"I hereby declare that I have read through this report entitle "**Fruit Sorting By Machine Vision Technique**" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechatronics Engineering.

Signature   : ....

Supervisor's Name : ....

Date   : ....

FRUIT SORTING BY MACHINE VISION TECHNIQUE

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**A report submitted in partial fulfilment of the requirements for the degree of
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Faculty of Electrical Engineering

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2016

I declare that this report entitle "**Fruit Sorting By Machine Vision Technique**" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature　　:　...

Name　　　:　KHOR CHIN WE
....

Date　　　:　2/6/2016
....

To my beloved mother and father

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ABSTRACT

Nowadays, automation system such as machine vision system is widely used in many industrial. Fruit sorting by machine vision technique is a potential automation system which is able to obtain their target in term of productivity and quality. However, there are several problems such as camera resolution, illumination and performance that need to be considered for using the machine vision technique. Hence, the objectives of this project is to design a high accuracy algorithm that is able to classify apples based on color and size. Furthermore, the performance of fruit sorting system is needed to be evaluated and optimized by manipulating the illumination, thresholding value and camera distance. MATLAB is an analysis tool that has been used in this research project. There are three experiments such as HSV value comparison, thresholding value performance comparison and the different camera distance performance comparison. The experiments are aim to define the tolerance limits of hue value and number of pixels. The tolerance limits are used for the purpose of categorizing the type of apple. At the end of the experiment, the analysis and discussion explained about the performances of each variation of parameters. The problems such as low illumination condition and the limitation of different thresholding value and distance of camera are described as well in the analysis and discussion. As conclusion, the performance in term of accuracy and precision of the designed algorithm has been evaluated and optimized at the end of this project.

ABSTRAK

Pada masa kini, sistem automasi seperti sistem penglihatan mesin digunakan semakin luas dalam pelbagai industri. Sistem pembahagian buah-buahan dengan mengunakan teknik penglihatan mesin adalah satu sistem automasi yang berpotensi dan bermampu untuk mendapatkan meningkatkan produktiviti dan kualiti dalam sesebuah industri. Walau bagaimanapun, terdapat beberapa masalah seperti resolusi kamera, pencahayaan dan prestasi yang perlu dipertimbangkan semasa menggunakan teknik penglihatan mesin. Oleh itu, projeck penyelidik ini bertujuan untuk merekabentuk sebuah algoritma yang berketepatan tinggi dan mampu membezakan epal berdasarkan warna dan saiz. Tambahan pula, prestasi sistem pembahagian buah-buahan dapat dioptimumkan dengan memanipulasi pencahayaan, nilai ambang dan jarak kamera. MATLAB adalah alat analisis yang telah digunakan dalam projek penyelidikan ini. Terdapat tiga eksperimen seperti HSV perbandingan, prestasi perbandingan dan jarak camera perbandingan telah dilaksanakan untuk menentukan batas-batas toleransi nilai warna dan bilangan piksel. Had toleransi digunakan untuk mengkategorikan jenis-jenis epal. Bahagian analisis dan perbincangan telah menjelaskan bahawa tentang prestasi setiap perubahan parameter. Masalah-masalah seperti pencahayaan rendah, had nilai ambang yang berbeza dan jarak kamera berbeza telah diterangkan serta dalam analisis dan perbincangan. Kesimpulannya, prestasi dari segi ketepatan algoritma telah dinilai dan dioptimumkan pada akhir projek ini.

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CHAPTER 1

INTRODUCTION

This chapter review the introduction of automation fruit sorting system. The motivation, problem statement, objective and scope about this research project are discussed in this chapter. Besides, the thesis organization is described at the last part of this chapter.

1.1   Introduction

There are several handling steps of fruit process in fruit processing industries. The fruit after collecting from farm, it will undergo the process of washing, sorting, grading, packing, transporting and storage before going to sell in market [1]. Fruit sorting and grading can be considered as the heaviest processing task compared to the other steps. Normally, more time and effort will be invested in this process. This process can be either operated in manual sorting method or automatic sorting method. Manual fruit sorting is a method operated by human in order to identify and separate fruit manually while automatic fruit sorting is a method can be operated by using the technique of machine vision. One of the advantages of machine vision is high precision [2]. Machine vision can be carried to get measurements without any touch on the surface on objects, so there is no damage or dangerous on the fragile parts. Besides that, machine vision can operate continuously and the operating and maintenance costs are low. The high flexibility of visual system becomes the reason for people to choose machine vision system rather than optical sensors.

