gred pisang dan membezakan antara tiga perbezaan kelas pisang yang tidak masak, masak dan terlalu masak. BGS menggunakan sistem komputer untuk menganalisis dan mentafsir imej bahawa koresponden dengan mata dan minda manusia. Kajian ini diambil kira empat jenis buah-buahan pisang yang 'Pisang Lemak Manis', 'Pisang Mas', 'Pisang Putar' dan 'Pisang Berangan'. Ia cuba untuk membentuk keputusan dengan menganalisis warna kulit dan keadaan. Sistem Penggredan Pisang (BGS) dilakukan secara manual yang membawa perubahan keputusan untuk penggredan pisang. Sejak warna merupakan salah satu kriteria yang paling penting yang berkaitan kepada pengenalan buah-buahan dan kualiti buah, ia adalah petunjuk baik untuk perihal masaknya. Oleh itu, buah-buahan menggred dalam kajian sekarang hanya menganggap warna kulit pisang. Kaedah yang digunakan untuk membangunkan bgs ini adalah imej kaedah pemprosesan dalam sebutan histogram warna RGB. Kaedah warna histogram menilai nilai purata merah, hijau dan biru untuk mengklasifikasikan pisang. Dalam BGS ini, lima puluh sampel pisang diuji. Daripada keputusan kajian ini, kadar kejayaan menggred pisang adalah lima puluh peratus manakala kadar ralat adalah lima belas peratus. Berdasarkan objektif sistem ini adalah untuk membangunkan sistem penggredan untuk menilai tahap kematangan dan untuk menyeragamkan gred pisang berdasarkan tahap kematangan, objektif berjaya mencapai matlamat. Masalah mengenai sistem penggredan dengan menggunakan Sistem Visualisasi Manusia juga diselesaikan. Kos sistem penggredan manual, masa untuk menggred pisang dan penggunaan tenaga kerja dikurangkan.

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LIST OF ABBRIEVIATION

BGS	Banana Grading System
HSV	Human Visualization System
RGB	Red, Green, Blue
JPEG	Joint Photographic Experts Group
CCD	Charged Coupled Device
RAD	Rapid Application Development
CASE	Computer Aided Software Engineering
JAD	Joint Application Design
BIOS	Basic Input Output System

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

The agriculture industry is one of the industries that bring the economic development. This agriculture deals with the groups of crops, herbs, plants, and fruits. This agriculture plays a significant role in economic development. The fruit and crops further classify into more fruits such as banana, watermelon, strawberry, etc. according to their shape, colours and size. From the available groups of fruits, this thesis takes into account of bananas fruits only. There are many types of banana that can be study such as ‘Pisang Putar’, ‘Pisang Mas’, ‘Pisang Abu’, etc.

This study is taken into account of four types of banana fruits which are ‘Pisang Lemak Manis’, ‘Pisang Mas’, ‘Pisang Putar’ and ‘Pisang Berangan’. It attempts to form the decision by analysing the skin colour and condition. Presently, the skin condition and skin colour of bananas are observed by using human visualization system (HVS). The HVS possesses an extraordinary capability to meticulously investigate things. This mode of examination is regarded as the gold standard for drawing comparison. Though this is an appreciated way of examination but at the same time it is also responsible in bringing out variable judgments.

Bananas Grading System (BGS) is been done manually which brings variation of the results for banana grading. Consequently, bananas which do not consumable is supplied to the market. To address this gap, there is need for some well-established automated system that has ability to control this variation.

These variations are creating pressing demands to arrange some automatic system that can efficiently and effectively address these problems. Consequently, the desired system is expected to provide more stable and reliable results. The proposed method is expected to introduce standardization of the grading the bananas. The standardization means bringing maximum possible reduction of variation of result.

The proposed system is expected to utilize the shape, colour and size of bananas for grading. The skin colour and skin condition provide helpful information to estimate the maturity and the quality of fruits. Since the colour is one of the most significant criteria related to fruit identification and fruit quality, it is a good indicator for ripeness. Therefore, fruits grading in present study only considers the colour of the skin of the bananas. This proposed fruits grading system works in three steps which are the image acquisition, image pre-processing (e.g.: noise removal) and colour identification[1].

The employment of image processing technique is expected to significantly contribute in agriculture industry. Through this technique, the challenging job of standardization is likely to be achieved. Along with standardization of the automated system is expected to bring economic prosperity, times and resource optimization[9].

1.1 PROBLEM BACKGROUND

Banana is one of the popular fruits among Malaysian. Malaysian usually eat it as fruits, as dessert, chips or eat when hi- tea time. As a result of which bananas market is growing in Malaysia day by day. For supplying this, careful grading of this commodity should be done. The bananas that have been sent to the supermarket, market, entrepreneur chips or fruit store has been graded into a few grade. Generally, the suppliers do manual grading by observing the skin condition and skin colours of the bananas. But, unfortunately this mode of making decision requires considerably large amount of time, more man power and higher cost.

In order to make this grading system time efficient, a computer based system is need of the hour. The introduction of this automated system will not only reduce the time required to observe and investigate the fruits but will also optimize the economic requirement needed in some business [9]. In term of economic requirement is where the suppliers of bananas will reduce the cost for hiring more peoples to observe the bananas and dividing the grade of bananas. Therefore, this research proceeded with the a few objectives that will be achieved.

1.2 PROBLEM STATEMENT

This study focuses for the introduction of standardization for investigating the bananas to be supplied to the market. The suppliers of banana usually use the human visualization grading system. Generally, the manual grading system is slow and it consuming the time. It will also increase the economic burden to the suppliers of banana in Malaysia. These economic burdens such as increase the cost of manual grading system, increase the time for grading the bananas and increase the man power uses.

The standardization of the bananas grade will be not achieved by using the human visualization grading system. This is due to the different consideration or observation of the skin condition of the bananas. So, it will bring the difficulties of suppliers of bananas in standardization of bananas grade.

1.3 OBJECTIVES

The objectives of this research of Bananas Grading System are:

1. To develop an automatic Banana Grading System to judge the maturity level in banana grading system for the supplying to the market.
2. To determine the appropriate algorithm in processing the banana and apply into the system.
3. To standardize the banana grading based on maturity level.

1.4 SCOPE

This study attempts to introduce a fully automatic banana grading system. The completion of the idea requires the digital camera with the calibration of the computer.

The usage of camera is to snap a few sample of banana image to be used in the proposed automatic banana grading system. While for computer usage is to store the image that has been taken by the camera. There are four types of banana has evaluate in this banana grading system which each type will have fifty sample from any level of ripeness that will be taken. The names of banana that has been evaluated are ‘Pisang Lemak Manis’, ‘Pisang Mas’, ‘Pisang Putar’ and ‘Pisang Berangan’. Other than camera and computer, the software for reading the data from the camera and computer is needed. It is also to do some pre-processing process and post-processing process steps. The software needed is the MATLAB. This software is used to build the automatic banana grading system. The user of this proposed system is the supplier of banana to the market and entrepreneur of chips. Consequently, the understanding of some elementary statistic for the presentation and analysis of the result is needed. This proposed system is standalone system which is do not requires the internet. The example of statistic recently research and proposed system should be analysed and making a comparison between each other. The statistic of the grade of the banana should be known in order to do the automatic banana grading system.

1.5 THESIS ORGANIZATION

Thesis organization is explaining about the chapter that we need to cover in our thesis.

Chapter 2: takes into account the existing techniques employed for grading the fruits. This chapter presents the critical review of the existing grading matrix by focusing their strength and weakness. Finally the chapter decides about the selection of one specific method that needs to be researched upon.

Chapter 3: It will address the methodology used in this thesis. It gives block schematic description of the proposed methodology. It also provides detail about the database to be used for completing this study.

Chapter 4: This chapter contains the implementation detail and describes the project implementation of the system of whole development of system are needed to implement.

Chapter 5: Discuss the result produced by the proposed methodology and discussion that are obtained from the data analysis, project constraint and future work suggestion. In project constraint, there are two parts that has been divided. There are development constraints and system constrain. The development constraint divided into four types which is the constructed system, the representational relationship, the nature of system and the process of construction.

Chapter 6: this chapter provides the conclusion of this study. It suggests the future direction in the light of the weaknesses observed in proposed methodology.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

In literature review chapter, some existing method and algorithm from the expert system in their research need exploration and study. Some method and algorithm of grading system can be explored and making a survey of the usage of algorithm and method in order to be implemented in the proposed grading system.

Generally, the appearance of fruits is one of the important things to discover the quality and maturity of fruits. It can be determined by skin condition and skin colour of the fruits and can be classifying the fruits according to the groups and can be categorized by the parameters that need to be evaluated in grading the fruits[9]. The parameters of the grading fruits such as skin colour and skin condition should be observed to prevent the inaccuracy of the quality and maturity[2].

The fruits grading system is use for grading and ranking the fruits according to the category and group. It is important to differentiate the grading of fruits in the different categories in order to grading it into the correct group. For example, papaya in local grading standard should be classified into a certain group such as ripe, raw and overripe[11]. Papaya that been grouped into level of ripeness should be with the orange skin colour of fruits with no deficiencies[3]. Then the papaya that been classified into group raw should be with the green skin colour of fruits with limited deficiencies. While the papaya that classify into group of overripe should be with the skin colour of brown which have much deficiencies. So, by differentiate these level of ripeness, the fruits will be place into a correct categories.

Generally, this fruits grading system not only considered one parameter which is the colour of grading the fruits. It is also deliberate for those who industrialized discrete correlation between other parameters such as overall quality and shape[4]. These are fundamentally used for classification and standardization of the fruits grading.

2.1 FRUITS GRADING SYSTEM

Fruits are having a few stages of growth. The stages of growing of the fruits can be measured depends on the shape, skin colour of the fruits and diameter of the fruits. The stages are important in order to know the maturity of the fruits. By knowing the maturity of the fruits, the usability of the fruits can be able to distinguish. For banana grading system, the maturity of the fruits can be determined depending on the skin colour of bananas. For the skin colour, the maturity can be differentiate between green colour, yellow colour, red colour and much colour that having in fruits. For the diameter, we can compare the size of fruits to determine the maturity same goes to the shape of fruits[4].

Nowadays, fruits grading system has been applied in many developing countries in order to replace the manual grading system. The fruits grading systems is more applicable and can standardize the fruits grading more accurate compare to manual grading system. The automated grading system is more advanced and commercial compared to manual grading system[6]. Generally, this automated grading system has been applied in agriculture industries to fulfil the needs in this industry. Consequently, it bring some advantages in grading the fruits because in this hour, it getting special interest for higher quality and graded fruits product as the demand in agriculture industries[5].

This automated grading system provides the accuracy, reliability and the consistency in the method and algorithm of implementation process in the standardization of grading the fruits. Automated grading system ensure that the grading of fruits having the standardization of each grade and the quality of fruits. Furthermore, it is also preferred to ensure the consistency of fruits quality and large volume handled.

Consequently, this automated grading system having the economic advantages and benefits in making the consumers sureness about the quality and grade of fruits.

2.2 CASE STUDY ON EXISTING SYSTEM

There are many existing system of automated grading system. But those existing system will not use the same method. There are many kinds of method and technique in various existing system. The technique that has been selected and practical depends on the appropriateness of parameters that used. The validation of the technique is must in order to make the suitability of technique chosen with the parameters. The study of existing system makes the differentiation of various techniques. The best technique will be found and will be used in order to implementing and developing the new automated grading system.

