UNIVERSITI PUTRA MALAYSIA

AGARWOOD CHIP GRADING BASED ON COLOR USING IMAGE PROCESSING AND ARTIFICIALINTELLIGENCE METHODS

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By

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Agarwood is the primary material especially in perfume industry. If agarwood with different grades are mixed, the quality will decrease and hence the products prices and quality will decrease. During the grading stages, human knowledge and experience is critically used in decision making. However, human characteristics often tender to fatigue where lead to produce misclassification. The price of agarwood is influenced by the resin content which can be indicated by the colour. The highest grade of agarwood chips has a shining black colour while the lower grade of agarwood chips has a black colour that is alternating with the brown colour. This study was conducted to determine the relationship of agarwoodcolour properties and its related price by adopting the method of artificial intelligence and image processing. Colouragarwood images in Red, Green, Blue, (RGB), Hue, Saturation, Intensity (HIS) and CIE colorimetric space (CIELAB) has been evaluated by comparing the performance of colour pixels classification using Fuzzy C-Means (FCM) method. The performance measurement was done through the evaluation of classification accuracy using 5 cluster validity indices. The result of cluster validity indices shows that CIELAB colorspace with 4 number of cluster proven the most consistent in FCM classification. In the later stage, the use of statistical measurement i.e. Analysis of Variance (ANOVA) and Duncan Multiple Range Test (DMRT) gave a significant relationship when classifying five out of seven grades of agarwood chips used i.e. RM250, RM350, RM800, RM900 and RM2500. Then, the artificial intelligence system using fuzzy logic and neural network concept has been developed and their performance has been compared. The result shows that fuzzy logic system successfully classified 62.8% of overall accuracy while neural network system gives 58% of overall accuracy in grading the agarwood chips. As a conclusion, the proposed system is helpful to the agarwood industry especially in determination of agarwood chips color during the grading process.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuki Ijazah Master Sains.

PENGASINGAN KAYU GAHARU BERDASARKAN WARNA DENGAN MENGGUNAKAN KAEDAH PEMPROSESSAN GAMBAR DAN KECERDIKAN BUATAN

Oleh

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Gaharu mendapat permintaan yang tinggi dalam industry minyak wangi. Jika gred gaharu adalah bercampur-campur, kualiti minyak gaharu akan berkurangan dan dengan itu harga produk dan kualitinya akan menurun. Semasa peringkat pengredan, pengetahuan dan pengalaman manusia telah digunakan secara kritikal di dalam membuat keputusan. Walaubagaimanapun, ciri-ciri manusia seperti keletihan dan tidak fokus telah menyebabkan berlakunya kesilapan semasa kerja pengredan dijalankan. Secaraamnya, sifat kolorimetrik kayu gaharu telah dijadikan sebagai pengukur kepada gred kayu gaharu disebabkan ianya sering dikaitkan dengan kandungan resin. Kebiasaannya, gred kayu gaharu yang tinggi atau mahal akan memberikan warna hitam bersinar manakala gred yang lebih rendah atau murah memberikan warna hitam yang berselang-seli dengan warna coklat. Di atas andaian tersebut, kajian ini telah dijalankan untuk mengkaji hubungan antara warna kayu gaharu dan harganya dengan mengguna pakai kaedah kepintaran buatan dan pemprosesan imej. Kajian ini dijalankan dengan mengambil gambar kayu gaharu dan seterusnya gambar ini ditukarkan kepada ruang warna Merah, Hijau dan Biru (RGB), Warna, ,Keamatan dan Ketepuan (HIS) dan Ruang Kolorimetric CIE (CIELAB) telah dinilai dengan membandingkan prestasi pengkelasan warna piksel menggunakan kaedah cara kabur (FCM). Pengukuran prestasi yang telah dilakukan berdasarkan atas penilaian ketepatan pengelasan menggunakan 5 indeks pengesahan kelompok. Hasil indeks pengesahan kelompok menunjukkan bahawa ruang warna CIELAB dengan menggunakan 4 nombor kelompok terbukti paling konsisten dalam pengelasan FCM. Di peringkat seterusnya, penggunaan statistic pengukuran iaitu Analisis Varian (ANOVA) dan Ujian Duncan Pelbagai (DMRT) member hubungan yang signifikan apabila mengklasifikasikan lima daripada tujuh gred kayugaharu yang digunakan iaitu RM250, RM350, RM800, RM900 dan RM2500. Kemudian, sistem kecerdasan buatan yang menggunakan konsep logic kabur dan rangkaian neural telah dibangunkan dan berbanding

