UNIVERSITI PUTRA MALAYSIA

OIL PALM FRUIT RIPENESS CLASSIFICATION USING OPTICAL-BASED COLOUR SENSOR

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

June 2016

DEDICATIONS

This thesis work is dedicated to my parents, who have always loved me unconditionally and whose good examples have taught me to work hard for the things that I aspire to achieve.

This work is also dedicated to my friend, Milad Faghihi, who has been a constant source of support and encouragement during the challenges of graduate school and life.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in Fulfillment of the requirement for the Degree of Master of Science

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June 2016

Chairman : Maryam Binti Mohd Isa, PhD
Faculty : Engineering

Harvesting oil palm Fresh Fruit Bunches (FFB) at right stage of ripeness is critical to ensure optimum quality and quantity of oil production. Colour of these fruits can be used as an indicator to predict the level of fruits maturity. The manual grading system based on the colour of the fruits, which is currently used in oil palm mills may cause conflict and misconduct in fruits classification. Therefore, developing an automated fruit classification system is essential. A number of automated fruit sorting methods have been offered and tested for practical usage during the past few years but most of them are costly, bulky and time consuming.

In this study, a reflective colour sensor is used to determine the ripeness of the palm fruit. A portable optical-based sensor system to classify oil palm fruits based on fruits ripening stages has been designed. Several coloured papers were used to verify the effectiveness of the measurement. Analyses setup on distance, angle and position of the transmitter and receiver of the sensor were carried out. The best wavelength of the light source was chosen for the fruit classification system. All the measurements carried out are non-destructive and the oil palm fruit is possible to be measured on-site.

Results from the measurements set-up analyses show that 180º is the best angle between transmitter and receiver. The gap between transmitter and receiver and the gap between fruit and receiver are 1cm and 0.5cm-0.75cm respectively for high accuracy detection. The palm fruit is positioned vertically to the sensor for best detection. 1.5cm-2.3cm of fruit diameter range up to a week old fruit plugged ` the bunch in a dark room (LUX=0) is the best condition for oil palm fruit ripeness classification for this system.

The system is able to categorise the colour of different ripeness of oil palm fruit based on its colour reflection. The voltage ranges for unripe, ripe and overripe fruits are 0.478V to 0.511V, 0.674V to 0.714V and 1.22V to 1.24V respectively. The system also indicates the category of the fruit ripeness by displaying green, orange and red light for ripe unripe and overripe fruits respectively.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

KELAPA SAWIT FRUITS KEMATANGAN KLASIFIKASI MENGGUNAKANOPTICAL BERASASKAN COLOR SENSOR

Oleh

KIMIA SAADAT

Jun 2016

Pengerusi : Maryam Binti Mohd Isa, PhD
Fakulti : Kejuruteraan

Penuaian Kelapa Sawit Buah Tandan Segar (FFB) pada peringkat awal kematangan adalah sangat penting bagi memastikan kualiti dan kuantiti pengeluaran minyak yang optimum. Warna buah kelapa sawit boleh digunakan sebagai indicator dalam meramalkan tahap kematangan buah tersebut.

Sistem penggredan manual adalah berdasarkan warna buah-buahan, yang kini digunakan di kilang-kilang kelapa sawit menyebabkan konflik dan salah laku dalam pengklasifikasian buah kelapa sawit. Oleh itu, pembangunan mengautomatikkan dalam sistem pengklasifisian buah-buahan adalah penting. Terdapat beberapa kaedah pengklasifisian buah kelapa sawit secara mengautomatikkan telah diuji dengan penggunaan praktikal sejak kebelakangan, tetapi kebanyakan ujian tersebut sangat mahal, mengambil ruang yang besar dan memakan masa yang panjang.