2.2.1 Automated Oil Palm Fruit Grading System using Artificial Intelligence

Z.May and M.H Amaran has been done this research[1]. According to them, this system is basically about the automated oil palm fruit grading system. The ripeness of the palm oil fruits is determined by this system. The determination of grading the ripeness of palm oil fruits has been done manually by the human visualization graders before the existences of automated oil palm grading system. This manually grading has different perspective and may vary from each other. So, the other ways of standardization of grading system is introduce the new automated grading system by using RGB color model and artificial intelligence logic. This new automated grading system is developing in order to distinguish between the three different classes of oil palm fruits which are underripe, ripe and overripe. the differences of color intensity with the color ripening index has been experimental in order to recognize the ripeness of the oil palm fruits[1].

2.2.2 Fruit Size Detecting and Grading System Based on Image Processing

According to the Hongshe dang, Jinguo Song and Qin Guo who are doing the research on this study says to improving the fruits quality and production efficiency, the automated detection technology should be develop[2]. This automated detection technology is the process of detecting the fruits both internal and external quality without any defection. They also say that the quality of fruits shape, default, color and size nowadays can not only evaluated by using traditional method. The development of image processing technology can be more effective. The significant of develop this grading and detecting system it to reduce the cost and develop high speed grading system[2].

2.2.3 Development of *Jotrapha Curcas* Color Grading System for Ripeness Evaluation

Zulham Effendi, RizauddinRamli, Jaharah Abdul Ghani and ZahiraYaakob have been done this research[6]. Based on this research, this study in presented the automated grading system for *Jatropha curcsas* by using color histogram. *Jatropha curcsas*is planted widely for nut harvesting in biodiesel manufacturing. It gives the perspective value in biodiesel manufacturing because it categorized as non-edible oil and it not be threaten by food purposes that available nowadays. The quality of *Jatropha curcsas* depends on type and size of defect along with skin color and fruits size. This color histogram method has been develop to distinguish the level of ripeness depends on color intensity[6]. It analyzes the red, green and blue (RGB) color of *Jatropha curcsas*.

2.2.4 Shape Characteristics Analysis for Papaya Size Classification

This research is done by SlametRiyadi, Ashrani A. Abd. Rahni, Mohd. Marzuki Mustafa and AiniHussain[4]. This research system is about the grading the papaya size according to the shape of papaya. It discussed about the development of computer vision system for papaya size grading using shape characteristic analysis. In this system, the RGB images were converted to the binary images using automated thresholding depends on OTSU method. The shape characteristic that been analyzed are area, mean diameter and perimeter that extract from papaya images[4]. Then the classification of the papaya will depend on the characteristic that had been analyzed.

2.3 TECHNIQUES/METHOD/ EQUIPMENT/ TECHNOLOGY USED IN EXISTING SYSTEM

Technique, according to the dictionary is the skill or practical method that has been applied in particular task. Technique is one of the important thing to been applied on system. Without technique, the system cannot be handled. In this research of existing system, there are a few different techniques that have been used in different system. While method, according to the dictionary is define as way of procedure to accomplish something in a system. Method is also one of the important things to use in system.

2.3.1 Automated Oil Palm Fruit Grading System using Artificial Intelligence

In this system, the technique that has been applied is artificial intelligence of fuzzy logic. This system is developing using fuzzy logic and RGB color mode[1]l. There are a method is use in order to accomplished this system. The method is divided into four phases which are image acquisition, background removal, color feature extraction and grading.

a. Image Acquisition

In this phase, the palm oil is collected from the plantation. Then, the palm oil is stored on the laboratory that has been controlled by the lighting to undergo the capturing images. Total seventy five samples of images were taken. All images were converted to the JPEG format with 640x480 pixel dimension. This phase is all about the capturing, formatting and resizing the images. The image capturing device is used to generate the images of sample. This images need to be converted and resized to prevent from any error during test the system. Generally, the technology of device used in machine vision is the solid state charged coupled device (CCD). This technology has been implementing of digital camera which needed the additional component for converting the images.

b. Background Removal

In this phase, the unnecessary background is removed and converted to black because it became the noises to the images (eg: Noise removal). The background subtraction method is used to remove the white background[1]. Figure 2.1 is shown an example of background removal process which is the white background is removed and converted to black.

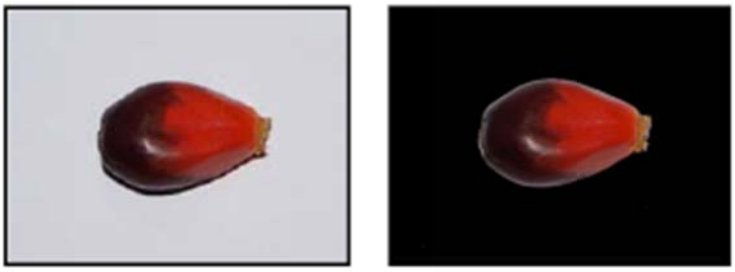

Figure 2.1 Background Removal of palm oil

c. Color Feature Extraction

In this phase, the color features are analyzed based on RGB color model. The color is classified into certain categories that are obtained a range of mean of value of red, green and blue layer. This ranges value are used as references of input of fuzzy logic system. There is also some calculation needed in order to find the range value of the color. In this color features, the number of pixel of the color and the mean value of color is most important things to know.

d. Grading

In grading phase, the fruits will be categories in certain level such as ripeness, shape or color. This phase is representing good approaches with the intention of interpret the decision making of process in the system. This phase is also making the standardization of some categories in the system.

The equipment is one the important things to have so as to complete the system. The equipment's that have been used in this research system are computer, CCD camera and MATLAB software. The CCD camera is used to evaluated and interpret image correspondent to the human eye and cognizance. The computer is used to develop a computer program for the image processing process like the calculation of color intensity and segmentation of color based on RGB color. The MATLAB software has been used to construct the fuzzy logic process in training the data and classification of the fruits and implementing the development of the system.

2.3.2 Fruit Size Detecting and Grading System Based on Image Processing

The technique that has been applied in this grading system is the image processing technique. In this system, the fruits are captured by side view images and the algorithm will extracted the characteristic of fruits. There is a method that been used in this grading system that are divided into five stages which are processing flow, image filter, edge detection, fruits size detecting algorithm and fruit size grading.

a. Processing Flow

The apple size is according to its diameter which is the longest distance in the apple's cross section. This detecting system is focused on calculating the diameter of apple. In this stage of method, it's explaining the grading flow of the fruits image size detecting. The detecting and grading flow is shown in Figure 2.2 below.

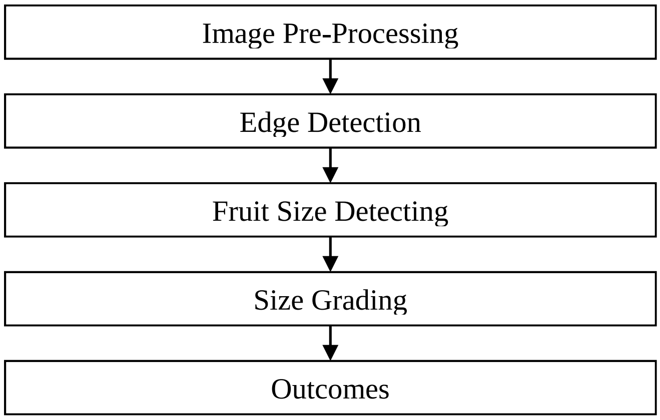

Figure 2.2 Schematic Diagram

b. Image Filtering

The image filter stage is about the image pre-processing algorithm and process of the detecting and grading system. This algorithm and process is important and must be competence and fast.

c. Edge Detection

This stage is the key factor of detecting the size of images. The Otsu's method is needed to get the fruits binary image automatically. Otsu method is automatically performing histogram shape-based image thresholding. It will reduce the gray level images to binary images. This Otsu method will be used after the image gray. The 8-Connected Boundary tracking method has been used to get the edge sequences. The steps are:

1. Searching new area from left top of binary images
2. Give the searching direction
3. Judge the value
4. Tracking edge

The capturing images after the processes image is shown in Figure 2.3

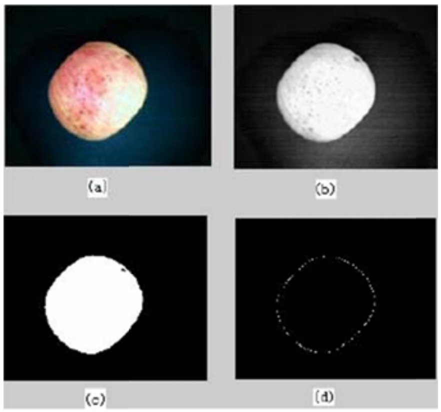

Figure 2.3 The processing image (a) original image (b) gray image (c) Diversion image (d) tracking edge

d. Fruit Size Detecting Algorithm

In this phase, the fruits size detecting algorithm contain two parts which is finding the center of coordinate of fruits shape in image and finding the fruits axis in images. This phase is also making the calculation of finding the coordinate and axis of the images. Some formula and calculation is needed in order to detecting the size of fruits. The axis point and center point of fruits images are shown in Figure 2.4 and Figure 2.5.

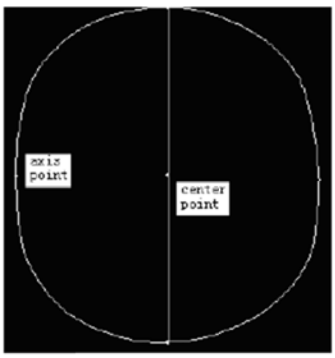

Figure 2.4 The fruits axis and center point of location 1

Figure 2.5 The fruits axis and center point of location 2

e. Fruit Size Grading

In this phase, the grading size of fruits is refereed by detecting the diameter of fruits.

2.3.3 Development of *Jotrapha Curcas* Color Grading System for Ripeness Evaluation

The technique that has practical in this grading system is image processing by consuming color histogram. This color histogram is applied in order to extricate the level of ripeness of the fruits based on color intensity[6]. In this research study, the method has been separate into three stages. The stages are image acquisition, training and testing.

a. Image Acquisition

In this stage, the image is collected from the sample that has been captured. The image of *Jotrapha Curcas* is captured using digital camera and saved in JPEG file format[6]. The images is stored in memory then graded into a group. Figure 2.6 showed the grading of the images.

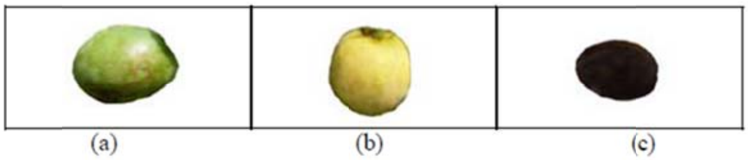

Figure 2.6 Sample data for each grade (a) raw (b) ripe (c) overripe

b. Training

In this stage, the RGB color data is analyze using the software that has been given specific names which is ImageJ. This software distinguishes the mean color intensity between ripeness of data sample in grade of raw, ripe and overripe. In the software, the mean color intensity will be used in order to distinguish between the ripeness of the fruits[6]. The formula has been used with the

$$\bar{x} = \sum_{i=1}^{n} P_{ri} \,/\, \sum_{i=1}^{n} P_{i}$$

Equation 2.1 Mean of RGB

$\bar{x}$ = mean of color which are red, green and blue

P_r = number of pixel of color which are red, green and blue

The means for entire fruits are obtained by calculating mean for each image of *Jatropha curcas.*

Figure 2.7, Figure 2.8 and Figure 2.9 showed the differentiation of the grade.

