UNIVERSITI PUTRA MALAYSIA

SEMI-AUTOMATED ROBOTIC ARM FOR OIL PALM FRESH FRUIT BUNCH HARVESTER

HELENA ANUSIA JAMES JAYASELAN

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BY

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in fulfiment of the Requirement for the Degree of Masters of Science

June 2011

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Abstract of Thesis presented to the Senate of Universiti Putra Malaysia in Fulfillment of the Requirement for Degree of Masters of Science

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June 2011

Chairman: Wan Ishak Wan Ismail, PhD

Faculty: Faculty of Engineering

Over the years, as the oil palm plantation grows bigger, more labourers are required to handle all the work. Over time, labor cost has increased so much that most operations in the field has to be mechanized. Mechanization is commonly recognized as a means of solving increasingly acute shortage of labor in the plantation sector. Mechanized harvesting was attempted with major achievement in the area of mechanized in-field FFB (fresh fruit bunch) collection namely the Mechanical Buffalo, Compact Transporter, and Crabbie.

The existing mechanized oil palm harvester located at Malaysian Palm Oil Board (MPOB) Bangi Lama, is inefficient in harvesting fresh fruit bunch. Based on the experiment performed before the automation process, the operator of the harvester takes a long time (3-5minutes) just to adjust the position of the cutter and grabber to perform the harvesting process, compared to a worker

who manages to harvest a tree in just a few seconds. Not only was the operation taking a long time, but the operator experiences neck aches and body pain after operating on only one tree. So, the ergonomic of the operator was also an issue here. As a solution to the inefficiency of the harvester, automation of the harvester was carried out. The novelty of this research is to transfer the image of FFB to the Denavit & Hartenberg (D-H) model in determining the position of the FFB to be harvested.

The D-H model is a simple way to portray robot links and joints and was used for the harvester configuration. Kinematic analysis was calculated based on the D-H configuration for the position and orientation of harvester arm, where position of harvester can be calculated instantly when all joint variables were known. Consequently, in order to place the harvester arm in a desired location, the amount of each joint movement was calculated through the inverse kinematic analysis. This was possible with the information of the position of the harvester arm with the help of High Resolution Webcam.

The webcam feeds the desired position coordinates in the form of pixel which was later converted into meters and was used for the inverse kinematics calculation to obtain the desired angle for the harvester arm movement. The image location and calculations were carried out through Matlab with help of the operator to click on the desired position on the screen. The webcam provides the x and y axes while the ultrasonic sensor provides the z axis measurements. Once the calculations were completed, information for each hydraulic cylinder was transferred to the Programmable Integrated Controller (PIC) controller to be sent to the respective manipulator's hydraulic cylinder. The PIC was suffixed on to a PIC Circuit Board (PCB) with corresponding relays where two relays were assigned to control one solenoid valve. Thus the cylinders move from their home position to the desired position and clamps on the FFB. Then,

the operator will cut the FFB manually using the lever since the cutting system is not efficient to be controlled automatically.

This study benefits the oil palm industry by increasing the efficiency of the harvesting process by introducing automation of the oil palm harvester manipulator. By automating the harvester, the work cycle time of harvesting process was reduced, thus indirectly improving the productivity of oil palm harvesting process. The semi-automated harvester was proven to move its arm around 60 to 70 percent faster compared to the mechanical harvester. A successful design, PCB fabrication, testing and implementation of concept of camera vision operation system for FFB harvester with a fully develop a graphical user interface (GUI) for outdoor agricultural activities was achieved.

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

SEMI-PENGAUTOMATAN LENGAN ROBOTIC BAGI PENUAI BUAH KELAPA SAWIT SEGAR

Oleh

HELENA ANUSIA JAMES JAYASELAN

Jun 2011

Pengerusi : **Wan Ishak Wan Ismail, Phd**

Fakulti : **Fakulti Kejuruteraan**

Peredaran masa membawa kepada perluasan pertanian kelapa sawit dimana lebih ramai pekerja buruh diperlukan tetapi ini juga menyebabkan kenaikan kos buruh yang mengakibatkan penggunaan mekanisasi bagi kebanyakkan operasi di ladang. Jentera biasanya digunakan sebagai penyelesaian masalah kekurangan buruh dan bagi operasi ladang yang memerlukan tenaga buruh yang intensif. Walaupun penggunaan jentera bagi penuaian buah sawit gagal diaplikasikan, jentera digunakan dengan meluas bagi pemungutan buah sawit dalam ladang termasuk penggunaan ‘Mechanical Buffalo’, ‘Compact Transporter’ dan ‘Crabbie’.

