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LIST OF ABBREVIATIONS

ISF	International Seed Federation
NASM	National Seed Association of Malaysia
APSA	Asia Pacific Seed Association
NKEAs	National Key Economic Areas
RM	Ringgit Malaysia
MARDI	Malaysian Agricultural Research and Development Institute
SJPM-2009	Paddy Seedlings Verification Scheme and the Malaysia Department of Agriculture Standard
ISTA	International Seed Testing Association
DOA	Department of Agriculture
SDA	Stepwise Discriminant Analysis
DFA	Discriminant Function Analysis
SVM	Support Vector Machine
NN	Neural Network
CCD	Charge Coupled Device
LabVIEW	Laboratory Virtual Instrument Engineering Workbench
GUI	Graphical User Interface
MADA	Muda Agricultural Development Authority
IADA	Integrated Agricultural Development Area
BLS	Barat Laut Selangor
KADA	Kemubu Agricultural Development Authority
KETARA	Northern Terengganu Integrated Agricultural Development Area
LPP	Lembaga Pertubuhan Peladang

FAO	Food and Agriculture Organization of the United Nations
BERNAS	Padiberas Nasional Berhad
USD	United State Dollar
MOA	Ministry of Agriculture
MOF	Ministry of Finance
MS	Malaysian Standard
PPK	Pertubuhan Peladang Kawasan
GLCM	Grey level co-occurrence matrices
PSIRS	Plant Seed Image Recognition System
VI	Virtual Instruments
MATLAB	Matrix Laboratory
BMP	Bit-mapped protocol
RGB	Red, green and blue
ROI	Region of interest
JPEG	Joint Photographic Experts Group
R	Red
G	Green
B	Blue
H	Hue
S	Saturation
I	Intensity
GLCM	Grey level co-occurrence matrices
PCA	Principal Component Analysis
PC	Principal Component
LED	Light Emitting Diode

CPU	Central Processing Unit
PNG	Portable Network Graphics
IMAQ	Image Acquisition
SPSS	Statistical Package for the Social Sciences
SMO	Sequential minimal optimization
QP	Quadratic problem
LS	Least square
RBF	Radial basis function
MLP	Multilayer perceptron
ANOVA	One way analysis of variance
SD	Standard deviation
Min	Minimum
Max	Maximum
DF	Degree of freedom
MSE	Mean square error
SS	Sum of Square
MS	Mean Square
RiSe IViS	Rice Seed Identification Vision System

LIST OF SYMBOLS

$	Dollar
%	Percent
°C	Degree Celsius
Δ	Delta
θ	Angle
μ	Mean
σ	Standard deviation
/	Per
C	Regularization parameter
E	Exponent
=	Equal
+	Plus
-	Minus or Negative
kg	Kilogram
ha	Hectare
mt	Metric Tonne
mm	Millimeter
CO_2	Carbon Dioxide
ppm	Parts per million
m^2	Meter square
cm	Centimeter
d	Displacement
m	Meter

min	Minute
K	Kelvin
t	Tonne

Identifikasi Biji Benih Padi MR 263 yang Ditanam dan Varian Padi Angin Menggunakan Sistem Penglihatan Mesin Berasaskan Kamera CCD

ABSTRAK

Tujuan utama kajian ini adalah untuk membangunkan sistem prototaip identifikasi benih padi untuk mengelas benih padi yang ditanam dan varian padi angin menggunakan sistem visi mesin dengan mengekstrak maklumat ciri morfologi, warna dan tekstur benih padi. Lima jenis sampel varian padi angin yang terdiri daripada tangkai terbuka, tangkai tertutup dan jejanggut telah dikumpul dari beberapa ladang komersil di Kedah. Benih padi MR 263 pula diperoleh daripada beg benih padi komersil daripada pengedar tempatan. Dalam kajian ini, sampel benih terdiri daripada 600 biji benih MR 263 dan 600 biji benih varian padi angin. Imej biji benih padi diperoleh menggunakan sebuah peranti digandingkan caj (CCD) kamera berwarna. Perisian *Laboratory Virtual Instrument Engineering Workbench* (LabVIEW) digunakan untuk memprogramkan pemprosesan imej, pengekstrakkan ciri dan analisis mengelas. Terdapat 12 ciri morfologi, 6 warna dan 5 tekstur telah di ekstrak daripada imej biji benih. 4 jenis model pengelasan yang dinamakan model morfologi, warna, tekstur dan morfologi-warna-tekstur telah ditubuhkan berdasarkan data yang telah diekstrak. Setiap model telah dianalisis untuk pemilihan ciri menggunakan SDA untuk membangunkan model ciri yang dioptimumkan. Kemudian, model-model ciri yang asal dan yang dioptimumkan telah dianalisis menggunakan 3 pengelas yang berbeza; analisis fungsi pembezaan (DFA), mesin sokongan vektor (SVM) dan rangkain saraf (NN). Analisis varians (ANOVA) telah dijalankan keatas ketiga-tiga pengelas untuk menilai min tahap ketepatan pengelasan 8 model ciri yang diekstrak. ANOVA menunjukkan tiada perbezaan ketara bagi min ketepatan pengelasan antara ketiga-tiga pengelas. Hasil pengelasan menggunakan ciri model morfologi-warna-tekstur mendapat tahap ketepatan mengelas yang lebih tinggi berbanding model-model ciri tunggal. Sebuah sistem identifikasi telah dibangunkan menggunakan LabVIEW untuk mengklasifikasi biji benih padi MR 263 dan padi angin menggunakan model ciri yang dioptimumkan bagi morfologi-warna-tekstur dalam DFA. Sistem yang dibangunkan itu dapat mengklasifikasi kedua-dua kumpulan biji benih pada tahap 99.4% dengan menggunakan set data ujian.