Figure 2.7 Raw image

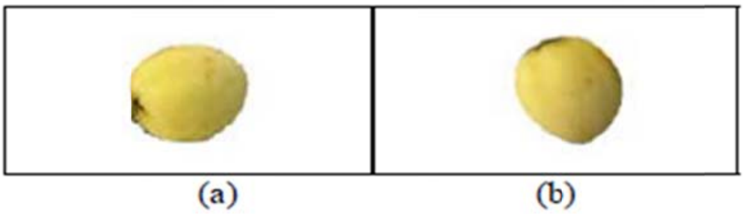

Figure 2.8 Ripe Images

Figure 2.9 Overripe Images

c. Testing

This testing stage is the final stage of this grading system. The program of calculating mean color intensity has been developed. After the calculation of the mean color intensity of RGB, the program runs a test for the grading of *Jatropha curcas* which is based on the standard mean of grading according to training stages.

The equipment's that have been used in this research system are computer and Olympus CamedianC-5050 digital camera. The Olympus Camedian C-5050 digital camera is used to capture the sample of images that need to use in the system. The computer is used to develop a computer program for the image processing process like the calculation of area, diameter and parameter.

2.3.4 Shape Characteristics Analysis for Papaya Size Classification

The technique that has been used in this research system is the shape characteristic analysis by using the neural network technique. In this system, the images of papaya have been taken and undergo some processes[4]. The system will analyze the area, mean diameter and perimeter of the papaya depends on the shape characteristic. There are the stages of method used in this shape characteristic analysis system such as data acquisition, image pre-processing and shape characterization (image processing)[4].

a. Data Acquisition

In this stage, the sample images are collected for data acquisition with the purpose to determining the weight digitally. Those images captured by using digital camera at random orientation. The standard room lightening is used in order to standardize the images with the usage of flash. In data acquisition, the two steps that significant are image acquisition and digital weight measurement.

b. Pre-Processing

This image pre-processing involves the procedure to make sure that the image is ready to be processed. The images then undergo the normalizing process to produce the standardization of size images and time processing reduces. Figure 2.10 below showed the converting from original image to the grayscale image. It also showed the image was resized to one third normal size.

(a) (b)

Figure 2.10 (a) Original image (b) Grayscale image

The thresholding process is occurring to make the segmentation of the images. This method is depends on the lowest point that selected between two classes of histogram that has been shown in Figure 2.11 below.

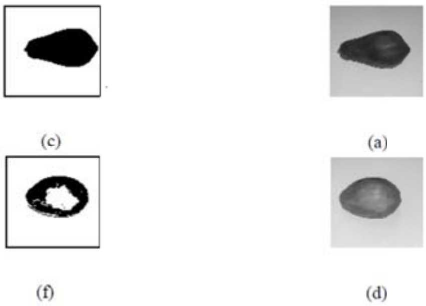

Figure 2.11 (a)(d) Grayscale image (c)(d) Segmentation result using global thresholding

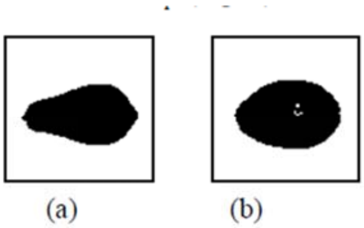

Figure 2.12 Segmentation results using automatic thresholding

The noises of the images are existence from the camera flash and lighting and will give the disruption to the images. Then, some algorithm need to be implemented in order to remove the noise in the images. Figure 2.12(a) showed the original image that has been taken in room lighting while Figure 2.12(b) showed the black dot the representing the noise in the image taken.

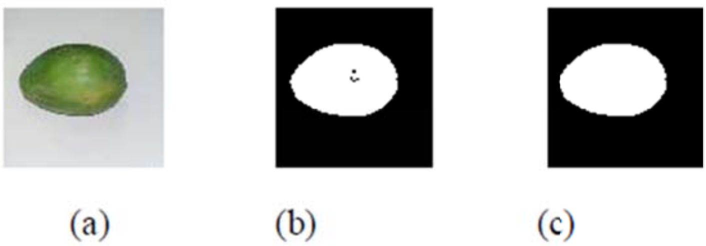

Figure 2.13 (a) Original (b) Binary image with noise (c) Noise free binary image

c. Shape characterization

The shape descriptor based on the area, mean diameter and perimeter. These descriptors are significant so as to shape characterization in classification[4].

The equipment's that have been used in this research system are computer and digital camera. The digital camera is used to taken the sample images. The computer is used to develop a computer program for the image processing process like the calculation of color intensity and segmentation of color based on RGB color.

2.4 COMPARISON METHOD BETWEEN THE EXISTING SYSTEMS

Table 2.1 below shows the comparison between those four existing system that has been study.

Table 2.1 Comparison between four existing system that has been study

Existing System	**Research about**	**Method used**
Automated Oil Palm Fruit Grading System using Artificial Intelligence	Ripeness of oil palm fruits in grading system	Artificial Intelligence of fuzzy logic and RBG color model
Fruit Size Detecting and Grading System Based on Image Processing	Improving the fruits quality with the detection of fruits size and grading system	Algorithm of image processing technique and edge detection
Development of *Jotrapha Curcas* Color Grading System for Ripeness Evaluation	Ripeness of *Jotrapha Curcas* depends on color intensity	Color histogram

Shape Characteristics Analysis for Papaya Size Classification	Grading the papaya size depends on shape of papaya	Artificial intelligence of neural network

2.5 CONCLUSION

In fruits grading system, fruits can be categorized in many class or group such as shape analysing, colour sorting, size detecting, etc. These groups of grading the fruits will give many benefits in order to produce the good quality of product like fruits. This automated grading system has the profits of making the standardization of grading the fruits. In existing system that has been study, there are many technique that has been used and many of the technique are successful develop a new automated grading system. For automated oil palm fruits grading system, the technique that has been chosen in order to develop a system is artificial intelligence fuzzy logic and RGB colour histogram. For the fruits size detecting and grading system, the technique that has been used is image processing technique which contain image acquisition, enhancement, feature extraction, object detection and object recognition. While for the development of *jotrapha curcas* color grading system, the technique that has been used is colour histogram method. The last existing system that has been studied is shape characteristic analysis for papaya size classification. In this system, the method that has been used is Otsu method. From all these method, the best method that can be implementing in order to create a new automated grading system is the artificial intelligent fuzzy logic method and colour histogram method. This method is very applicable in defining the fruits grading system that based on the skin colour condition. Colour histogram method will represent the distribution of colours in images. The colour histogram method will detect the colour of fruits can categories it based on the colour group. This method can be applied in the banana grading system because this proposed automated system will be grading the banana based on skin colour condition in order to group the level of ripeness. However, other than both best techniques will be used in implementing and developing the new proposed automated system, other technique also can be applied and implement in other proposed automated system. The methodology of proposed automated fruits grading system will be discussed in the next chapter.

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

This chapter will discuss about the methodology that will be implemented in developing the banana grading system. Generally, methodology that has been used is from one of the software life cycle model. Software life cycle model is explain how the software is developed, how to implement activities in each phase, how to signify the activities and product and how to generate products in order to accomplishing a software evolution. For developing this Banana Grading System (BGS), the Rapid Application Development (RAD) has been chosen. RAD has the several characteristic that are suitable for the development of BGS project. In this chapter, there are three section involve. The first section of this chapter will brief the introduction about RAD development method and the reasons of choosing the method. The second section will explain the implementation of the RAD method in BGS development while the last section will intricate the hardware and software that will be used in developing the BGS project.

3.1 RAPID APPLICATION DEVELOPMENT (RAD)

Rapid Application Development (RAD) model is one the standard kind of software life cycle that used the minimal planning in favour of rapid prototyping. RAD concept is to develop the product or system faster but high quality. RAD involves methods such as iterative development and software prototyping. The structured technique and prototyping are used in RAD to define the user requirement and designing the final system. The development of RAD starts with the development of preliminary data models and process model using the structured technique. The requirement is verified in the next phase by using the prototyping to analysis the data and process model. These phases will reiterate to achieve the result of further development. RAD methods will require the concerns in functionality and performances in exchange for enabling the faster development and facilitating application maintenance. RAD concept can be achieve through gathering the information with the group focus, early prototyping and reiterative user testing of design, re-use the software components, make a schedule that defers design improvement, less formality review and other team communication.

3.2 THE JUSTIFICATION OF RAPID APPLICATION DEVELOPMENT (RAD)

The process in developing the complete software solution in minimal time is one of the RAD goals. The process is described using the various structural procedures, (Computer Assisted Software Engineering tools) CASE tool and prototyping to increase the pace at which the software has been developed. RAD is a combination of entities such as defined methodology, dedicated and trained staff, efficient management practices and using both manual and computer tools. By using RAD, the problem that concern the users and developers can be solve. It can enable more rapidly visualization of end-design and allow rapid software testing. With this enabling, the customer are able to have a faster look at the design to add valuable inputs in order to make the design more effective. The faster update version can be enabling by using RAD in order to reach the end user by disregarding redundant steps systematically or using prototype method. RAD makes the development process more reliable by facilitating a scope for user to actively provide input in the development process. This RAD method will protects the current project from the variation in market.

3.3 IMPLEMENTATION OF RAPID APPLICATION DEVELOPMENT (RAD) IN DEVELOPMENT

In RAD method, there are four phases which are requirement planning phase, user design phase, construction phase and cutover phase.

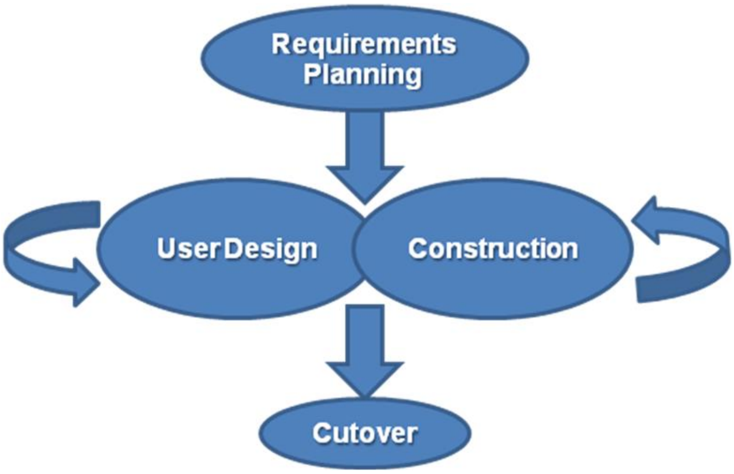

Figure 3.1 Rapid Application Development Lifecycle

- Requirements planning phase – In this phase, the element of system planning and system analysis is associated together. Users, managers and developer are discussed the project needs, project scopes, and constraint and system requirement. Requirement planning phase also known as concept definition stages which is the stages of determining the scope of system. In requirement planning phase, RAD depends on Joint Application Design (JAD) in order to determine the requirement system needed when each stages is completing associate elements such project scopes, project needs and constraint. In this phase, the system is planned smoothly in order to get complete development of system. Basically, in this phase, it will analyze and finalize the requirement needed and the needed hardware and software to be used in order to implement the system.

- User design phase – In this phase, the user interacted with systems analysts to developing the models and prototypes of system that represent all system processes, inputs, and outputs. The RAD groups are used a combination of Joint Application Development (JAD) techniques and CASE tools to translate user needs into working model and prototype. User design is a continuous interactive process that allows users to understand, modify, and eventually approve a working model of the system that meets their needs. In this phase, the client and developer are deliberated each other in order to get a compromising to developing the system. The user is described the needed and constraint in the system while the developer will try to achieve the client purpose. The figure below show the interaction between client, developer and system in user design phases.