Dalam kajian ini, sensor warna reflektif digunakan bagi menentukan kematangan buah sawit. Oleh itu, sistem sensor yang berasaskan optik mudah alih digunakan bagi pengklasifian buah kelapa sawit mengikut tahap kematangan buah telah direka. Beberapa kertas warna telah digunakan bagi mengesahkan keberkesanan pengukuran. Persediaan analisis terhadap jarak, sudut dan kedudukan alat pemancar dan penerima sensor telah dijalankan. Limitasi terhadap saiz sampel, pengukuran masa dan cahaya ambien telah dikaji dalam projek ini bagi mencapai keputusan yang tepat. Penggunaan sumber cahaya yang terang daripada beberapa jalur spektrum telah diuji dalam pengklasifian buah. Kaedah ini tidak memudaratkan dan tahap kematangan buah kelapa sawit boleh diukur di tapak sebagai sistem penggredan kelapa sawit.

Sudut terbaik antara pemancar dan penerima telah dikenalpasti oleh sensor ini, keputusannya menunjukkan bahawa kedudukan sensor antara dengan jurang pemancar adalah 1cm manakala jurang penerima adalah jurang 0.5cm- 0.75cm dengan buah-buahan serta penerima sensor berada dalam kedudukan yang baik bagi mengesan hasil ketepatan yang tinggi. Selain itu, pengklasifikasian buah yang dibuat dalam kedudukan menegak adalah lebih tepat daripada dalam kedudukan mendatar. Selain daripada itu,

faktor seperti saiz buah-buahan, cahaya ambien dan pengukuran masa yang memberi kesan kepada sensitiviti sensor dikaji dalam projek ini.

Secara keseluruhan, sistem ini dapat mengkategorikan jenis warna buah kelapa sawit. Nilai sensor berada di dari 0.478V ke 0.511V bagi buah-buahan yang belum masak, dari 0.674V hingga 0.714V bagi buah-buahan yang sudah masak serta dari 1.22V hingga 1.24V bagi buah-buahan terlebih masak. Indikator warna hijau akan dihidupkan apabila buah masak. Indikator warna oren dan warna merah akan dihidupkan apabila buah-buahan yang belum masak atau masak mengikut kematangan buah tersebut.

ACKNOWLEDGEMENTS

I praise God for all his mercy and grace, the beauties of the world and the chance that he has given us to discover its laws.

This dissertation would not have been possible without the guidance and help of several individuals who contributed their valuable assistance throughout this study.

Foremost, I would like to express my sincere appreciation to my supervisor Dr.Maryam Binti Mohd Isa for her patience, motivation and immense knowledge. Her guidance and support helped me throughout this research and the preparation of this thesis.

My special thanks also go to my Co-Supervisor Dr.Suhaidi Shafie for his support, motivation and knowledgeable guidance.

My sincere thanks also go to my friends in University Putra Malaysia: Sarah Rezaeien, Maral Faghani and Maryam Ehsani who always took the time to listen to me and share their knowledge.

Last but not the least; I would like to thank my parents, Kamran Saadat and Firouzeh Hatami, for their endless support and love they have provided me throughout my life. I would also like to thank them for encouraging and supporting me to pursue my Master's study. My siblings, Kambiz Saadat, Kaveh Saadat, deserve my wholehearted thanks as well.

I certify that a Thesis Examination Committee has met on 3 June 2016 to conduct the final examination of Kimia Saadat on her thesis entitled "Oil Palm Fruit Ripeness Classification using Optical-Based Colour Sensor" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science.The members of the Supervisory Committee were as follows:

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This is to confirm that:

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Signature: ______________________________
Name of Member of Supervisory Committee: Associate Professor Dr. Suhaidi Bin Shafie

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CHAPTER I

INTRODUCTION

1.1 Introduction

In order to specify the ripeness of the fruit via colour distinction, a true method is needed to be researched (MPOB, 1995). The colour presents very useful information about the maturity and the freshness of the fruits and vegetables (Alfatni et al., 2008). Therefore, colour can be used as one of the most significant factors for determining the oil palm fruits grade and quality (Wan Ishak et al., 2000; Rashid et al., 2004).

1.2 Background

Dura, Pisifera and the Terena are the most prevalent types of the palm fruits. The Terena palm has been used for this project because of its thick mesocarp and high production of fruits in comparison with its parent palms.