Identification of Cultivated Rice MR 263 Seed and Weedy Rice Seed Variants using CCD Camera-based Machine Vision System

ABSTRACT

The main purpose of this study was to develop rice seed identification research prototype system to classify cultivated rice and weedy rice seeds variants using machine vision system through the extraction of morphological, colour, and textural features of the seeds. Five different types of weedy rice seeds variants samples of open panicle, close panicle and awn type were collected from several commercial farms in Kedah. The MR 263 seed was obtained from a commercial rice seed bag from a local supplier. In this study, seed samples were consisted of 600 seeds of MR 263 and 600 seeds from weedy rice seed variants group. Images of the rice seed samples were acquired using a charge coupled device (CCD) colour camera. Laboratory Virtual Instrument Engineering Workbench (LabVIEW) development environment was used to program the image processing, features extraction and the classification analysis. There was 12 morphological, 6 colour and 5 textural features were extracted from the seed images. Four types of classification model namely morphology, colour, texture and morphology-colour-texture models were established based on the extracted data. Each of the models was analyzed for feature selection using stepwise discriminant analysis (SDA) to develop the optimized features model. Then, the original and optimized features models were analyzed using 3 classifiers; discriminant function analysis (DFA), support vector machine (SVM) and neural network (NN). Analysis of variance (ANOVA) was conducted on the 3 classifiers to evaluate the mean classification accuracy levels of the 8 extracted features models developed. The ANOVA showed that there is no significant difference of mean classification accuracies between the 3 classifiers. The classification results using morphology-colour-texture features model was found to obtain higher classification accuracy levels as compared to the single feature models. An identification system was developed in the LabVIEW to classify the cultivated rice MR 263 and weedy rice seed groups using optimized features of the morphology-colour-texture model in DFA. The developed system was able to classify both seed groups at 99.4% accuracy level using testing data set.

CHAPTER 1

BACKGROUND OF STUDY

1.1 Research Justification

Rice is one of the world's most important staple foods, being served to about half of the world's population. In Southeast Asia, the predominant rice consumers, 80% of the population eats rice in their everyday meal. Throughout maintaining rice production at the highest level is not only an issue of food availability but also of security.

In rice cultivation, the productivity depends on a number of factors such as the quality of seeds or planting materials, labour, fertilizer, irrigation, crop protection and cultivation practices, climate and others. However, the primary and essential starting point in any agricultural production is the seed (Mahmood, 2006). To a certain extent, the country's food security can be directly linked to the strength of its seed industry. Current technology in the seed industry value chain including processing must be developed and implemented to achieve high productivity of seed production as well as its quality. Therefore, the country's advancement in seed industry must be parallel with other international seed industry.

According to the International Seed Federation (ISF), an association that facilitates the international movement of seeds, the commercial world seed market is

estimated to be worth $45 billion for the year 2012. In Malaysia, the National Seed Association of Malaysia (NSAM) is an official forum for producers, exporters, importers, scientists and extension agents to interact in current matters related to the seed industry. NSAM is a member of Asia Pacific Seed Association (APSA); the largest regional seed association in the world representing the Asia and Pacific regions. Such an affiliation is important to the advancement of national seed industry so as to be paralleled with the international seed industry.

The development of seed industry is of significantly importance to Malaysia's progress towards achieving a developed nation status by 2020 that the National Key Economic Areas (NKEAs) policy under the Agriculture Sub-sector is the Seed Industry Development Program. The seed industry is expected to contribute about Ringgit Malaysia (RM) 467 million to the country's gross national income (Bernama, 2011). The strategies to develop seed industry to support NKEAs is also featured National Agro-food Policy (2011-2020) document recently released.

In Malaysia, more than 60% of paddy seed supply comes from the private companies (*Berita Harian*, 2013). The annual paddy seeds requirement in paddy cultivation is estimated to be about 60,000 t/year; 53,000 t are produced locally leaving a deficit of 7,000 t (Izham et al., 2003). In 2013, the government allocated RM2.2 billion in subsidies and incentive to increase paddy seed and rice production as well as to reduce production cost. The incentives allocated (RM35 million) also included the production of 80,000 t of high quality certified paddy seed each year. The sole production and distribution of breeder and foundation seeds (250 - 300 t/year) to the

certified seed producers is carried out by the Malaysian Agricultural Research and Development Institute (MARDI).

The production of the seed in Malaysia is regulated under Paddy Seedlings Verification Scheme and the Malaysia Department of Agriculture Standard (SJPM-2009) to ensure seed uniformity in term of production procedure and standard. Seed testing procedure is carried out by following the standard procedure of International Seed Testing Association (ISTA).

In the rice field, weedy rice (*Oryza sativa* complex) is a serious threat to direct seeded culture especially in Malaysia because of its taxonomic and physiological similarities to cultivated rice (Azmi et al., 2012). It is reported that the main sources of weedy rice infestation are caused by rice seeds contaminated with weed seeds and weedy rice seed bank in soil (Labrada, 2002).

Weedy rice is difficult to control by the conventional herbicides because of the close genetic relationship to the commercially grown rice varieties and the similarity in morphological characteristics make it more difficult to control compared to other weeds in the field. A heavy infestation of weedy rice can contribute in lodging of weedy rice plants and it can potentially cause total yield loss under tropical climatic conditions (Azmi et al., 2012). Thus, it is very important to avoid weedy rice contamination in certified seeds bags produced by the local processors to reduce weedy rice infestation in the field to avoid yield loss and cost for weeds control.

The current process used by the seed producers to separate weedy rice seeds from certified rice seeds before retail packaging for farmers is entirely rely on the