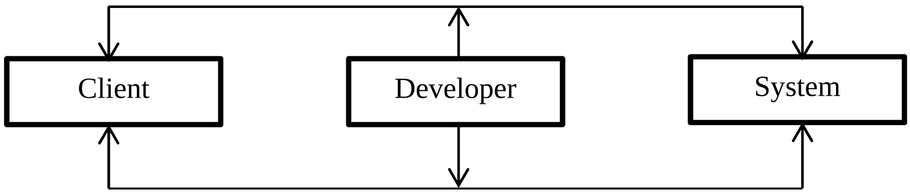

Figure 3.2 Interactions Between Client, Developer and System.

- Construction phase – In this phase, the program and application development is focused. Construction phase is known as development stages which the system will be completing the construction of physical application and implement work plans. In RAD, the construction phase is implementing after the user design phase is complete. In the banana grading system, the system is connected with the database of banana images. In this phase also, the task of programming and application development, coding, unit- integration and system testing is implementing in the software used which is MATLAB 2010. The interface (GUI) of the system is developed and the code is implemented in the GUI of the system.

- Cutover phase – In this last phase of RAD method, the final task are resembled including data conversion, testing, changeover the error of the system and user training. In this phase, the side preparation, document preparation, personal training, system cutover and system release are included. The user can test the banana grading system and checking the system error and the upgrading of implementation in order to achieve the goal of banana grading system. In this phase, the testing part is applied in the system. The error of the system is checked and fixed in order to build zero-error system. After finished this phase, the new system is build, delivered and places on operation sooner.

3.3.1 Requirement Planning Phase

3.3.1.1 Research on Current Situation

Nowadays, the implementation of grading system is using Rapid Application Method (RAD) due to easiness of developing and implementing the system. RAD method can make the developer checking the error and go back to stage before in order to upgrading the implementation. RAD method is contrast to waterfall method which the system cannot go back to previous stages if the error of the system occurs. RAD is the best method for banana grading system which the system needs the review and upgrading the system in order to maintaining the functionality.

3.3.1.2 Analyses and Finalize Requirement

In this stage, the information requires is collected. For banana grading system, the interface design and platform is needed. Several requirement needed are listed in order to implementing the system. The requirement such as hardware, software and tools needs are finalized and listed for the development of the banana grading system. These all requirements are used in implementation and developing the banana grading system.

3.3.1.3 Software and Hardware Tools

Computer software is a collection of computer programs and associated data that provide the guidelines to communicate a computer. Software is an intangible entity which is a set of computer programs, procedures, and associated documentation concerned with the operation of a data processing system. Program software performs the function of the program it implements by directly providing instructions to the computer hardware. Personal computer hardware are component devices which are installed into a computer to create a personal computer upon which system software is installed include a BIOS and an operating system which supports application software that performs a desired functions. Operating systems usually connect with devices through hardware buses by using software device drivers.

3.3.1.4 Hardware

There are a few hardware requirements that needed in order to developing the project. The requirement is showed in the table below. The hardware software will work with the software needed. Generally, we use Intel^R Core i3^R dual-core processor as a processor, 3.93 GB RAM, DVD/CD-ROM Drivers to install the software, 90 GB size hard disk as a storage to store all the data in developing system, camera to capture bananas images, light source as a back or front light while capturing the images and also four types of banana which each type are 25 bananas as an object samples.

Table 3.1 List of hardware requirements used in the system

Item	**Minimum Requirement**
Processor	Intel^R Core i3^R dual-core processor T3200 (2.00Ghz, 1.32MHz, 1.93MB L2 cache)
RAM	3.93 GB
DVD/CD-ROM Drivers	HL-DT-ST DVDRAM GSA-T50N
Hard Disk	90 GB
Camera	3 Mega pixel
Light Source	220-240V 50Hz fluorescent lamp
Others	A black colored box Four types of bananas :

	1. 'Pisang Mas' 2. 'Pisang Berangan' 3. 'Pisang Lemak Manis **4.** 'Pisang Putar' Fifty sample of banana

3.3.1.5 Software

The software requirement in developing the system is shown in the table below. The requirements used are mainly basic software that must have in developing the system such as operating system and software needed. The software such as MATLAB, Microsoft word, Microsoft PowerPoint and camera are playing a role as platform in order to develop the system, to capture images, to prepare documentation and presentation.

Table 3.2 List of software requirements used in the system

Item	**Name**	**Purpose**
Operating System	Microsoft Windows 7 Professional	As the operating system
Software	MATLAB R2010a	As a platform in developing and running the system
	Microsoft Office Word 2010	To document the system's documentation
	Microsoft Office Project 2007	To produce system Gantt Chart
	Microsoft PowerPoint 2010	To do system presentation
	Adobe Acrobat Reader 9.0	To read the journal and research paper from internet

	Adobe Photoshop CS5	To edit the images To design the system’s poster
	Camera	To capture images

3.3.2 User Design Phase

User design phase is explaining the detail of system design and image processing technique that is implemented in the system. The technique chosen is going through certain steps in order to achieve the goal of developing the grading system. The flowchart of implementing the banana grading system is shown below as well as the schematic diagram of the method that is applied in the system.

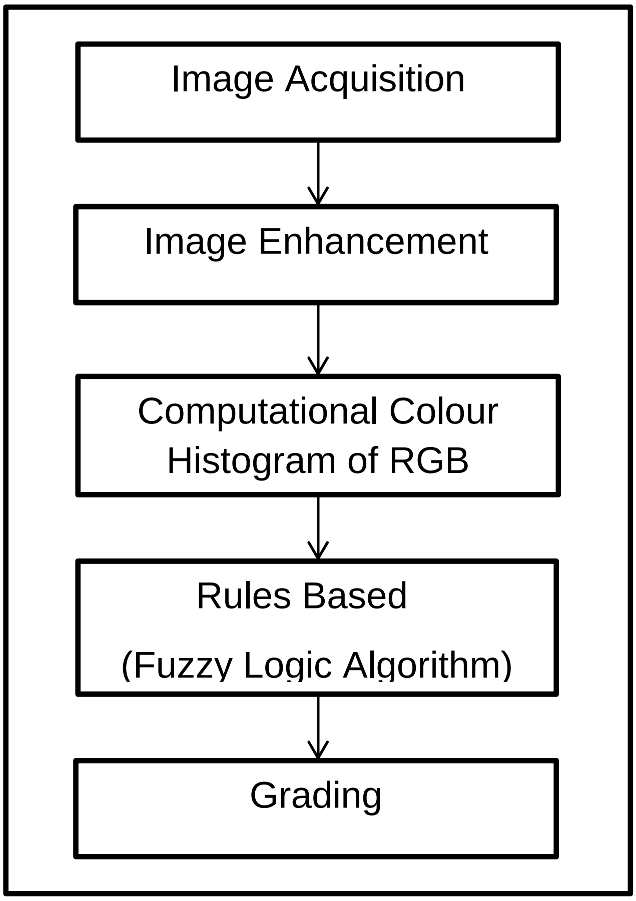

Figure 3.3 Schematic Diagram of Banana Grading Syste

Flowchart

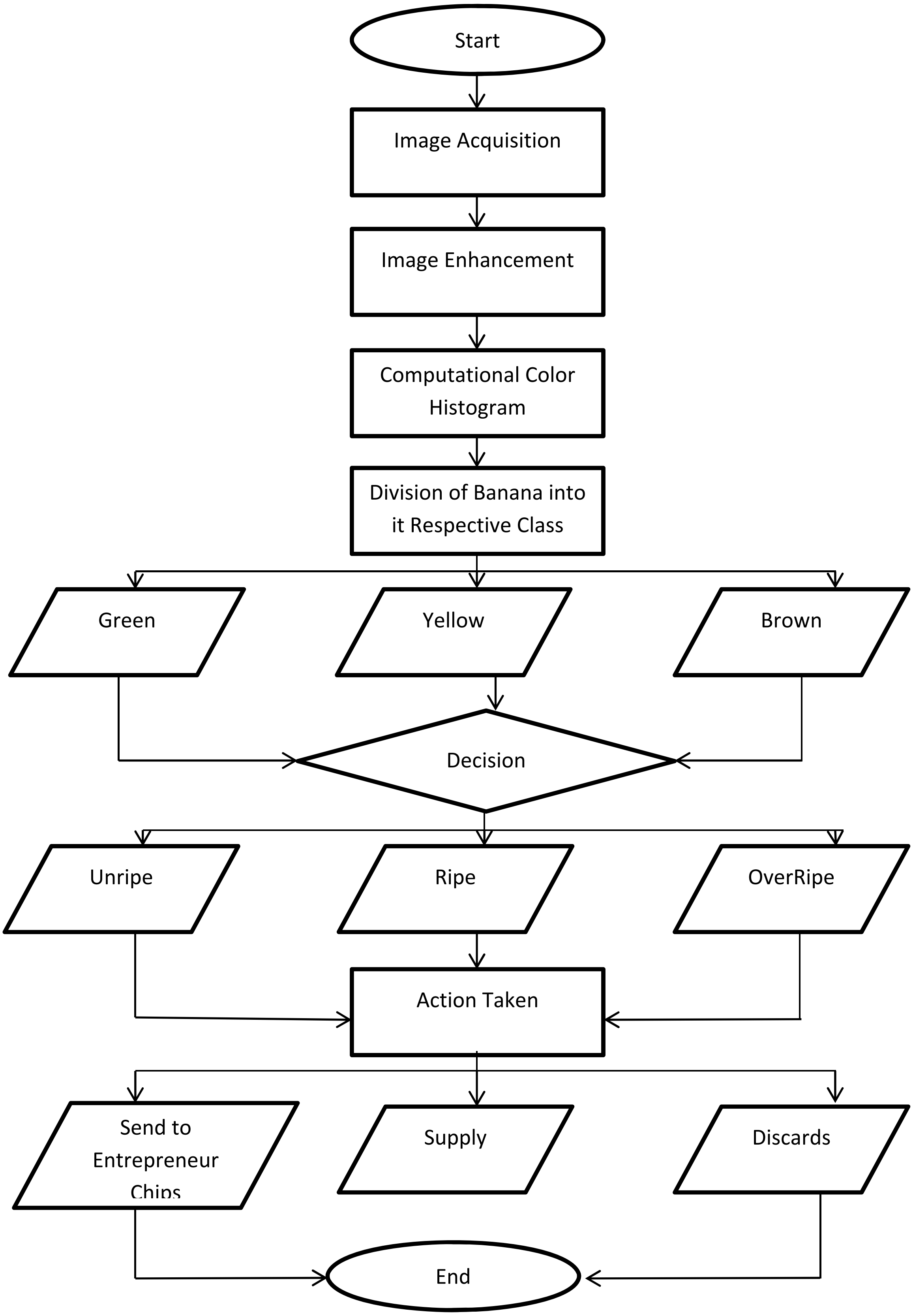

Figure 3.4 Flowchart

a) Stage I: Image Acquisition

In this image acquisition technique, the images of bananas are captured. There are four types of banana sample that will be capture which are ‘Pisang Mas’, ‘Pisang Putar’, ‘Pisang Berangan’ and ‘Pisang Lemak Manis’. The sample of different ripeness are collected and stored in the database. The images that will be taken are about 25 samples for each types of banana. The images are captured in the box with the black background and the control of lighting by using the camera. Approximately, the camera was placing about 150mm from the top of the banana. After the image is captured, it is transferred to the computer and converted the file format of the images to the JPEG format and resizing the images in order to facilitate the processing of the images. Figure 3.5 below shows the different classification of the banana that already captured. By using human visualization system, we can see that there are a few images of banana with different maturity and different types of banana. Eventhough the maturity of the banana can be seen by using human visualization system, but the standardization of the maturity of banana may be different from each human. So, by using this system, the standardization of the classification of banana maturity can be achieved.

a) Unripe **b) Ripe** **c) Overripe**

Figure 3.5 Sample of classification of banana

b) Stage II: Enhancement

The enhancement technique is used in order to improve the quality of the sample images that has been collected. The image enhancement is applied to make the visual perception of human. In enhancement technique, the pixel of image is transformed or moved to a new set of pixel. The new image is formed with the better quality for the analysis steps. The enhancement will undergo the average filtering, thresholding and trace boundaries method in order to remove noise, moving the pixel to form the new images and trace the boundaries and edges of the banana. Figure 3.6 shows the image enhancement technique that is used.

