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Differentiation of Agarwood Oil Quality Using Support Vector Machine (SVM)

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Abstract: This research presents an Agarwood oil grading system using Support Vector Machine (SVM). Agarwood is grown in tropical parts of Asia (including Malaysia) and is a valuable international commodity. It is used primarily in fragrance and medicine. Data collected from 96 Agarwood oil samples of different qualities were used to train several SVMs with different Kernel functions. Implementation of the project was done using MATLAB v2010a. It was found that nonlinear Kernels were able to produce 100% accuracy, outperforming the linear Kernel (87.5% accuracy).

Key words: Agarwood oil, support vector machines, quality grading, commodity, implementation, outperforming

INTRODUCTION

Agarwood is dark resinous heartwood that forms in aquilaria and gyrinops trees from the plant family thymelaeaceae (Akter *et al*., 2013) typically used to make perfumes, traditional medicinal preparations and incense (Akter *et al*., 2013; Najib *et al*., 2011; Ismail *et al*., 2013). Altogether, Agarwood consists of 15 species, growing on particular sites in tropical Asia such as India, Pakistan, Myanmar, Laos, Thailand, Cambodia, South China, Malaysia, Philippines and Indonesia (Suharti *et al*., 2011).

The demand for high-quality Agarwood oils is high, especially from countries such as United Arab Emirates, Saudi Arabia, China and Japan (Ismail *et al*., 2013). The current global market for Agarwood is estimated to be in the range of US$ 6-8 billion. High-quality oils may cost between USD126-USD633 per tola (12 mL) while the prices of superior Agarwood quality may fetch up to USD 100,000 per kg (Ismail *et al*., 2013).

The oil extracted from the Agarwood contains complex volatile compounds producing its distinct aroma (Najib *et al*., 2011; Ismail *et al*., 2013; Ali *et al*., 2012). The quality of the Agarwood oil depends on these compounds which in turn, affects its price. Agarwood oil is generally divided to 5 grades arranged in decreasing order: Super A, A, B, C and D. The grade of the oil is dependent on the quality of raw materials the method of distillation and the method of processing the Agarwood oil.

Traditionally, post-harvest Agarwood quality is evaluated by experts graders trained to differentiate Agarwood quality based on its odor. However, this method has several limitations as it requires years of experience to develop the skills necessary and limitation of the number of samples that can be processed at a time especially during continuous production (Najib *et al*., 2011). Thus, evaluation based on the Agarwood's chemical profile would be a more objective measure to ensure the quality of the product (Sidik, 2008; Latif, 2009).

This study proposes the use of support vector machine classifier to perform automated grading of Agarwood oils based on its chemical composition. The chemical composition is extracted using Gas Chromatography-Mass Spectrometry (GC-MS) and classified using CFNN to indicate either high (1) or low quality (0).

Support Vector Machine (SVM) and previous works on Agarwood oil classification: The SVM was introduced by Vladimir Vapnik as a binary classifier by building a separating hyperplane using various Kernel functions that discriminates between two data cases (Ismail *et al*., 2013).

Abdullah *et al*. (2012) an image processing-based method was used to classify Agarwood quality. A total of 74 Agarwood images were obtained. Then, the pre-processing phase improves the image contrast and brightness characteristics reduce its noise content and sharpen the image features. Image segmentation was then performed to remove non-interesting features. Quality determination was done by analyzing the grayscale values of the images. Since, Agarwood with more resin is darker it was found that a higher percentage of grayscale values were indicative of better-quality Agarwood.

Research by Azah *et al*. (2013) used analysis of resin content to determine the quality of Agarwood. Ground

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Agarwood samples were diluted with ethanol and left to sit for 1 h. Filtration was done after refluxing. The evaporated product was then dried and cooled. Finally, the sample was weighted to determine the percentage of its Agarwood content.

