Feasibility Study of Utilising Electronic Nose to Detect BSR Disease in Oil Palm Plantation

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Feasibility Study of Utilising Electronic Nose to Detect BSR Disease in Oil Palm Plantation

by

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LIST OF ABBREVIATIONS

2D	=	2 Dimensions
3D	=	3 Dimensions
ADC	=	Analog to Digital Converter
ANN	=	Artificial Neural Networks
BP	=	Backpropagation
BSR	=	Basal Stem Rots
C-320	=	Cyranose 320
CA	=	Cluster Analysia
CAD	=	Computer-aided Design
CDA	=	Canonical Discriminant Analysis
CNS	=	Central Nervous System
COM	=	Communications Port
CP	=	Conducting Polymer
DAS	=	Dimension Auto-scaling
DC	=	Data Collection
DNA	=	Deoxyribonucleic Acid
EEPROM	=	Electrically Erasable Programmable ROM
ELISA	=	Enzyme Linked Immunosorbant Assay
E-nose	=	Electronic Nose
FELDA	=	Federal Land Development Authority
FIS	=	Fuzzy Interefence System
GC	=	Gas Chromathography
GC-MS	=	Gas Chromathography – Mass Spectrometry

GUI	=	Graphic User Interface
HPLC	=	High-performance Liquid Chromatography
HPTLC	=	High-performance Thin Layer Chromatography
KNN	=	K-nearest Neighbour
LC-MS	=	Liquid Chromatography Mass Spectrometry
LCD	=	Liquid Crystal Display
LDA	=	Linear Discriminant Analysis
MLP	=	Multilayer Perceptron
ml	=	mililitre
MOS	=	Metal Oxide Sensor
MSE	=	Mean of Squared Error
OCM	=	Odour Capturing Module
PARC	=	Pattern Recognition
PC	=	Personal Computer
PC1	=	Principle Component 1
PC2	=	Principle Component 2
PCA	=	Principle Component Analysis
PCB	=	Printed Circuit Board
PCR	=	Polymerase Chain Reaction
PLS	=	Partial Least Squares
POD	=	Proper Orthogonal Decomposition
Ps	=	Power Comsumptions
QCM	=	Quartz Crystal Microbalance
RBF	=	Radial Basis Function
R_L	=	Load Resistor

RS232	=	Recommended Standard 232
rRNA	=	Ribosomal RNA
SAW	=	Surface Acoustic Wave
SOM	=	Self-organising Map
sp.	=	Species
SSE	=	Sum of Squared Error
VAS	=	Vector Auto-scaling
VB	=	Visual Basic
VNORM	=	Vector Normalisation

ABSTRAK

Kajian Kebolehlaksanaan Menggunakan Hidung Elektronik Untuk Mengesan Penyakit BSR di Ladang Kelapa Sawit

Industri pertanian telah lama bergantung kepada kepakaran manusia untuk mengesan penyakit pokok. Walau bagaimanapun, manusia mengambil masa yang lama untuk menjadi seorang pakar, tidak konsisten dan mempunyai kelemahan. Kerja yang dibentangkan ini adalah kerja yang dilakukan menggunakan hidung elektronik menggabungkan kepintaran buatan untuk mengesan penyakit pokok, khususnya, penyakit pangkal batang reput yang diakibatkan oleh *Ganoderma boninense*, sejenis kulat yang mengancam ladang kelapa sawit di Asia Tenggara. Hidung elektronik komersial, Cyranose 320, digunakan sebagai pengesan hadapan manakala rangkaian neural buatan yang dilatih dengan algoritma Levenberg-Marquadt diguna untuk membuat keputusan. Untuk peringkat pertama, satu pembelajaran tentang pengelasan corak terbenam pada Cyranose 320 dan rangkaian neural buatan telah dijalankan menggunakan beberapa jenis bauan. Peringkat ini akhirnya mengenalpasti bahawa ANNs lebih baik dari pengelasan corak terbenam dari segi ketepatan dan ia patut digunakan untuk experimen yang akan datang. Peringkat kedua melibatkan pengesanan kulat *Ganoderma boninense* di dalam makmal dan di ladang kelapa sawit. Peringkat ini membuktikan bahawa bau kulat ini boleh dikesan selepas diuji dengan menggunakan beberapa jenis parameter bau. Peringkat seterusnya ialah untuk mendiskriminasi pokok kelapa sawit yang sihat dengan berpenyakit di dalam ladang. Kerja yang dijalankan telah menunjukkan bahawa penggabungan antara hidung elektronik dengan ANNs mempunyai kebarangkalian-boleh untuk mendiskriminasi pokok berpenyakit di ladang. Hasil kajian ini juga digunakan untuk membangunkan hidung elektronik sendiri untuk kajian asas dan menyediakan hidung elektronik yang berkos rendah. Kesimpulannya, kerja yang menggunakan hidung elektronik and ANNs ini berkeupayaan untuk mengesan dan mendiskriminasi penyakit BSR di dalam makmal dan ladang.