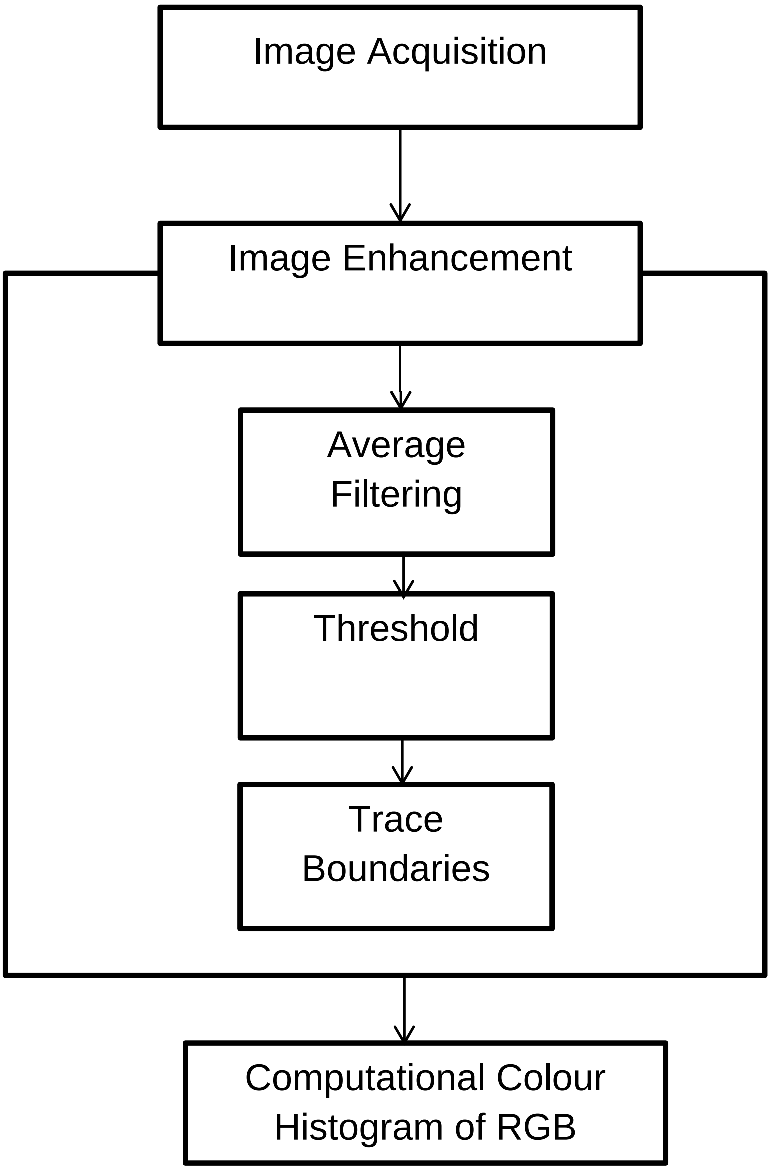

Figure 3.6 Enhancement technique

The average filter that is implemented in this enhancement technique has been calculated the average of the grey level values within a rectangular filter window surrounding each pixel. Each output pixel is a weighted sum of pixels. With this calculation, the smoothing of images for blurring images and noise removal can be achieved. Figure 3.7 has shown the filter windows 3x3.

a1	a2	a3
a4	a5	a6
a7	a8	a9

Figure 3.7 Filter windows 3x3

Thresholding is the method of reducing the color of images and changing the binary images to the greyscale images. Trace boundaries is the method to find out the boundaries and edge tracing between the background and banana image. With this method, the edges of banana are traced.

b) Stage III: Computational Histogram of RGB

Computational colour histogram is used to identify and separate the portions and colour the images of bananas are collected. In this technique, the different colour of the bananas in the images collected has been separated and differentiates based on RGB colour types. Colour feature can be extracted by the Colour Histogram method based on the rule created in the MATLAB. This technique is used to see the different colour value of the sample. Figure 3.8 shows the schematic diagram for the technique used

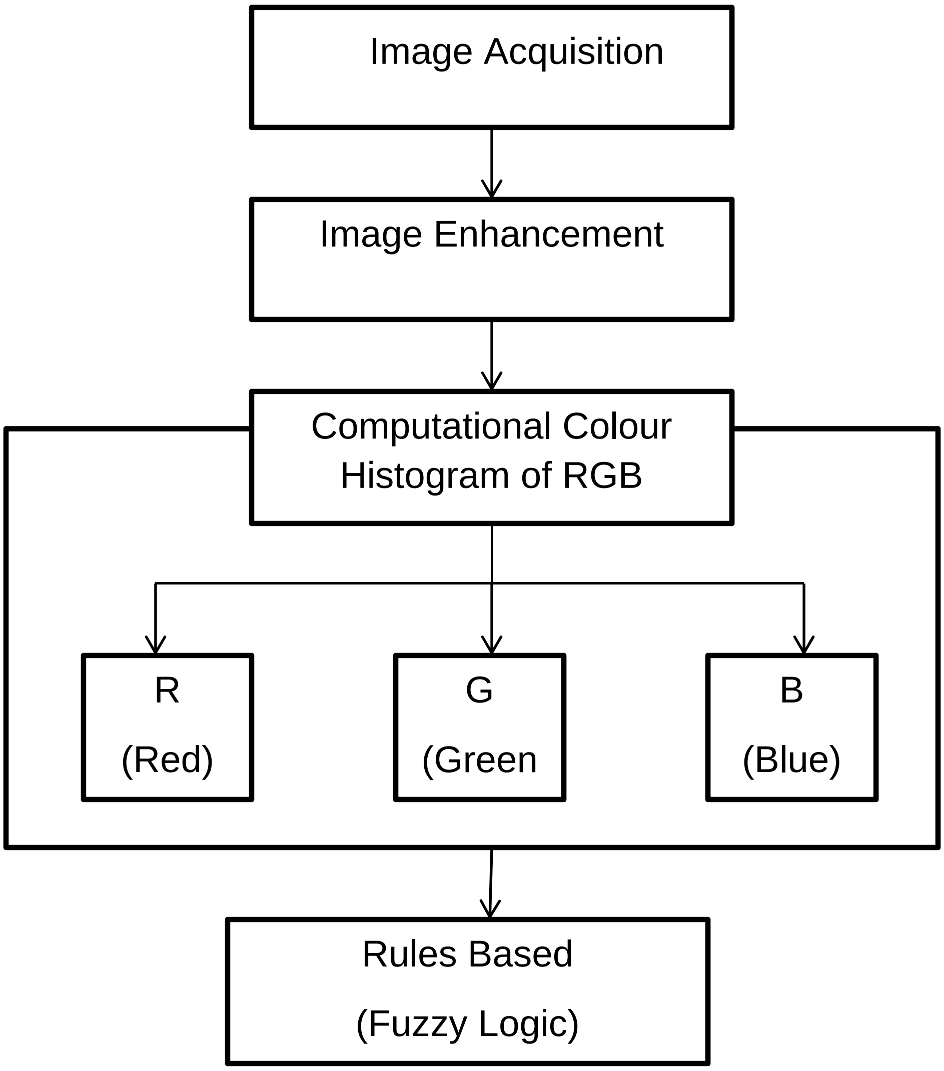

Figure 3.8 Computational Colour Histogram of RGB techniques

c) Stage IV: Rules Based (Fuzzy Logic Algorithm)

Rules based fuzzy logic algorithm is used to classify the maturity of banana. In this technique, the rules are created based on the average of RGB value colour. The average value of RGB is calculated and divided into three classifications which are unripe, ripe and overripe based on maturity of banana. Figure 3.9 shows the schematic diagram for the technique used.

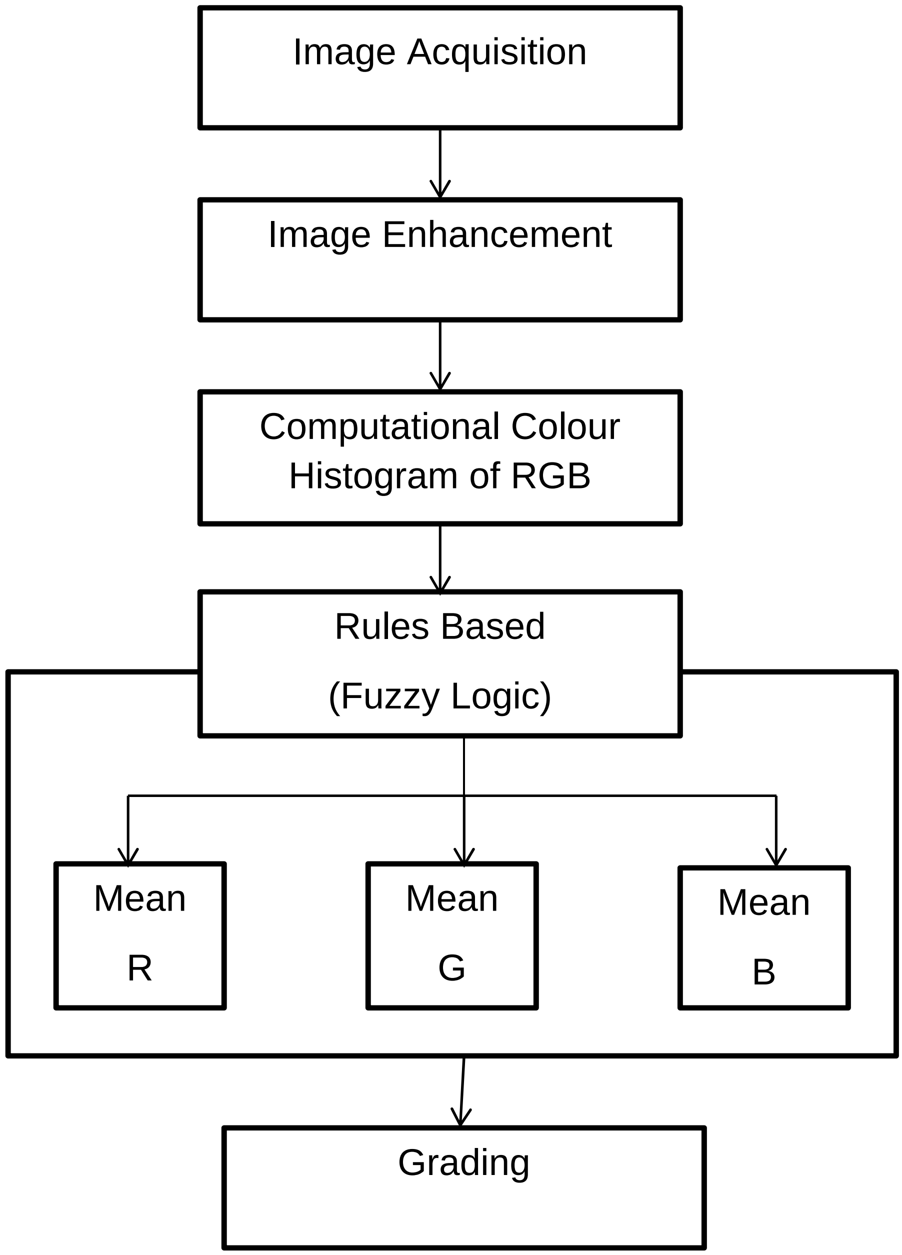

Figure 3.9 Rules Based (Fuzzy Logic) Technique

3.3.3 Construction Phase

In this construction phase, the development the Banana Grading System is implemented by using MATLAB 2010. In this phase, the coding and programming of the system is executed. The suitable and user friendly graphical user interface (GUI) of the banana grading system is developed and the code is implemented in the GUI in order to develop the system and make it executable system. The code that is used in this development of banana grading system is the MATLAB code. In the coding of the system, the processing process of the banana image is applied. The system is executed the process of image processing of the banana which include image acquisition, image enhancement, computational colour histogram of RGB and rules based of fuzzy logic.