Palm oil has a wide-ranging of usage; its plantation is extensively practiced by East Asian farmers and organisations including Malaysia. Malaysia is one of the largest exporters of palm oil in the world, contributing 3.2% to the country's real gross domestic product (Basiron, 2007). It has an enormous contribution to the income of the country. Malaysia is placed as the second highest producer of the oil palm with 39% of the worldwide oil palm production (USDA, 2012).

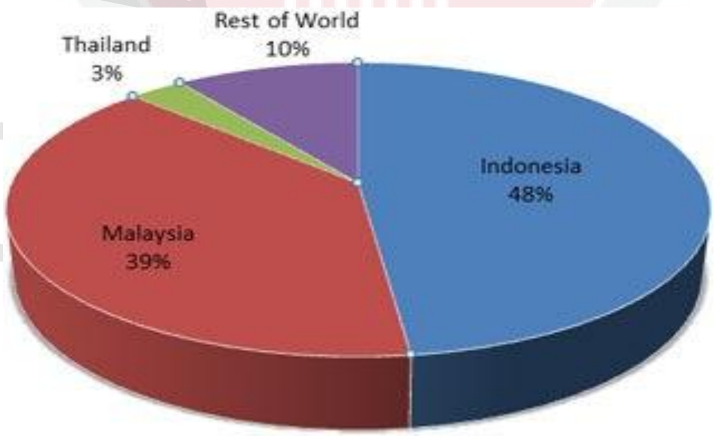

Figure 1.1 : Five-year (2007–2011) palm oil average production by weight (USDA, 2012).

To facilitate and maximise the production of the palm oil, it is necessary to harvest the palm fruit at the right time (Wan Ishak et al., 2000). In case of an early harvest, the bunch will be unripe and favourable amount of oil content might not be reached. Whilst, an overripe fruit harvest results in extraction process issues since the quality will be decreased by high acid existence (Ariffin, 1985). Therefore, harvesting the fruit at the right time is needed.

Colour gives important information in evaluating the development and analysing the ripeness of fruits. Colour also is one of the most important factors that presents the fruit identification and is a good indicator for ripeness. This is also applicable for the oil palm fruits where the fruit colour changes with its maturity, so it can be a good parameter to estimate the fruits ripeness.

This research proposes a portable and cost effective grading system of an optical technique by exploiting colour measurement to identify oil palm ripeness. This method of optical technique will use reflected value, which sent back from oil palm fruits. This system consists of a light source to illuminate the fruits and a photo detector to receive and detect the reflected light from the fruits. Saeed O.M.B reported a comparison of reflectance value from oil palm fruit bunches with four spectral bands 570nm, 670nm, 750nm, and 870nm; it is proved that there is a distinct difference between reflectance values among different categories of oil palm fruits with 670nm spectral bands, which is red light (Saeed et al., 2012). Thus, a red led has been selected as a light source in this project and a phototransistor has been used as a light detector. Phototransistor detects the reflected light from the fruits and the sensor system converts it to a specific range of voltage for each group of the fruits based on the fruit surface colour. In this project, the best physical positions and configuration of each element have been tested in order to have an accurate and effective sensor to classify the fruits. Several LEDs with different wavelengths have been tested for the best light source.

In this study, the right specification of the sensor have been analysed and the colour range of the oil palm fruit have been determined.

1.3 Problem statement

There have been a few studies to investigate oil palm ripeness classification. In current researches, the chemical analysis methodology is time and energy consuming which are very crucial in industries. While the process of oil content determination in each fresh fruit is costly and destructive. Hence, the physical scanning is highly recommended since it is less time consuming with respect to the daily-required sample quantity.

The major drawbacks in the manual grading system based on the surface colour of the fruits are labour fee, slow and inaccurate. Therefore, developing an automated fruit classification system is required.