Jentera penuaian yang sedia ada dikatakan tidak berjaya kerana kurang berkesan bagi menuai buah kelapa sawit. Ini disebabkan masalah yang dihadapi bagi meletakkan mata pemotong penuai pada tandan buah sawit semasa menuai. Melalui eksperimen yang dijalankan, dapati pengemudi jentera mengambil masa yang lama (3-5minit) bagi meletakkan pemotong di lokasi yang dikehendaki berbanding pekerja buruh yang berkemampuan memotong buah sawit dalam

beberapa saat. Bukan sahahja masa yang diambil oleh operator terlalu lama, malah dia juga mengalami kesakitan leher dan badan sejurus selepas menuai hanya satu pokok sawit. Oleh sebab demikian, agronomi operaor turut menjadi isu tambahan kepada ketidakberkesanan jentera penuai. Ini boleh diselesaikan dengan aplikasi pengautomatan yang telah dijalankan.

Model perwakilan 'Denavit & Hartenberg' (D-H) adalah cara mudah bagi mewaliki robot dan telah digunakan sebagai permulaan proses pengautomatan bagi mempersembahkan sendi dan penyambung jentera penuai. Cara perletakkan dan orientasi tangan (boom) penuai dikira menggunakan configurasi D-H untuk menjalankan analisis kinematiknya, dimana posisi tangan akan diketahui apabila semua sudut sendi telah didapati. Kemudiannya, bagi meletakkan tangan pada posisi yang dikehendaki, analisis kinematik berbalik digunakan bagi mendapatkan sudut pergerakkan bagi setiap sendi. Perkara ini adalah mungkin dengan pengetahuan cordinat posisi yang dikehendaki melalui 'Webcam' beresolusi tinggi.

Kamera tersebut memberikan infomasi berkenaan cordinat posisi buah sawit yang dikehendaki yang kemudiannya ditukarkan kepada unit meter dan digunakan bagi analisis kinematik berbalik untuk mendapatkan sudut pergerakkan tangan penuai. Imej berkenaan posisi buah dan pengiraan dijalankan menggunakan Matlab dengan bantuan operator untuk klik pada skrin, bahagian yang akan dipotong. 'Webcam' tersebut memberikan nilai ukuran paksi x dan y manakala alat 'ultrasonic sensor' memberikan ukuran paksi z. Apabila pengiraan ditamatkan, informasi bagi setiap silinder akan dihantar ke unit pengawal, PIC (Programmable Integrated Circuit) yang menyampaikannya kepada silinder hidraulik masing-masing. Maka, setiap silinder akan bergerak dari posisi rehat(rumah) ke posisi yang dikehendaki dan menyepit buah sawit. Seterusnya, operator akan memotong buah sawit secara manual kerana pisau pemotong yang sedia ada tidak efisian bagi system pengautomatan.

Projek ini membawa kebaikan kepada industri pertanian kelapa sawit dengan aplikasi pengautomatan yang dapat mengurangkan masa penuaian buah sawit dan meningkatkan produktiviti penuaian buah kelapa sawit. Jentera penuai semi-automatik telah berjaya membuktikan pengurangan masa penuaian sebanyak lebih kurang 30 peratus berbanding penuai mekanikal. Perekaan, pembuatan, penilaian dan pengaplikasian konsep operasi sistem visi kamera dengan Perhubungan Pengguna Bergrafik (GUI) bagi aktiviti pertanian telah berjaya dijalankan.

ACKNOWLEDGEMENT

I wish to express my profound appreciation and sincere gratitude to the chairman of the supervisory committee, Professor Ir. Dr. Wan Ishak Wan Ismail for his kind assistance, support, advice and encouragement throughout my work and preparation of this thesis. And to Universiti Putra Malaysia for their financial assistance, Graduate Fellowship Fund(GRF) during my studies.