3.3.4 Cutover Phase

Cutover phase is the phase which the testing and validation of the system will be implemented. In this phase, the testing and validation of banana grading system is implemented. The user can test the Banana Grading System (BGS) and checking the system error and the upgrading of implementation in order to achieve the goal of banana grading system. The error of the system is checked and fixed in order to build zero-error system. After testing and validation is done, the BGS is ready to be used.

3.4 CONCLUSION

The technique that is used to implement the Banana Grading System is the Rapid Application Development (RAD) method. RAD method is the method that is faster but high quality. The concept of RAD is developing the system with the faster way and having a high quality of the product. Other than that, it is also used to develop a complete solution in a minimal time as possible. By using RAD, the problem by users and developer that occur in the system will be solved. RAD method is also reliable and applicable method which the system can be successful develops and can be used. RAD also will be facilitating a scope for user to actively provide input in developing process. RAD method will be implement and developing the system using a systematic direction which is by using stages and step by step which are consist of four phases that are very applicable. The four phases are requirement planning, user design, construction and cutover. In requirement planning, the user and developer need to discuss the project needs, project scopes, and constraint and system requirement. After requirement planning phase, the user design phase will be occur. In user design phase, the user will interact with the system analyst to developing the models and prototype of system that will represent processes, inputs and outputs. The construction phase will occur after user design stage. In this phase, the program and application development occur. The implementation process will take place. The last phase is cutover phase. This phase is the final task in developing the system. It will resembled data version, testing, the changeover of the error in the system and user training. By using this method, the objectives of proposed automated grading system will be achieve in a fast and high quality way. The cost and energy used can be reducing in short time while the standardization of the banana grade will be obtained. As conclusion, the RAD method is the best method in developing the Banana Grading System.

CHAPTER 4

IMPLEMENTATION

4.1 IMAGE ACQUISITION

In banana grading system, there are a few steps that need to be accomplished in order to develop fully automated grading system. The first step is image acquisition. In this step, the image is captured as the main sample. For Banana Grading System, the image of banana is captured by using digital camera. The camera is set approximately 150 mm from on top of the banana. The image is captured with the control of lighting and placed on the black coloured box. The banana image that is captured then stored in the database of MATLAB.

The Banana Grading System is run on personal computer that acts as a platform to execute the system. The software platform that is used to execute the system is MATLAB 2010. In this system, the image is loaded from the database of MATLAB by the user. User can choose which image that want to be load.

When the user click the *Load Image* button, the system start to search the image of banana on the database in `[filename, pathname] = uigetfile('*.jpg','Select an Image File')` then the image loaded is stored as `bI_rgb`. In this system, `bI_rgb` is a three-dimentional (M-by-N-by-3) array which representing a colour image. Figure 4.1 shows the function of the code to load the image.

```
%load an image into the system (Image Acquisition)
try
[filename, pathname] = uigetfile('*.jpg','Select an Image
File');
bI_rgb = imread ([pathname,filename]);

%To show image  of banana from the front side loaded at
axes1
axes(handles.axes1);
imshow(bI_rgb);

%show original image
handles.bI_rgb = bI_rgb;
guidata(hObject,handles);
```

Figure 4.1 Image Acquisition Code

4.2 IMAGE ENHANCEMENT

The second step in Banana Grading System is the image enhancement step. In this step, the enhancement of the banana image is implemented. The image that is acquired is in RGB format. So, the image not converted to other format because this system is using RGB colour format. The image is only converted to the greyscale image which after undergo filtering process

4.2.1 Filtering

One of the processes in image enhancement is the filtering process. The function of the filtering process is to smoothing the image acquired and to clear the noise that contain in the image. The average filtering is applied in this Banana Grading System. Filtering function is to smooth the image and clear noise on the image. In this system, we used averaging filtering, h = fspecial('average') as the type of filtering by the function of imfilter(I_lab,h,'symmetric'). The input array values outside the bound of array are computed by using function Symmetric. Figure 4.2 shows the code of filtering process.

```
%Filter using average filtering
h = fspecial('average');
bI = imfilter(bI_rgb,h,'symmetric');
```

Figure 4.2 Filtering Process Code

4.2.2 Threshold

After undergo the filtering process, the image then is converted to the greyscale image. The function of `bI = rgb2gray(bI_rgb)`is used to converted the image. This function is also used for stretching and contrast the grayscale image. The single intensity value of the grayscale value is specify for each pixel of the image. The value is adjusted by using `imadjust(bI,stretchlim(bI),[])` function. The specific lower and upper limit for intensity value is 1% top of all pixel values for each. After the specification of value, the grayscale image is converted to binary by using `im2bw(bI,threshold)` function. Figure 4.3 shows the code for threshold process.

```
%Convert to bw and threshold image
bI = rgb2gray(bI_rgb);
bI_rgb2 = imadjust(bI,stretchlim(bI),[]);
threshold = graythresh(bI_rgb2);
BW = im2bw(bI,threshold);
axes(handles.axes2);
imshow(bI_rgb2);
```

Figure 4.3 Threshold Process Code

4.2.3 Trace Boundaries

After undergo threshold process, the trace boundaries process is occur. In this process, the boundaries of the banana are traced. The `bwboundaries (BW,'noholes')` function is implemented. Nonzero pixel of the outer boundaries banana image is traced and 0 pixels controlled the backgrounds. The image that is showed is the outline of trace boundaries on the banana image.

```
%Show traced boundary
axes(handles.axes3);
imshow(bI);


hold on;
[bI] = bwboundaries (BW,'noholes');
for k=1:length(bI)
boundary = bI{k};
plot(boundary(:,2),boundary(:,1),
'w','LineWidth',3);
```

Figure 4.4 Trace Boundaries Process Code

4.3 COMPUTATIONAL COLOUR HISTOGRAM OF RGB

The third step in Banana Grading System is the Computational Colour Histogram step. In this step, the color histogram of RGB value of the banana image is implemented. The image acquired is carried each value of red, green and blue color channel separately. The background of the image is removed before separation of the RGB value.

4.3.1 Remove Background

In this computational colour histogram step, before RGB value is extracted, the background of the image needs to be removed. The `KM2 =imfill(KM,'holes')` function is used. `KM` is an empty array with the size of `BW.` The image which placed within the boundaries is assigned 1's as pixel values. The value then fills the holes of the array.

```
%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');
```

Figure 4.5 Remove Background Process Code

4.3.2 Separation of RGB Value Channel

In this process, the RGB colour is separated to obtain each red, green and blue value. The function of `MyRGB(:,:,1)` is used in order to store the value of each RGB colour. After R,G and B colour is obtained, value is converted in double value using `double (MyRed)`, `double (MyGreen)`, `double (MyBlue)` function. Figure 4.6 shows the code for separation of RGB value channel.

```
% Extract out the R, G, and B images individually
   MyRed = MyRGB(:,:,1);
   axes(handles.axes6);
   imhist(redMean);

   MyGreen = MyRGB(:,:,2);
   axes(handles.axes7);
   imhist(greenMean);
```

```
MyBlue = MyRGB(:,:,3);
axes(handles.axes8);
imhist(blueMean);



% Change to double
MyRed = double (MyRed);
MyGreen = double (MyGreen);
MyBlue = double (MyBlue);
```

Figure 4.6 Separation of RGB Value Channel Process Code

4.3.3 Obtain Mean Value of RGB

After the RGB channel is separated and placed the value, the mean value of RGB colour is obtained. The function of `Mean(mean(MyRed))`, `Mean(mean(MyGreen))`, `Mean(mean(MyBlue))` is used in order to calculate the mean value of RGB. The histogram of each R,G and B value is placed by using `imhist(redMean)`, `imhist(greenMean)`, `imhist(blueMean)` function. Figure 4.7 shows the mean value of RGB code.

```
%Calculate mean of RGB value
redMean= Mean (mean(MyRed));
greenMean = Mean (mean(MyGreen));
blueMean = Mean (mean(MyBlue));
avgRGB = redMean + greenMean  + blueMean;
```

Figure 4.7 Obtain Mean Value of RGB Code

4.4 CLASSIFICATION OF BANANA USING FUZZY LOGIC

Banana Grading System is classified based on mean of RGB color. This RGB color is determined into three classifications which is unripe, ripe and overripe. The classification of the banana is made in order to standardize the grading of banana that needs to be supplied to the market and entrepreneur of chips and exported. The classification of the banana grading is shows in the Figure 4.8.

In this classification, rules based of fuzzy logic is implemented in IF ELSE function. The function of `result = 'Unripe'`, `result = 'Ripe'`, `result = 'Overripe'` are the classification of the banana grading. This result is based on mean of RGB value. The function of `suggestion = 'Send to entrepreneur chips'`, `suggestion = 'Can supply to the market'`, `suggestion = 'Please disposed the banana'` are suggestion that is made to the user regarding the classification of the banana.

```
%classification

if (avgRGB< 14.0);
 result = 'Unripe';
suggestion = 'Send to entrepreneur chips';

elseif (avgRGB > 14.1 && avgRGB <28.0 );
 result = 'Ripe';
suggestion = 'Can supply to the market';

 elseif (avgRGB > 28.1);
 result = 'OverRipe';
suggestion = 'Please disposed the banana';

else warndlg('Something Wrong!!',
'BANANAGRADINGSYSTEM', 'modal');
```

```
 set(handles.resultText, 'string','Not
identified');
 guidata(hObject,handles);
 set(handles.qualityText, 'string','Not
identified');
guidata(hObject,handles);


end
set(handles.resultText, 'string',result);
guidata(hObject,handles);



set(handles.qualityText, 'string',suggestion);
guidata(hObject,handles);

set(handles.suggestion, 'string',suggestion);
guidata(hObject,handles);
```

Figure 4.8 Classification of Banana Grading

CHAPTER 5

RESULT AND DISCUSSION

5.0 INTRODUCTION

In Banana Grading System, 50 samples from four types of banana is used in the testing phase of system. The samples is undergo all phases in the implementation of the system which is image acquisition, filtering, threshold, trace boundaries, removing background, separation of RGB colour value and classifications. In this chapter, the result from the implementation of the Banana Grading System is discussed. The testing result is located in the Appendix B to be referred. 56 chilies were used as sample data in the testing phase of this project development.