1.2   Motivation

Manpower contributed by labour is flexible and fast. Meanwhile, machine vision is type of automatic system which is dependable and precise. Many manufacturing industries have tried to implement the automated system to reduce the use of manpower.

The Figure 1.1 shows the number of robots in use in the five largest global markets. From the graph, the demand of robots from 4 countries except Japan shows the trend of increase from year 2012 to 2017. According to the German-based International Federation of Robotics, China is already the world's largest market for industrial robots [3]. These trends will keep increasing in the next few years. Hence, the trend obviously indicate that automatic fruit sorting method is more preferable choice for fruit industrial compared to manual sorting method.
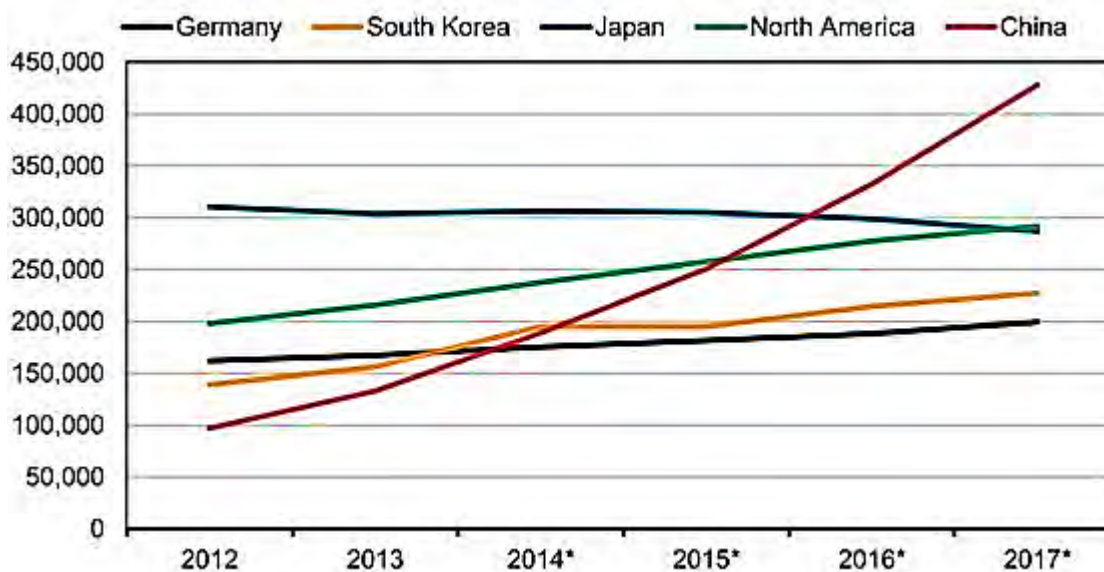
Figure 1.1: The number of robots in use in the five largest global markets, projected to 2017 [3]

The Figure 1.2 represents the differences in term of profit, cost, and sales between manual operating system and automated system. The sales of both systems are the same but the operating cost of automated system decrease drastically while the profit increases by time. The trends clearly indicate that most of the industries choose automation system rather that manual system.
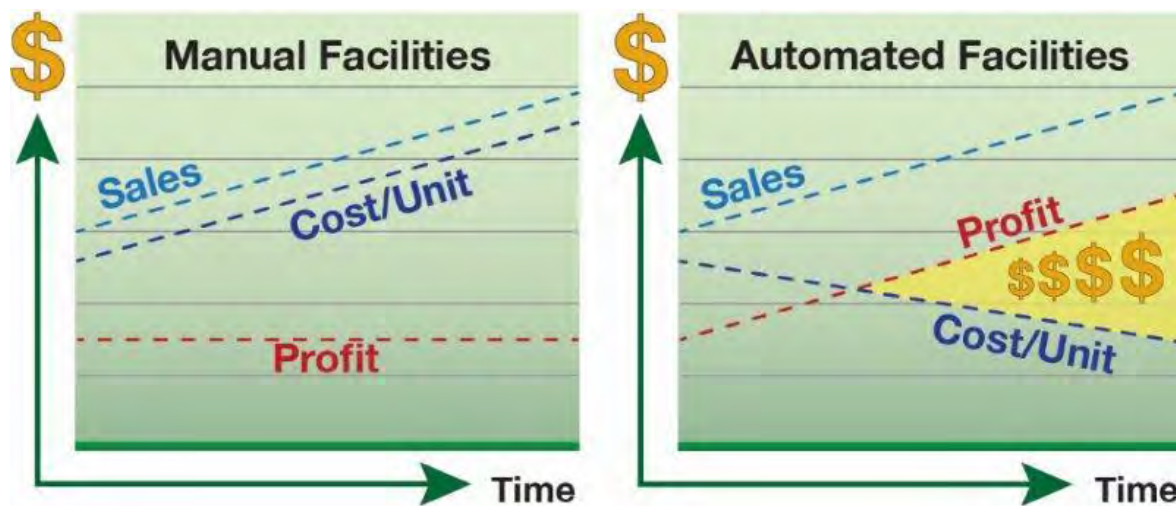
Figure 1.2: The efficiency of implementing manual facilities and automated facilities [4]