prestasinya. Hasilnya menunjukkan bahawa sistem logic kabur Berjaya mengelaskan 62.8% untuk keseluruhan ketepatan manakala sistem rangkaian neural memberikan 58% ketepatan keseluruhan dalam proses penggredan kayu gaharu. Kesimpulannya, sistem yang dicadangkan ini dapat membantu industry gaharu terutamanya di dalam penentuan warna kayu gaharu semasa proses pengasingan.

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LIST OF ABBREVIATIONS

CMV	Computer Machine Vision
TRP	Tropical Rainforest Project
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
TRAFFIC	Report from The Wildlife Trade Monitoring Network
MINT	Malaysia Institute of Nuclear Technology
CAT	Computed Tomography
LDC	Linear Discriminant Classifier
SVM	Support Vector Machine
BPNN	Back Propagation Neural Network
FFT	Fast Fourier Transform
CART	Classification and Regression Tree
NN	Neural Network
FCM	Fuzzy C-Means
PC	Partition Coefficient Index
CE	Classification Entrophy Index
FS	Fukuyama and Sugeno Index
XB	Xie and Beni's Index
FHV	Fuzzy Hypervolume Index
PD	Partition Density Index
S	Separation Index
SC	Separation Compaction Index
DI	Dunn Index
DN	Digital Number
RGB	Red Green Blue

HSI	Hue Saturation Intensity
HSV	Hue Saturation Value
CIELAB	CIE colorimetric space
NHLA	National Hardwood Lumber Association
FMMIS	Fuzzy Min-Max Neural Network Method
HVCC	Hierarchical Vector Connected Components
KNN	K-Nearest Neighbour
SOM	Self Organizing Map

CHAPTER 1

INTRODUCTION

1.1 Background

Agarwood, eaglewood, aloeswood, *karas* or *gaharu*; are just a few names that synonyms for the resinous, fragrant and greatlypreciousheartwood produced by *AquilariaMalaccensis* and other species of the tree genus *Aquilaria*(Asia-Taipei & Asia, 2005; Asia, 2008; Barden, et al., 2000; Chua, 2008).Naturally, agarwood formation is caused by the trees response to a injury associated with the wood. In brief, the tree has two response mechanisms to injury. The first is the response of tree to produce callus growth and secondly by the resinification process which is a chemical defence over the injury(Gunn, et al., 2003).

This dark and heavy heartwood is traditionally used for its fragrance in perfume industry, aromatherapy, medicine, ceremonial and spiritual rituals and it's depending on the grade(Asia-Taipei & Asia, 2005; Barden, et al., 2000; Chua, 2008; Gunn, et al., 2003). The demand for Agarwood is high especially in Asia and Middle East country(Asia). This species are widely distributed in Bangladesh, Bhutan, India, Indonesia, Malaysia, Myanmar, Philippines and Thailand (Asia-Taipei & Asia, 2005; Asia; Barden, et al., 2000; Chakrabarty, et al., 1992; Gunn, et al., 2003). In Malaysia, most of the domestics trade are in a form of woodchips, powder or sawdust (Chua, 2008).Internationally, the trade of agarwood is in form of wood, chips, powder, oil, and medicines.