5.1 IMAGE ACQUISITION

Fifty samples of banana are used in the testing phase of Banana Grading System. The samples is taken from four types of banana which are ‘Pisang Mas’, ‘Pisang Putar’, ‘Pisang Lemak Manis’ and ‘Pisang Berangan’ with the different classifications. From 50 samples of banana, 45 are goods banana sample while the other 10 are overripe banana. From the 45 samples, 24 are unripe banana and the remaining is ripe banana.

Figure 5.1 below shows the image that is tested in Banana Grading System. The original image is captured by using camera digital and stored in database then loaded into the system.

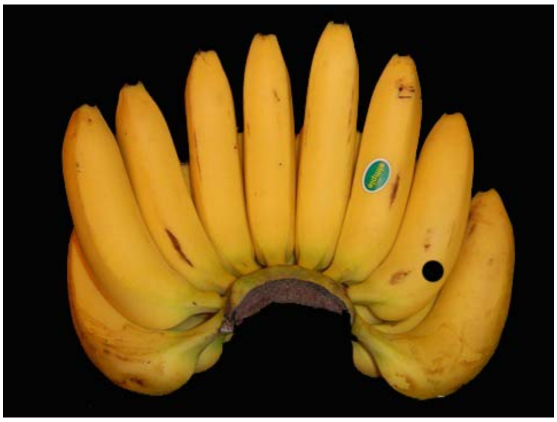

Figure 5.1 Original Image

5.2 IMAGE ENHANCEMENT

In image enhancement phase, there are three processes that is implemented to the image of banana that is loaded which is filtering process, threshold process and trace boundaries process. The image is undergoing filtering process to create filtering image. Then, the threshold process is took part when filtering process complete to produce binary image that contains only 0s and 1s pixel in the image.

5.2.1 Filtering Process

Since the original image is in RGB format, the converting process to other format is not needed. The original image is then converted to the grayscale image in order to undergo filtering process. Figure 5.2 shows the original banana is converting to grayscale image. After the image is converted to the grayscale image, the image then undergoes the filtering process. Figure 5.3 shows the grayscale image to the filtering image.

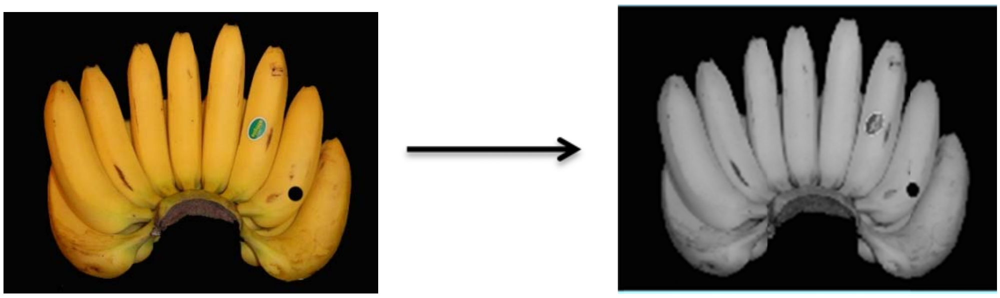

Figure 5.2 Original Image to Grayscale Image

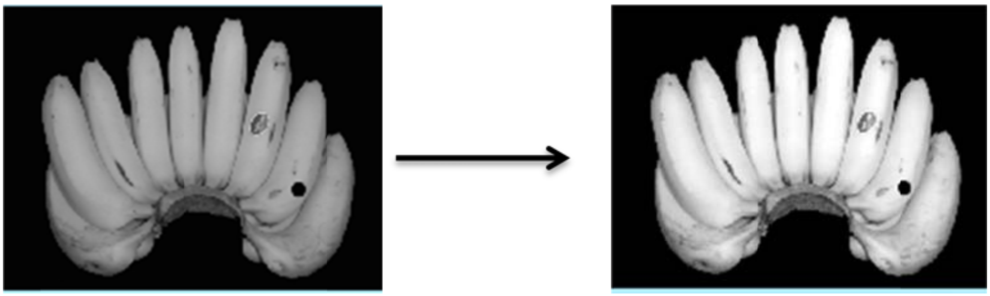

Figure 5.3 Grayscale Image to Filtering Image

5.2.2 Threshold Process

In threshold process, the grayscale image which is two dimensional images is converted to the binary image. Figure 5.4 shows the grayscale image is converted to the binary image.

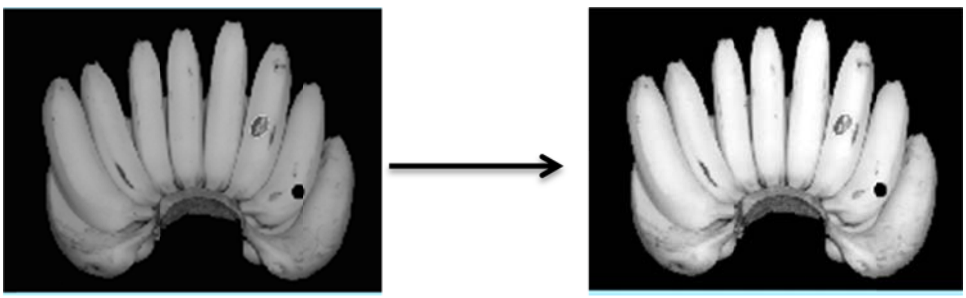

Figure 5.4 Grayscale Image to Threshold Image

5.2.3 Trace Boundaries

In trace boundaries process, the boundary in the image is traced by using certain function. The binary image is converted to the trace boundaries image in this process. Figure 5.5 shows the binary image is converted to the trace boundaries images.

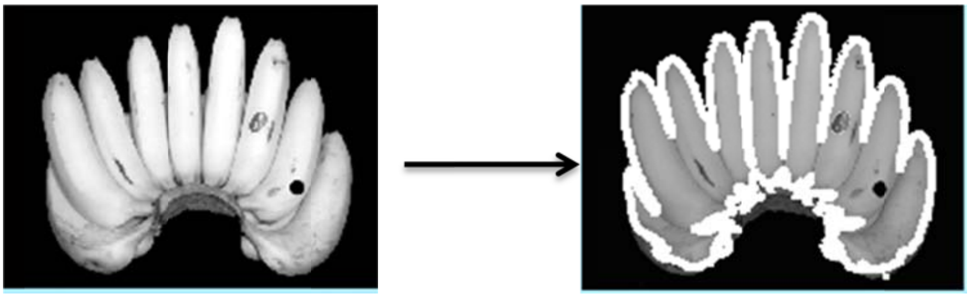

Figure 5.5 Binary Image to Trace Boundaries Image

5.3 COMPUTATIONAL COLOUR HISTOGRAM OF RGB

In this phase, the image is showed in histogram image. The RGB colour is separated into histogram image. Before the separation of RGB channel, the removing of the background process is firstly undergoing. After the background is removed, the separation of the RGB colour is took place.

5.3.1 Remove background

The boundary area of the image is been drawn before. So, by taking the size of the boundary area drawn at previous stage and filling the area with pixel 1s the influence of the background has been removed. The result obtained should visibly resemble the threshold image. This is to make sure that the area that visible is within banana only. Figure 5.6 shows the removing background image.

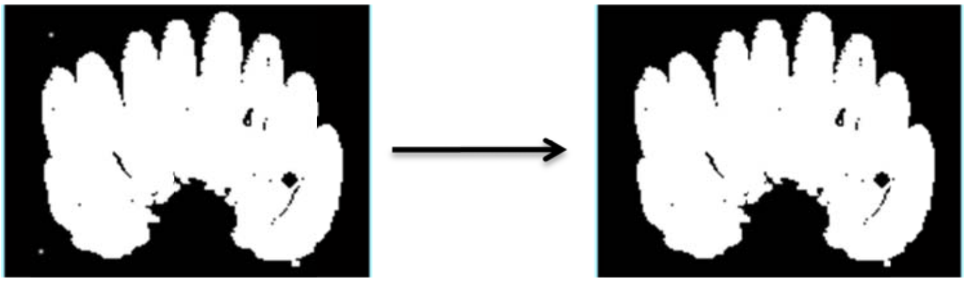

Figure 5.6 Remove Background Image

5.3.2 Separation of RGB Channel

In this process, the RGB value is separated into histogram image. The red, green and blue value is carried own value. Figure 5.7 shows the histogram image of red, green and blue channel.

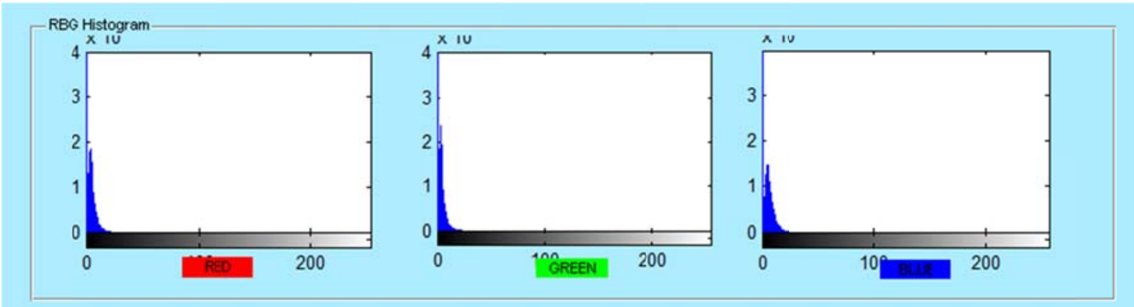

Figure 5.7 Separation of RGB channel

5.4 CLASSIFICATION OF BANANA

The mean values of RGB value is calculated to get the classification of the banana. The classification of maturity level of banana is based on mean value of RGB colour. Figure 5.8 shows the interface of Banana Grading System.

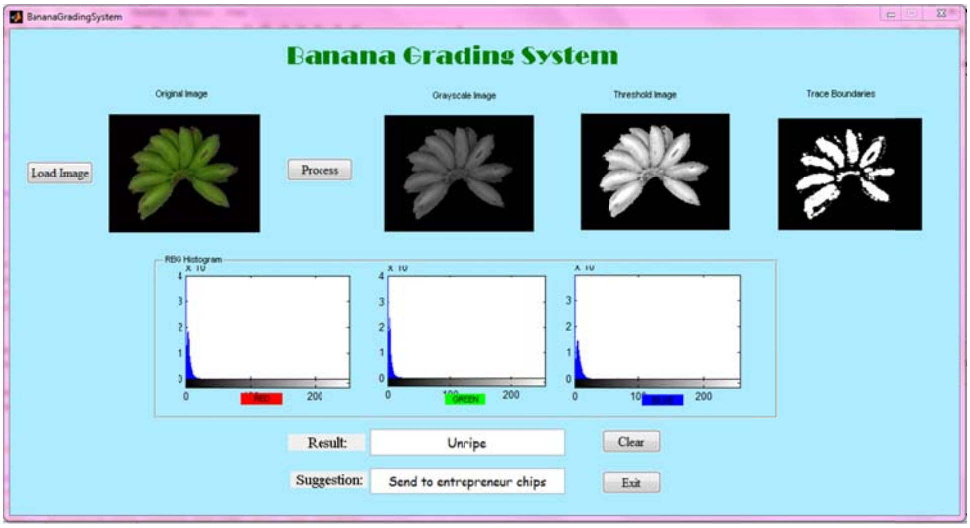

Figure 5.8 Interface of Banana Grading System

5.5 TEST RESULTS

In the testing process, the fifty samples of banana images are successfully tested. Table 5.1 shows the result analysis from the testing process.

