UNIVERSITI PUTRA MALAYSIA

*DEVELOPMENT OF 360-DEGREE VIEW IMAGING USING L*a*b* COLOR SPACE FOR FRESH FRUIT BUNCH IDENTIFICATION*

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By

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January 2020

Chairman : Muhamad Saufi bin Mohd Kassim, PhD
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The palm oil industry is well known as a significant agricultural industry in terms of economic benefit for several tropical countries, particularly in Malaysia (Yoshizaki et al., 2013). Total amount of bunches in each of the tree is an important aspect in oil palm harvesting process. In every cycle of harvesting operation, farmer does not have any information on how many bunches and which oil palm tree will be harvested. By introducing 360^o view imaging model for bunch identification, number of Fresh Fruit Bunch (FFB) can be identified in a certain plantation area. Black bunch census was done manually to estimate yield. This can be improved by video acquisition using a high-resolution 360^o camera integrated with an image processing software for video image processing to get a 360^o view of each tree. Based from the standard planting pattern, it is a time consuming process to circle each tree to acquire the 360^o view of each tree. In order to overcome this, a new method of data collection was established with the execution of All-Terrain Vehicle (ATV) between rows in the plantation area for video acquisition. The video recorded was processed in a software in order to construct a 360^o view of each oil palm tree for further FFB identification process could be done. Image extraction was done using the processing software by referring the data from range sensor installed at the ATV throughout the data collection process in the oil palm plantation. After useful image were extracted, MATLAB software was programmed to process all the selected images for the detection of FFB of each tree. Image pre-processing was conducted where errors in the image were corrected to detect the oil palm bunches. In order to present an appropriate format of image processing system, the RGB images were converted into grayscale images. Image segmentation was done based on a threshold value of L*a*b* to separate between canopy and trunk, fruit bunches and background image. The features were extracted from each pixel of the RGB image. As a result, a new method

for video acquisition is established as well as a processing method for bunch counting for large scale plantation area.

In this research, mean value for L*a*b* color space was determined by using 90 images samples for image threshold in order to identify the FFB on tree crown. Using L*a*b* color space, image was threshold to identify black and both red and black FFB. In this research, image verification was done by using the mean L*a*b* value for black bunch identification. Model threshold verification for 48 samples of images resulted with Coefficient of Determination, R^2 of 0.8029 to identify black bunch on each tree crown. The outcome for this research will help to fully automate the process for bunch identification in the future.

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

PEMBANGUNAN MODEL IMEJ PANDANGAN 360 DARJAH UNTUK MENGENALPASTI TANDAN KELAPA SAWIT MENGGUNAKAN RUANG WARNA L*a*b*

Oleh

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Industri kelapa sawit terkenal sebagai industri pertanian yang signifikan dari segi faedah ekonomi bagi beberapa negara tropika, terutamanya di Malaysia (Yoshizaki et al., 2013). Penuaian kelapa sawit dengan pada masa yang sesuai adalah satu elemen penting; terutamanya jumlah tandan di setiap pokok. Dalam setiap kitaran operasi penuaian, petani tidak mempunyai maklumat tentang bilangan tandan dan pokok kelapa sawit yang akan dituai. Dengan memperkenalkan teknologi baru ini, bilangan Tandan Buah Segar (FFB) boleh dikenalpasti di kawasan perladangan tertentu. Banci buah hitam dilakukan secara manual untuk menganggar hasil. Ini boleh diperbaiki dengan pemerolehan video menggunakan kamera 360° beresolusi tinggi yang dilengkapi dengan perisian pemprosesan imej untuk memproses imej dan video untuk mendapatkan pandangan keliling bagi setiap pokok. Berdasarkan corak penanaman piawai, masa yang diambil untuk mengelilingi setiap pokok untuk memperoleh pandangan 360º setiap pokok agak lama. Untuk mengatasinya, satu kaedah baru diperkenalkan dengan penggunaan ATV di antara baris pokok kelapa sawit di dalam ladang untuk pengambilan video. Video yang dirakam akan diproses dalam perisian untuk mendapatkan pandangan sudut 360º bagi setiap pokok kelapa sawit untuk proses pengenalpastian FFB selanjutnya. Pengekstrakan imej akan dilakukan menggunakan perisian pemprosesan dengan merujuk pada data yang diperolehi daripada sensor jarak yang dipasang di ATV sepanjang proses pengumpulan data di ladang kelapa sawit. Selepas imej berjaya diekstrak, perisian yang diprogramkan akan memproses semua imej yang dipilih untuk mengesan imej setiap tandan pada pokok. Pemprosesan imej dijalankan menggunakan proses penapisan imej untuk mengesan tandan kelapa sawit. Untuk mempersembahkan sistem memperoleh imej yang bagus, imej RGB ditukar menjadi imej skala kelabu. Segmentasi imej dilakukan berdasarkan nilai penapisan untuk memisahkan antara kanopi dan batang, tandan buah dan latar belakang. Ciri-ciri itu diekstrak dari setiap piksel imej