The reason of using machine vision system that can be able to increase the profit is high productivity. However, some industries hire more labours in order to seek and achieve higher productivity but normally manual fruit sorting causes unwanted problems that may directly influence the production result. Hence, training is basically to be provided for labours in order to produce skillful, experience and quality worker but high investment cost on labours will highly reduce a company profit.

Machine vision technique is a reliable system to be implemented in fruit sorting for fruit industries. It is time-saving and high efficient system which is able to significantly hit the production target in fruit industries. The designed system not only can operate continuously day and night without any tiredness, the production output quality is also hugely trustable. The capability of fruit sorting by machine vision is truly high compare to human vision.

Besides, the visual results generally are highly dependent on labours mental and physical fitness. Humans are not able to have fully concentration while making many decisions within a certain time. Human decisions are variable and difficult to be standardized. In addition, the task of visualizing fruit is quite tedious. It probably causes the problems of difficulty to hire workers and labours turnover. Therefore, fruit sorting by using the technique of machine vision is recommended system to be implemented.

1.3   Problem Statement

Machine vision technology is highly used in factory automation. It is a system that camera captures products' picture and interprets them to find defects and categorize them. Nowadays, camera has become common in our life. Camera has been transformed from analogue to digital camera and even the mobile phone has the function of high quality camera. Thus, with this huge change of camera, it has become a selective device to detect object or feature.

There are thousand types of camera in the market. Different cameras have different image processing quality. Camera quality is a constraint that should be considered in machine vision system. Normally, high Mega-Pixels of camera will cause a challenge in having too much information. In real system operating time, high resolution camera will cause unacceptable processing time [5]. Large image sizes require longer time to compute and collect data from camera. Thus, selecting an appropriate type of camera based on the requirement is able to improve a vision system in term of efficiency.

Besides, another problem should be overcome is the illumination conditions that surround the camera. The colour detection and ability to distinguish an object are can be affected by the surrounding environment [5]. The surrounding lighting condition should be standardized in order to get precise analysis result. In addition, reflection of light on an object causes analysis errors during image processing.

For an algorithm design, the accuracy is important in measuring the size and colour of apples. A good algorithm is able to reduce the percentage of the errors such as systematic

error and random error from happening. Thus, the result consistency is highly maintained with a good design of image processing algorithm.

1.4   Objectives

The objectives of the research project are:

1. To design and develop an algorithm for fruit classification based on size and colour.
2. To evaluate the system performance for fruit sorting and classification in term of accuracy and precision.
3. To optimize the system performance by manipulating the illumination, thresholding value and distance of camera.

1.5   Scopes

The scopes of the research project are listed as the following:

1. Apple is chosen as the analysis material for this fruit sorting system.
2. Algorithms are developed based on the size and colour of apple.
3. Algorithms are designed by using MATLAB computer software.
4. Analysis is based on the data of static image.

1.6   Thesis Organization

This report is the study about the fruit sorting by using the machine vision technique. In this report, the chapter 1 will cover about the motivation and problem statement for designing an image processing algorithm of fruit sorting system. Besides that, chapter 1 will state about the objective and scope. For chapter 2, it will cover the theoretical background and basic principle of machine vision. The previous related research of automatic fruit sorting system and machine vision are also covered in chapter 2 and the methods and techniques in designing an image processing algorithm of fruit sorting system will be discussed in chapter 3. Finally, the result and conclusion will be covered in the last two chapters which are chapter 4 and chapter 5.