ABSTRACT

Feasibility Study of Utilising Electronic Nose to Detect BSR Disease in Oil Palm Plantation

The agricultural industry has been, for a long time, dependent upon human expertise to detect plant disease. However, human experts may take years of training and can be inconsistent, as well as prone to fatigue. Presented in this thesis is the work conducted on utilising electronic nose incorporating artificial intelligence to detect plant malaise, specifically, basal stem rot (BSR) disease that is caused by Ganoderma boninense, a type of fungi affecting oil palm plantations in South East Asia. A commercial electronic nose, Cyranose 320, was used as the front-end sensors with artificial neural networks trained using Levenberg-Marquardt algorithm employed for decision making. For the first stage, a study on Cyranose 320 embedded pattern recognitions and artificial neural networks (ANNs) was conducted using a few types of essences. This stage confirmed that the ANNs is better than the embedded pattern recognitions in terms of accuracy and hence should be used for the next experiments. The second stage involved the Ganoderma boninense fruiting bodies detection in laboratory and oil palm plantation. This stage proved that the fungi odour can be detected after being tested using a few types of odour parameter. The next stage is to discriminate the healthy and non-healthy oil palm trunk in the plantation. The conducted work indicates that the combination of the electronic nose and ANNs has the ability to discriminate the infected trunk. The findings of the work were also used to develop an in-house low cost electronic nose to support further fundamental study and implementations. As a conclusion, this work confirms that it is feasible to utilise the electronic nose and ANNs to detect and discriminate the BSR disease both in the laboratory and in the plantation.

CHAPTER 1

INTRODUCTION

1.0 Background

Odour is a distinctive smell, a lingering quality or impression (Soanes, C. et al, 2005). It functions to signal pleasure, avoidance, sexual attraction and many others. Odours are also called smells, which can refer to both pleasant and unpleasant odours. The terms fragrance, scent, or aroma are used primarily by the food and cosmetic industry to describe a pleasant odour, and are sometimes used to refer to perfumes. In contrast, stench, reek, and stink are used specifically to describe unpleasant odour.

Odours and volatile compounds have been widely used in a variety of studies. For example, the agricultural industry has been, for a long time, dependent upon human expertise in using odour for classification, grading, differentiating and discriminating different types of produce. The odour was used to determine the stage of fruit ripeness as well as the state of health of crops (Brezman, et. al, 2005; G´omez, et. al, 2006; Keller, et. al, 1995; Marrazzo, 1999; Md Salim, et. al, 2005).

Odour analysis traditionally involves the use of a panel of human sensory analyst (Shafiqul Islam, 2006). The former uses qualitative analysis, where the difference in odours detected, even complex combinations of volatiles, is discriminated by perception and feels based on experience, and not quantitative analysis. The use of human panellists is not, however, without disadvantages. Human panellists are prone to fatigue, inconsistencies as well as costly, in addition to requiring long training periods. Also, the decisions made by human panellists may be subjective, and not suitable for certain types of analyses such as those involving toxic organic molecules.

The second method is to use advance analytical instruments in the laboratories (Shafiqul Islam, 2006). These techniques can give very detailed information about the precise contents of the odour. These classical analytical techniques involve gas chromatography (GC-MS), liquid chromatography mass spectrometry (LC-MS), high-performance liquid chromatography (HPLC), high-performance thin layer chromatography (HPTLC) and etc. Since odour is usually composed of complex mixture of volatiles, such techniques are too cumbersome for practical everyday applications and costly to set-up. Also, many volatile chemicals are of very minute quantity and beyond their detection limit. Moreover, the relationship between the physical and chemical properties of the odourant molecules and their sensory impact is still unclear, in-spite of a number of research efforts.

In addressing these problems and limitations, a device that mimics the mammalian olfactory system commonly referred to as electronic nose (e-nose) has been developed. This device consists of headspace sampling, gas sensor array and pattern recognition modules to generate signal pattern that are used to characterise odours, and achieved through qualitative analysis (Keller, 1995).

To some extent, e-nose provides rapid odour analysis and addresses the issue of subjectivity of the human sensory technique. The applications of these devices are wide ranging, from agricultural applications to solving environmental issues (Brezman, et. al, 2005; G´omez, et. al, 2006; Keller, et. al, 1995; Laszlo, 2005; Marrazzo, 1999; Masila, 1998; Md Salim, et. al, 2005).

The agricultural industry can benefit tremendously from the use of such systems as the e-nose. It provides the flexibility and rapid training of qualitative analysis of a variety of odours. Hence the use of this system may replace traditional methods that are labour intensive, inconsistent, sometimes impractical and time consuming (Md Salim, et. al, 2005). Among the applications of the e-nose for the agricultural industry are to assist product quality monitoring, fruit ripeness determination, inspection of fish as well as other post-harvest activities (Brezman, et. al, 2005; G´omez, et. al, 2006; Keller, et. al, 1995; Marrazzo, 1999; Md Salim, et. al, 2005).

1.1 Problem Statements

The oil palm (*Elaeis guineensis* Jacq.) tree is a leading source of edible vegetable oil production in the world, with production figures of more than 32 million tonnes of oil in 2003 (Adom, A.H. et al, 2007). In Malaysia, the production of palm oil has exceeded that of natural rubber, and its importance has been further boosted by the introduction of bio-diesel (Singh, H. et al, 2006).