RGB. Sebagai hasil, kaedah baru untuk pengambilalihan video ditubuhkan serta kaedah pemprosesan untuk mengira bilangan tandan untuk kawasan ladang berskala besar mampu dikecapi.

Dalam kajian ini, nilai purata bagi kumpulan warna L*a*b* telah dikenalpasti untuk menapis imej untuk pengiraan FFB pada pokok. Dengan menggunakan kumpulan warna L*a*b*, imej boleh menjadi ditapis untuk mengenal pasti tandan hitam mahupun tandan merah dan hitam padan pokok. Dalam kajian ini, pengesahan imej telah dilakukan dengan menggunakan nilai purata untuk mengenalpasti tandan hitam. Pengesahan penapisan model untuk 48 sampel imej menghasilkan Regression (R^2) bernilai 0.8029 untuk mengenal pasti tandan hitam pada setiap pokok. Melalui hasil penyelidikan ini dapat membantu untuk mengotomatisasi sepenuhnya proses untuk mengenal pasti kumpulan tandan pada masa akan datang.

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

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TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

UPM	Universiti Putra Malaysia
ATV	All-Terrain Vehicle
FFB	Fresh Fruit Bunch
R^2	Coefficient of Determination
FELDA	Federal Land and Development Authority
DOF	Degrees of Freedom
3D	Three-dimensional
CMOS	Metal Oxide Semiconductor
CCD	Charge-coupled Device
ARD	Agricultural and Rural Development
2D	Two-dimensional
POV	Point of View
IDE	Integrated Development Environment
ROI	Region of Interest
GUI	Graphical User Interface

CHAPTER 1

INTRODUCTION

1.1 Overview

Agricultural expansion is one of the leading causes of deforestation in the tropics and in Southeast Asia was driven by large-scale production for international trade. Peninsular Malaysia has wide history of plantation agriculture which has been a predominantly resource-based economy where expanding plantations such as oil palm continue to replace natural forests (Shevade et al., 2019). According to Corley et al. (2009), by 2050 oil palm demand will probably reach 240Mt. In order to fulfill such demand an improved field management system need to be considered especially in harvesting operation. In every cycle of harvesting operation, farmer does not have any information on how many bunches and which oil palm tree will be harvested. By implementing 360^{o} view imaging technology, farmer or plantation manager can use this information to manage their workers, machines and other agricultural recourses. Rapid and efficient decision-making process is one of the important aspects that need to be considered for effective and well-organized data collection for big scale plantation area. In order to achieve this target, the exact number of bunches of each tree need to be identified. FFB weight and total number of bunches are two major parameters used to estimate the salary of harvester in oil palm estates. Worker's salary per harvested bunch and total count of bunches can be easily projected in advance and yield for every harvesting cycle could easily be calculated. New trend of agricultural practices and agricultural consumer demand requires early information on yield and quality of the agricultural product. Availability of this information enables effective field management.