Furthermore, I would like to take this opportunity to forward my deepest appreciation and gratitude to the supervisory committee members Professor.Ir.Dr.Desa Ahmad and Dr. Samsuzana Abd Aziz for their helpful advice. I am also grateful to Phd students Mr. Mohammad Saufi and Mr.Mohd Hudzari Razali as well as the Automation Lab technician Mr. Zakaria for their fruitful discussions and constant encouragement.

A particular note of thanks is also given to the Research Officer, Mr. Rahim Shuib and also to the technician, Mr. Nordin at Malaysian Palm Oil Board (MPOB), for their assistance to perform this work. My gratitude goes to Mr. Aminuddin Shah Siraj from Maalif.Sdn.Bhd and technicians Mr. Mohd Irfan Othman and Mr. Azizul Sufian Suri for their cooperation.

Thanks and acknowledgments are meaningless if not extended to my parents, Mr. and Mrs. James Jayaselan, who deserve my deepest appreciation. I am grateful for countless sacrifice they made to ensure I could pursue my Masters, and always being there for me.

Lastly but not least, a very special thanks to all who have taught me in the duration of this project, especially my sisters; Katherine Kalaivani and Linda Santhi, friends; Urmil Shah, Angeline Ho Mei Yi, Muhammad Ridzuan Mohamed Nazir, Mohd Razi, Stephen Spencer and relatives for their love, support and encouragements.

APPROVAL

I certify that a Thesis Examination Committee has met on 24th June 2011 to conduct the final examination of Helena Anusia James Jayaselan on her thesis entitled "SEMI-AUTOMATED ROBOTIC ARM FOR OIL PALM FRESH FRUIT BUNCH HARVESTER" 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 Degree of Masters of Science in Biological and Agricultural Engineering.
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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement of the degree of Masters of Science in Biological and Agricultural Engineering. The members of the Supervisory Committee were as follows:

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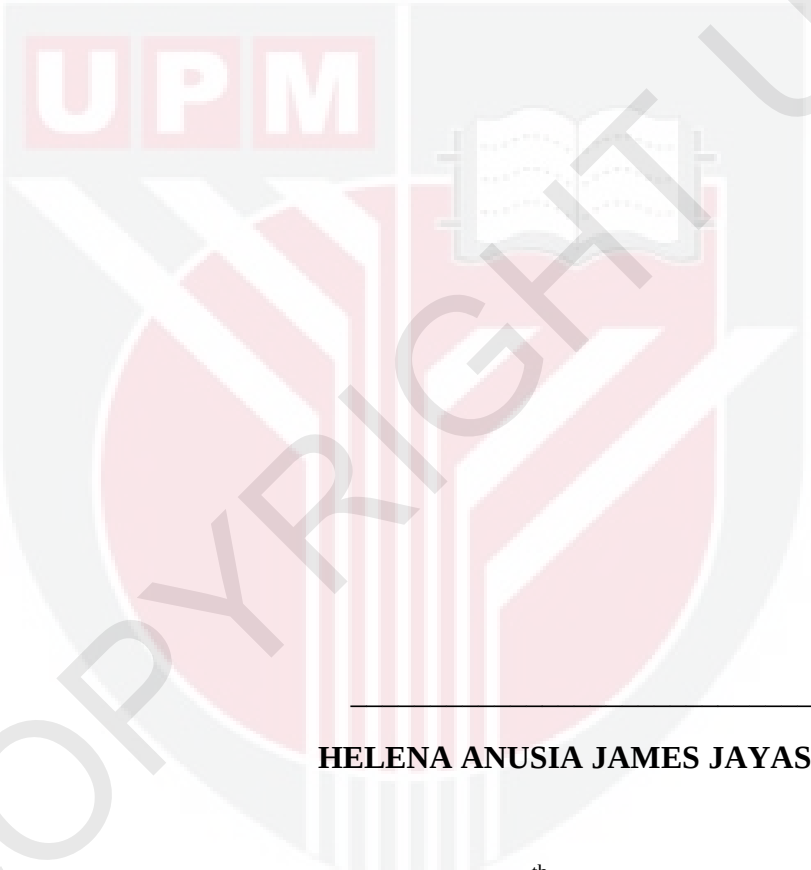
DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or any other institution.



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HELENA ANUSIA JAMES JAYASELAN

Date: 24th June 2011