Before the grading process is done, it is essential to prepare a consistent agarwood chips in order to optimize financial returns. The process of preparing high valuable wood (agarwood) is by removing of undesirable wood from the whole wood. This is normally involves removing light sap wood using sharp knives or special hooked knives(Asia-Taipei & Asia, 2005). These processes are laborious and time consuming. Final product of agarwood chips should be uniform in color in order to achieve the best grading(Asia-Taipei & Asia, 2005).The grade of agarwood, and thus its value depends on a complex set of factors such as the resin content, size, fragrance, color, flammability and the country of origin (Asia-Taipei & Asia, 2005; Asia, 2008; Barden, et al., 2000; Chakrabarty, et al., 1992; Chua, 2008; Donovan & Puri, 2004; Gunn, et al., 2003; Keong, 2006; Soeharto & Newton, 2001, 2002; Zich & Compton, 2001). Traditionally, grading agarwood is a subjective and complicated process(Asia-Taipei & Asia, 2005; Chakrabarty, et al., 1992; Chua, 2008; Gunn, et al., 2003).

During the grading process, the agarwood chips is usually graded by human and the agarwood chips grade is decided by the buyer or seller which is always tend to inconsistency. Currently, there is still no standard method and system that have been used in grading the agarwood(Barden, et al., 2000). Consequently, the grades vary from country to country and from buyer to buyer.

1.2 Motivation

Agarwood is a product that is in high demand in the perfume industry. Each product or applications is highly depending on the agarwood grade. To become a grader, it takesmany years and experiences to accurately grade the agarwood. Color is one the important criteria in deciding the Agarwood grade,if different grade of agarwood is mixed, the agarwood oil quality will decrease and hence the products prices and quality will decrease.Therefore, the machine vision technology is suggested to overcome this problem.It also used to transfer human knowledge to an artificial intelligent knowledge. Furthermore, registration and labeling systems for agarwood products in trade is needed by Malaysian government to ease the management and improve transparency in the agarwood trade.

In this century, the expectation of high quality and safety agricultural product is in demand. Therefore, the need for accurate and reliable system or machine continues to rapidly grow(Brosnan & Sun, 2004). Computer machine vision (CMV) can provide one of the alternative solutions. The declining cost and increasing speedof the hardware capability of the CMV provides a significant impact to create a system which is cost effective, non-destructive and automated(P. Chen & Sun, Z. 1991). The other benefits of using CMV are generation of precise descriptive data, quick and objective, reducing tedious human involvement, non-destructive and undisturbing. There are many applications using CMV has been introduced in the agricultural sectors and one of it isin fruits and food physical (external) measurement using color as the sensorial indicator (optical properties) with a combination of artificial intelligent or pattern recognition technique to evaluate product quality(Y.-R. Chen, et al., 2002).Agricultural product quality assessment is subjective with the attribute of physical appearance, smell (odour), flavour, texture and also human personal view(Blasco, et al., 2003). However, recent study on CMV mainly based on camera and computer technology has proven successful in most of the objective especially in investigated the physical and optical properties of agricultural product(Mendoza, et al., 2006).

1.3 Objective of study

This research is attempted to develop an automaticsystem by employing CMV and pattern recognition technique for the inspection of different grades of agarwood chips. The specific objectives include the following:

1. To determine suitable colorspace for the agarwood images processing.
2. To determine the specific color features (optical properties) that can independently represent each of the agarwood grades used.
3. To develop and comparethe performanceoffuzzy logic and neural network system for the agarwood grading.

1.4 Limitations

There are several limitations has been considered within the context of this research. First, this study considered only seven agarwood grades from *aquilaria malaccenssis* species. The chips were obtained and graded by an expert from Malaysia Institute of Nuclear, Malaysia. Therefore, the study material may or may not be representative of total agarwood species in Malaysia. Second, the limited study in agarwood industry especially in colour properties of agarwood chips has led toa difficulty for the researcher to determine the correct grading manually. Furthermore, there is also no single literature that scientifically describing the optical properties for agarwood chips available. Therefore, the stated results and conclusions of this work should be interpreted within the context of these limitations.

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