Kassim et al. (2009) developed a color imaging models to determine maturity stages of FFB. By color imaging technique, the date of harvesting could be estimated. With a systematic data of harvesting schedule, FFB yield also can be forecasted as well as the performance of oil palm tree, which also enable additional feature in producing the harvesting map to support the operation of site-specific harvesting. Black bunch census technique could not be implemented in plantation scale since the operation of image data collection was time consuming and tedious process due to the height of the oil palm tree and position of the oil palm bunches. In this research, rapid imaging system will be explored in order to overcome the problems and to develop 360^{o} imaging system. Thus, this system also aims to collect comprehensive data of oil palm tree focusing in the application of big scale oil palm plantation area. This project focusing on the developing 360^{o} vision system to identify the figure of FFB on each palm oil tree. Plantation management can estimate the yield production of the FFB. A 360^{o} camera view of oil palm tree will be captured to obtain a best image for better analysis and interpretation of the FFB for each tree.

1.2 Problem Statement

Current technologies to determine the number of FFB on tree crown requires a long period of time where farmers need to approach each tree in order to have a clear view of FFB located at each tree crown. Some of the tree in the oil palm plantation area grows in different height, which depends on the age of the tree itself thus it does affect in the aspect of ergonomically for the data collection. Jayaselan et al. (2012) stated that machine automation technology is an alternative to optimize the number of workers as well as to provide comfortable ergonomic working condition. Nawi et al. (2013) conducted a study for the evaluation of working posture during harvesting oil palm fresh fruit bunches. In addition, he stated that ergonomics plays an important role to improve occupational health and work productivity in most industries in Malaysia including agriculture. However, most of the workers in Malaysia especially in oil palm plantation failed to emphasize regarding ergonomics awareness as priority for their safety and health by still using manual tools and consequently exposed to ergonomics risk factors. This operation is tedious and requires plantation manager to hire workers to count FFB manually on the tree crown especially in large plantation scale. Systematic information about number of bunches on each tree will be useful to perform precise oil palm harvesting operation. In addition, due to the high oil palm tree in the palm oil plantation, it is hard for farmers to have a clear view of the FFB to identify the number of FFB on each tree. Thus, the data may not be accurate due to unclear view of the FFB on the tree. With the 360^o view of the FFB, it is possible for farmers to get a clear and closer view of the bunch. By introducing the 360^o view imaging technique, a large plantation area will not be a problem for the process of data collection. Other problem found is the sorting and storing data for each oil palm tree where nowadays, data are collected manually in field. With the 360^o view imaging technique, a large data collection can be stored in a controlled manner. Data sorting of attributes for each oil palm tree can be easily retrieve from the database in the software.

1.3 Objectives

The main objective of this project is to develop a 360^o view imaging model for the identification of FFB in oil palm plantation area. In order to develop a 360^o view imaging model for FFB identification, the following objectives were carried out in this research:

1. To develop 360^o view imaging system using 360^o camera for data acquisition in oil palm plantation area.

2. To develop image processing model using L*a*b* color space for bunch identification.

3. To verify model using mean value of L*a*b* color space generated from analysis of images.

1.4 Research Scope and Limitations

1. This study focuses on the development of 360^{o} view imaging model for the identification of oil Palm (*Elaeis Guineensis*) FFB in oil palm plantation area located in Universiti Putra Malaysia (UPM).

2. This study includes the determination of moving pattern on Polaris Sportsman 550HP ATV as a mover to acquire data in form of video to acquire FFB data in plantation environment. Image and range data extraction was done using MATLAB 9.4 version R2018a (2018) software. The range data was acquired by using HC-SR04 Ultrasonic (US) range sensor during the video recording in the oil palm plantation area.

3. L*a*b* color space was selected as features to develop the model. The selected mean threshold value of L*a*b* was used in the process of FFB identification and unwanted background removal.

4. This project is up to the identification of FFB on tree crown based on the final mean threshold value of L*a*b* (result from item 3) and verification of the developed model in oil palm plantation environment.

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