CHAPTER 2

LITERATURE REVIEW

This chapter presents the overview about the preview research project which related to fruit sorting and grading system. Furthermore, the methods and theories of image processing which related to fruit sorting process are reviewed and analyzed. The constraints of applying machine vision technique are described in this chapter as well.

2.1 Fruit Sorting and Grading System

The demand of fruit based on the quality is getting high in market. Sorting and grading are the important process to maintain the quality of fruit [6]. Many machine vision systems have been proposed for agricultural applications such as fruit grading, fruit maturity analyzing and fruit sorting. Machine vision has been used in the research of mango inspection and grading system, mango maturity prediction and vegetable automation sorting by machine vision [7]. The fruits such as citrus fruits, apple and strawberry have been used.

A distributed computer machine vision system for automated inspection and grading of fruits was presented to control the quality of fruits [8]. The automation system is designed for food industries so that the quality of food is able to meet the international standards. Generally, maturity of fruit needs experts to be justified. Manual sorting is time cosuming, laborious process and diffult to judge by human according to fruit maturity. Maturity prediction system is used to predict the maturity of harvested mango [9]. The system is design to solve the problem of manual sorting system.

For some small agro-industrial companies, it is burdensome to procure a high cost sorting machine in order to maintain and increase their product quality. A portable smart sorting and grading machine by using computer vision was presented to solve the problem of heavy built-up system [9].

Grading and sorting system by using machine vision is very useful in maintaining the consistency, uniformity and depletion of time. An integral automation industrial fruit and vegetable system and the research is aim to meet the market standards, classified according to quality levels based on the maturity, size, weight, density and skin defect [10]. To analyzing the image, algorithm should be designed. There are different kinds of fruits that can be different by applying the image processing technique. Image processing is widely used in different agriculture products such as apple, tomatoes, mango, strawberry, cherries, orange, lemon and banana was presented [11]. Besides, the application analysis of machine vision technology in agricultural inspection consist various kind of problems [12]. The problems such as surrounding light intensity should be taken serious to get a precise result.

2.2 Background of Machine Vision

Machine Vision (MV) is the technology and method that provide digital imaging information from the environment and use it for analysis purpose. The analysis method by using MV can be applied in many fields such as industrial inspection, medical visualization, law enforcement and artistic effect. MV is highly demanded in many fields due to speed, consistency and rest period. Machine Vision can process hundreds or thousands pieces of information in a few seconds. Whereas human operative system cannot process information as fast as machine vision based system. Besides that, the consistency of output process by human is truly unstable compared to machine vision system. Humans are not able to work 24 hours per day but machine vision system can operate continuously with stop unless maintenance.

Machine Vision is the method about digital processing image. Digital processing image define as the process from a given input image in order to obtain a required output image. There are basically 3 categories of digital image processing which are image processes, image analysis and computer vision. For image processes, it is used in the

application of camera. The camera will capture a scene and the internal processor will process the data of input image. The image will undergo noise removal, sharpening, brightness adjustment and etc. Finally, the output image will be stored in the memory and it has been ready for photo printing. For image analysis, the image after capturing or recording, it will be undergoes the analysis process. The analysis process is basically running based on the features, shape and texture of an object. The application of image analysis can be used in object recognition and segmentation. Computer vision is basically the high level image process which is used the computer system and digital processing image system. For this digital processing image category, it needs to design a set of program based on requirements and used for scene understanding and autonomous navigation. Normally, this kind of technique has been applied for face recognition, fingerprint system and object tracking system.

2.3 Components of Machine Vision System

The basic components of a machine vision system consist of a camera, a computer and a lighting system [13]. The computer should be equipped with an image acquisition board. Besides, computer software is needed for transmitting electronic signals to computers, acquiring images and performing storage and processing of the images.

2.3.1 Lighting

The lighting unit selection is dependable for different applications. With a suitable-chosen lighting system, recognition and analysis process will be taken easier in the optimal way [14]. Also, eliminating the tedious image processing procedures is one of the reasons to choose a best lighting system.

Due to the high sensitivity of of image processing to illumination, constant environment conditions is important in achieving a robust performance of algorithm. Hence, methods of controlling the environment conditions is to prevent the camera and objects from