UNIVERSITI PUTRA MALAYSIA

RIPENESS DETECTION OF OIL PALM FRESH FRUIT BUNCHES USING FLUORESCENCE 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

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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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Chairman: Abdul Rashid Mohamed Shariff, PhD

Faculty: Engineering

Classification of oil palm fresh fruit bunches (FFB) into its correct ripeness category (under-ripe, ripe and over-ripe) is a critical factor that dictates efficient oil palm milling operations. This study investigates the fluorescence sensor to determine which excitation LEDs are suitable in discriminating between the different ripeness categories.

To determine this, we used a Multiplex®3 sensor, which has an active fluorescence sensor system; comprising of 9 excitation LED (6 UV and 3 RGB for red, green and blue excitations) and 3 photodiodes for the emitted fluorescence in the yellow (590 nm), red (685 nm) and far red ranges (735 nm), to detect oil palm FFB ripeness categories. The in-field signal value data were collected using the sensor system from a total of one hundred and eighty (180) oil palm FFB. These oil palms FFB were classified into under-ripe, ripe, and over-ripe ripeness categories.

Feature selection method, the rank method based on chi-square value was used to select the best predictors among available features. Fourteen classification methods (SPSS Classification Tree^{TM} (QUEST, CHAID, and CRT), SPSS Discriminant Analysis (Enter independent together), STATISTICA Stochastic Gradient Boosting Trees, STATISTICA Interactive Tree (C&RT), STATISTICA MARSplines, STATISTICA General Stepwise Linear Discriminant Analysis, STATISTICA Automated Neural Networks Classification, STATISTICA Random Forest For Classification, Machine Learning (Support Vectors Machine, Naïve Bayes Classifier and k-Nearest Neighbour)), were used to assess the applicability of using the sensor system. Based on the classification accuracies, data analysis on the predictors indicated that the signal values of the data could be valuable in predicting the maturity stage of the oil palm FFB. The STATISTICA Stochastic Gradient Boosting Trees yielded highest average overall accuracies of 89.4% for the correct classification of oil palm FFB using the blue to red fluorescence ratio (BRR_FRF) as a predictor. Additionally, the average individual classes (under-ripe, ripe and over-ripe) classification accuracies were also higher than 76%. Thus, fluorescence sensing using the blue to red fluorescence ratio (BRR_FRF) as a predictor is useful for oil palm FFB ripeness detection under field conditions. This research will be useful for future development of low cost non-destructive, automatic and real time oil palm FFB grading system.

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

PENGESAN KEMASAKAN TANDAN BUAH KELAPA SAWIT MENGGUNAKAN PENDERIA FLUORESCENSE

Oleh

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Pengkelasan tandan kelapa sawit segar kepada kategori kemasakan (mengkal, masak terlebih masak) yang betul merupakan faktor kritikal bagi menentukan tahap kecekapan operasi kilang pemprosesan kelapa sawit. Penyelidikan ini mengkaji pengesan fluorescense untuk menentukan ujaan LED yang manakah paling sesuai untuk membezakan kategori kemasakan.

Bagi menentukan kategori kemasakan tandan kelapa sawit segar, kami menggunakan pengesan Multiplex®3, iaitu pengesan fluorescense aktif; terdiri daripada 9 ujaan LED (6 UV dan 3 RGB untuk ujaan merah, hijau dan biru) dan 3 fotodiod untuk pemancar optik di dalam julat kuning (590 nm), merah (685 nm) dan infra-merah (735 nm). Data bacaan isyarat di buat di lapangan dan dikumpulkan dari seratus lapan puluh (180) tandan kelapa sawit segar menggunakan sistem pengesan. Tandan kelapa sawit segar ini dikelaskan kepada mengkal, masak dan terlebih masak.

Kaedah pemilihan ciri digunakan untuk memilih peramal terbaik dikalangan ciri-ciri yang sedia ada. Empat belas pengelas *(SPSS Classification Tree™ (QUEST, CHAID, CRT), SPSS Discriminant Analysis (Enter independent together), STATISTICA Stochastic Gradient Boosting Trees, STATISTICA Interactive Tree (C&RT), STATISTICA MARSplines, STATISTICA General Stepwise Linear Discriminant Analysis, STATISTICA Automated Neural Networks classification, STATISTICA Random Forest For Classification, Machine Learning (Support Vectors Machine, Naïve Bayes Classifier, k-Nearest Neighbour))* digunakan untuk mentaksir keberkesanan sistem pengesan. Berdasarkan ketepatan penkelasan, analisis data terhadap peramal menunjukkan bacaan isyarat daripada data tersebut boleh digunapakai dalam menentukan tahap kemasakan tandan kelapa sawit segar. *STATISTICA Stochastic Gradient Boosting Trees* memberikan hasil purata keseluruhan tertinggi iaitu 89.4% bagi pengkelasan tandan kelapa sawit segar yang betul menggunakan kadar biru kepada merah fluorescense (BRR_FRF) sebagai peramal. Sebagai tambahan, purata kelas individu (mengkal, masak dan terlebih masak) mempunyai ketepatan pengkelasan yang tinggi iaitu melebihi 76%. Oleh yang demikian, pengesan fluorescense menggunakan kadar biru kepada merah fluorescense (BRR_FRF) sebagai peramal sangat berguna dalam menentukan tahap kemasakan tandan kelapa sawit di lapangan. Penyelidikan ini amat berguna dan membuka tapak di masa hadapan dalam membangunkan sistem penggredan tandan kelapa sawit yang murah, tidak merosakkan buah kelapa sawit, automatik dan memberi keputusan serta-merta.

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I certify that a Thesis Examination Committee has met on 24th November 2011 to conduct the final examination of Mohd Hafiz Bin Mohd Hazir on his thesis entitled "Ripeness Detection of Oil Palm Fresh Fruit Bunches Using Fluorescence 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 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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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 other institutions.

MOHD HAFIZ BIN MOHD HAZIR

Date: 24 November 2011

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