Table 5.1 Results from the testing process

Banana Classification	Samples of Banana	Successful Rate	Error Rate
Unripe	24/24	80%	20%
Ripe	21/21	85%	15%
Overripe	5/5	90%	10%
Total	50/50	85%	15%

From Table 5.1, the result shows that from fifty samples of banana, five of bananas are rotten while the remaining is good banana. Twenty four out of forty five bananas is classify as unripe banana while twenty one out of forty five is classify to ripe banana. The unripe banana then suggested to be supplied to entrepreneur chips while the ripe banana is suggested to be supplied to the market. There might have constraint based on the result and it might cause by the freshness of the banana sample for testing purpose. The sample images of banana is taken early before the testing process. it might been keep for several days after taken from the field and the freshness decrease a little bit and might affect the testing result.

5.6 ADVANTAGES AND DISADVANTAGES

In this part, the advantages and disadvantages of the system will be discussed in order to improve the existing system.

5.6.1 Advantages

The advantages of this prototype are:

i. The system is able to classify the maturity level of banana automatically without using workers which using manual system.
ii. The prototype provides a better alternative compared to using manpower in determining the classification of maturity which will easy to error due to tiredness or bias.

5.6.2 Disadvantages

The disadvantages of this prototype are:

i. The prototype is process one bunch of banana in one side only for each process which may contain error while evaluating the classification of banana.
ii. The prototype was not able to differentiate banana with other fruits or vegetable that contains yellow, green and brown color.

5.7 CONSTRAINTS

There are several main constraints that may affect the delivering and results of the system. There are mainly:

i. The lighting effects : The lighting effects may cause reflection or other effect on banana during the image acquisition

			process and these might cause the result of the image taken to be inconstant.
ii.	The system process one bunch of banana in one side only	:	Currently, the prototype is process one bunch of banana in one side only. This may cause erroneous during process.
iii.	The resolution of digital camera	:	The higher resolution the digital camera has, the higher accuracy results can be produced.
iv.	Freshness of banana	:	Maturity level of banana is estimated within less than a week upon the banana image is taken.

5.8 ASSUMPTIONS AND FUTURE RESEARCH

There were several assumptions that have to be considered along with the development of this prototype in order to make evaluation of the prototype's accuracy to the users. Further research should be carried out in order to improve this current problem in the view for the disadvantages that have been identified in the system.

5.8.1 Assumptions

There are three possible assumptions that were taken in consideration during the development of Banana Grading System. They are:

i. The banana does not been exposed to direct sunlight throughout the testing period.
ii. The banana were stored in a room temperature environment throughout the testing period which means it were not being chilled in refrigerator nor being stored near heater.
iii. The banana have stored in an isolated place like a room which has not contact with other substance that might affect the rate of ripeness, for example fruits and other vegetable.

5.8.2 Future Research

There are several recommendations that can be used to improve the Banana Grading System through the agricultural sector in Malaysia that needs the use of technology to improve and expand more agro products which maybe can be exported to the other country.

The first idea is to capture the image of one bunch of banana in two sides to be processed. This could increase the efficiency of the system and the erroneous of grading process will be decreased due to overall sides of banana is being captured.

Nowadays, image processing techniques has been exposing into peoples life. Towards the progressive and innovative progress, we should improve the prototype and the system function so that our system is unique, productive, and useful and had a perspective of future different from others

5.9 CONCLUSION

Banana Grading System is developed in order to judge the maturity level of banana based on skin colour condition of banana. By developing this system, the classification of banana is obtained. The classification of banana is depended on the level of maturity of banana which is unripe, ripe and overripe. The system is using the mean of RGB colour to determine the classification. If the mean of RGB colour more to green, the banana is classify to unripe banana. If the mean of RGB colour more to yellow, the banana is classify to ripe banana while the mean of RGB colour is more to brown, the banana is classify to overripe banana.

The testing process is done in Chapter 5. From the testing process shows that ninety percent out of hundred percent of fifty samples from four types of banana is not overripe. This finding is contributed by sixty percent of the banana samples is unripe. This sixty percent of unripe banana is supplied to entrepreneur of chips for making chips. While the other forty percent from the contribution of ninety percent of banana that is not overripe is ripe banana. This forty percent of ripe banana is supplied to supermarket to be sold. The ten percent out of hundred percent of the banana is overripe. This ten percent of the overripe banana is trough away. Thus, the findings proved that successful rate classification of Banana Grading System is eighty five percent while the error rate is fifteen percent.

As a conclusion, based on the objective of this system which is to develop grading system to judge the maturity level and to standardize the banana grading based on maturity level, the objective is successfully achieved the goal. So, the objective of the system is accomplished. Other than that, the problem regarding grading system by using Human Visualization System also solved. The cost of manual grading system, the time for grading the bananas and the man power uses is decreased. However, the usability of this prototype was being restricted due to the disadvantages, constraints and assumptions as discussed in Chapter 5 which discussed more about the constraints. Hence, further research in adjusting alternative approaches in processing the image for improvement to current prototype is very motivating.

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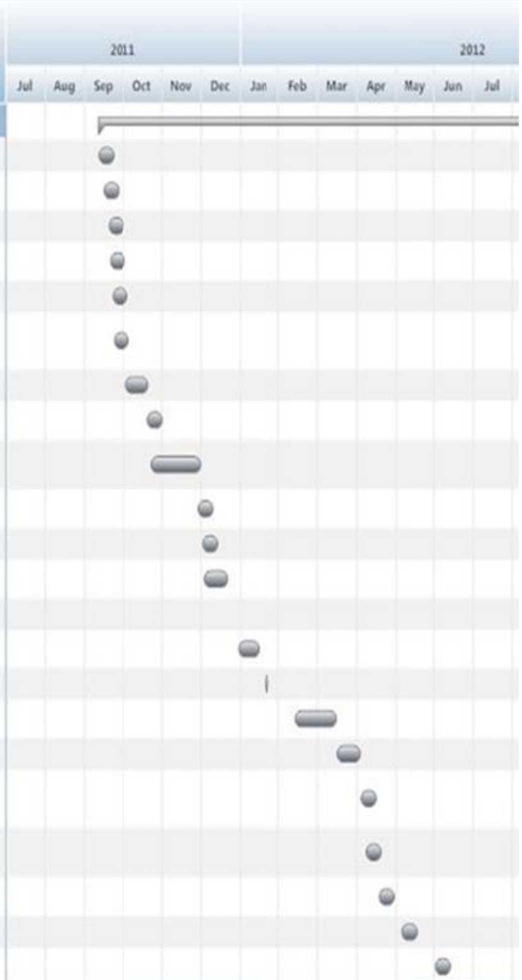
APPENDIX A:

GANTT CHART

	Task	Assigned To	Start	End	Dur	%
	Project		9/12/11	12/28/12	329	
1	Discuss topic research with SV		9/12/11	9/14/11	3	
2	Collect Information from Client		9/16/11	9/17/11	1	
3	Interview the client		9/20/11	9/20/11	1	
4	Analyze data		9/21/11	9/21/11	1	
5	Submission Introduction Chapter		9/23/11	9/27/11	3	
6	Finding additional information for Literature Review		9/24/11	10/2/11	5	
7	Completing Literature Review		10/3/11	10/20/11	13	
8	Submission Literature Review		10/20/11	10/21/11	2	
9	Finding additional information for methodology		10/23/11	11/30/11	26	
10	Completing Methodology Chapter		11/29/11	11/30/11	2	
11	Submission Methodology Chapter		12/2/11	12/2/11	1	
12	Correction whole chapter (1 -3)		12/3/11	12/21/11	13	
13	Submission Full report PSM 1		12/24/12	12/28/12	4	
14	Preparing for presentation PSM 1		12/30/11	1/15/12	11	
15	Presentation PSM 1		1/16/12	1/17/12		
16	Project Implementation		2/14/12	3/15/12	22	
17	Testing System for SV/Client		3/16/12	4/3/12	13	
18	Submission Implementation Chapter		4/4/12	4/7/12	3	
19	Submission of Result & Discussion Chapter		4/8/12	4/13/12	5	
20	Submission Conclusion Chapter		4/18/12	4/20/12	3	
21	Final Report Submission (1 - 6)		5/5/12	5/18/12	10	
22	Preparing for Presentation PSM 2		6/2/12	6/4/12	1	



APPENDIX B:

TESTING RESULT

		RGB values			Value Mean
No.	Images	Mean R	Mean G	Mean B	RGB
1		2.5406	2.3133	2.7937	7.6473
2		2.7193	2.5250	2.9716	8.2159
3		2.7553	2.5215	3.0504	8.3321
4		3.1301	2.8857	3.5236	9.5394
5		4.0946	3.6400	3.7038	11.4384
6		3.4959	3.2180	3.1825	9.8964
7		3.0817	2.8968	3.7505	9.7290

8		4.3396	4.4467	4.8771	13.6634
9		22.4692	21.2559	20.5390	64.2641
10		24.9227	24.2549	19.3973	68.5750
11		23.5356	23.0966	20.7777	67.4099
12		3.5396	3.3118	3.9146	10.7660
13		4.0007	3.6806	4.6076	12.2889
14		4.2430	3.9993	4.7684	13.0707

15		3.3387	3.0450	3.3398	9.7234
16		2.8080	2.5017	2.5993	7.9090
17		4.2867	3.8204	3.9056	12.0127
18		3.3387	3.0450	3.3398	9.7234
19		3.1211	2.9385	3.4783	12.0127
20		30.0312	29.3119	23.1228	82.4657
21		2.8689	3.6627	3.552145	11.89387
22		3.3060	3.5226	3.4587	10.2873

23		2.9559	2.7828	3.2949	9.0336
24		1.8841	1.7549	2.0899	5.7291
25		3.0897	2.8376	3.3864	9.3138
26		13.6866	12.5093	12.0218	38.2188
27		23.4508	23.1264	21.0218	68.5557
28		11.0599	9.2996	6.7388	68.5557
29		2.5406	2.3133	2.7937	7.6473
30		2.7193	2.5250	2.9716	8.2159

31		2.7553	2.5215	3.0504	8.3321
32		3.1301	2.8857	3.5236	9.5394
33		4.0946	3.6400	3.7038	11.4384
34		3.4959	3.2180	3.1825	9.8964
35		3.0817	2.8968	3.7505	9.7290
36		4.3396	4.4467	4.8771	13.6634
37		3.5396	3.3118	3.9146	10.7660
38		4.0007	3.6806	4.6076	12.2889

39		4.2430	3.9993	4.7684	13.0707
40		3.3387	3.0450	3.3398	9.7234
41		2.8080	2.5017	2.5993	7.9090
42		4.2867	3.8204	3.9056	12.0127
43		3.3387	3.0450	3.3398	9.7234
44		3.1211	2.9385	3.4783	12.0127
45		2.8689	3.6627	3.552145	11.89387
46		3.3060	3.5226	3.4587	10.2873

47		2.9559	2.7828	3.2949	9.0336
48		1.8841	1.7549	2.0899	5.7291
49		3.0897	2.8376	3.3864	9.3138
50		3.3060	3.5226	3.4587	10.2873
	Total	286.0595	277.0590	206.52389	893.91021
	Average	5.72119	5.54118	4.1304778	17.8782042