By employing the spectral reflectance of the oil palm fruits, the different fruit colour can be identified. Some methods that are conducted for machine vision-based the fruits categorising such as optical RGB cameras (Ismail et al., 2000; Abdullah et al., 2001; 2002; Devadas et al., 2009; Alfatni et al., 2007; 2008; Jamil et al., 2009), hyper spectral imaging cameras (Junkwon et al., 2009), magnetic resonance imaging and bulk nuclear magnetic resonance sensors (Shaarani et al., 2010). Shaarani et al. (2010) have presented the capability of utilising optical sensors as a part of oil palm fruits identification.

1.4 Project objective

The aim of the project is to develop a portable optical-based sensor system for determining the oil palm fruit ripeness. The project objectives are:

1. To develop an optical-based sensor system.
2. To verify the performance of the developed sensor by detecting the ripeness of randomly selected oil palm fruits.

1.5 Project scope

Three different coloured papers in black, red and orange colour have been used to represent the colour of the fruit for unripe, ripe and overripe fruits respectively. If actual fruits are being used, the fruits life time reduced the measurements process speed. In addition, Terena type of fresh oil palm fruits was collected by farmers in University Putra Malaysia (UPM). The farmers categorised fruits in three clusters (unripe, ripe and over ripe) to measure the fruit surface colour. The measurements were conducted in a dark room with fairly eminent room heat of about 25ºC and a light meter employed to certify the absence of ambient light, which interferes the experiments. The measurement also has been repeated in a room with lightning and outdoor as well. The fruits have been tested after harvesting and then covered with paper and kept in the fridge to prevent fruit evaporation. The samples were tested every day within 1 week to reveal the fruit reliable time for measuring.

1.6 Project significance

This project significance is developing a new palm oil maturity grading method based on the fruit colour. The mentioned method benefits the agriculture sector higher performance achievement in term of palm oil production, which results in the Malaysia economic development. This model benefits those students who have palm fruit oil related assignments and help them finish their work easier and faster. This project helps the researchers developing colour based identification methods.

The workflow of the study in Figure 1.2 shows the order of the tasks that have been done in this project.

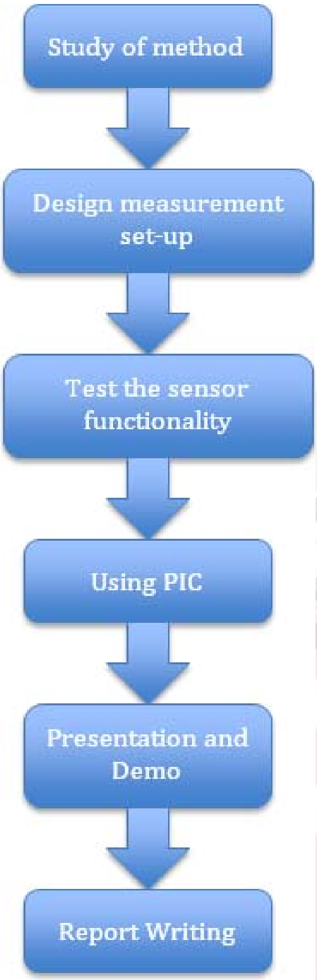

Figure 1.2 : Work flow of this project

1.7 Organisation of the thesis

This report contains five chapters. The first chapter is an introduction; the literature review is included in the second chapter, the research methodology is described in the third section, fourth chapter includes findings and discussion and the conclusion and future studies are explained in the last chapter.

Chapter one will explain the background of palm oil, the problem statement, the project scope and significance of the study. The main objectives of the study are elaborated as well. At the end of the first chapter few points are highlighted as the benefits of the project.

Chapter two reviews the technique and some of the existing similar projects as developing grading palm oil prototype guidance. The literature review is essential in this project as it provides evidence and a proven conclusion to support this project.

The research methodology, which is used in this research, is explained in chapter three. This chapter will describe the overall process of the project development. Chapter four discusses the results and findings of the project. Finally, chapter five divided into three main sections, which are the conclusion, the recommendation and the summary.

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PUBLICATION

K. Saadat, M. M. Isa, S. Shafie (2015), A portable reflective colour sensor for assessing oil palm fruits maturity. In: 7 th International Conference on Sustainable Agriculture for Food, Energy and Industry in Regional and Global Context 2015.

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