A common method for determining Agarwood quality is by analyzing its chemical profile using Gas Chromatography and Mass Spectrometry (GC/MS) (Ismail *et al*., 2013; Jayachandran *et al*., 2015). Sample essential oil were heated to vapor in the GC where an inert gas carried it along a column. When the vaporized oil passes inside the column it separated into a number of constituents of a singular molecular state and interacted with phases from the stationary column (Ismail *et al*., 2013; Jayachandran *et al*., 2015). The constituents were then ionized and its chemical constituents were detected using MS.

Research by Najib *et al*. (2011) used the Multi-Layer Perceptron (MLP) for classification of Agarwood oil quality. Data collection was done from a selection of 32 e-Nose sensors. Principal Component Analysis (PCA) was used to recognize significant patterns in the data before being fed into the MLP.

In Ismail *et al*. (2013) a Multi-Layer Perceptron (MLP) neural network was trained as a pattern classifier to discriminate between different types of Agarwood quality. Key chemical components of various Agarwood oil samples were extracted using the Gas Chromatography Mass Spectrometer (GCMS) technique. Z-score analysis was then used to identify significant compounds. The MLP was then trained using these significant compounds.

MATERIALS AND METHODS

The data used to train the CFNN were gathered from 96 Agarwood samples collected by the Forest Research Institute Malaysia (FRIM) and University Malaysia Pahang (UMP) (Ismail *et al*., 2013). Firstly, the chemical compounds of Agarwood oil are extracted using Gas Chromatography-Mass Spectrometry (GC-MS). After that Z-score technique is performed to identify the significant chemical compounds of Agarwood oil.

The data collected by Ismail *et al*. (2013) indicated that seven compounds contribute significantly to the quality of Agarwood oil. The compounds are shown in Table 1. The compounds gathered from the samples were used to train several SVMs with different Kernel functions (linear, polynomial, radial basis and quadratic). The SVM output classifies between high (1) and low (0) quality Agarwood.

The performances of the SVMs were analyzed using the Confusion Matrix (CM). CM visualizes the performance of the classifier by depicting the number of cases that belong to these groups: True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN). The data was split into training and testing datasets. The training dataset was used to build the model while the testing dataset was used to predict the class labels.

Table 1: Significant Agarwood chemical constituents used for classification (Quality '1' for low and '2' for high)

Oils	C1	C2	C3	C4	C5	C6	C7	Quality
CKE	0.00	0.00	6.42	0.00	0.17	0.00	0.00	1
R5	0.00	0.00	0.00	3.24	16.41	3.16	10.15	1
HD	0.10	0.60	0.50	2.80	0.00	0.00	3.00	1
MN	0.00	0.00	3.41	8.03	0.00	0.00	0.00	2
MS	0.00	0.00	2.64	8.87	0.00	0.00	0.00	2
M	0.00	0.00	3.33	13.80	0.00	0.00	0.00	2
MPE	1.02	2.06	11.14	4.40	0.00	0.00	0.00	2
LG	0.36	0.00	1.25	1.62	0.00	0.00	0.00	2
RG	3.96	2.98	21.01	1.38	0.00	0.00	0.00	2
HG	3.47	2.41	9.58	11.11	0.00	0.00	0.00	2
CM	0.88	0.00	10.31	7.83	0.00	0.00	0.00	2
MNS	2.21	1.42	5.04	12.36	0.00	0.00	0.00	2
EO3	0.00	0.00	4.04	15.67	0.00	0.00	0.00	2
High	2.37	2.01	10.34	9.92	0.00	0.00	0.00	2
EO4	0.00	0.00	10.21	0.00	0.00	0.00	0.00	2
EO2	6.77	0.00	3.63	5.88	0.00	0.00	0.00	2

C_1 = β-Agarofuran, C_2 = α-Agarofuran, C_3 = 10-epi-γ-Eudesmol, C_4 = γ-Eudesmol, C_5 = Longifolol, C_6 = Hexadecanol, C_7 = Eudesmol

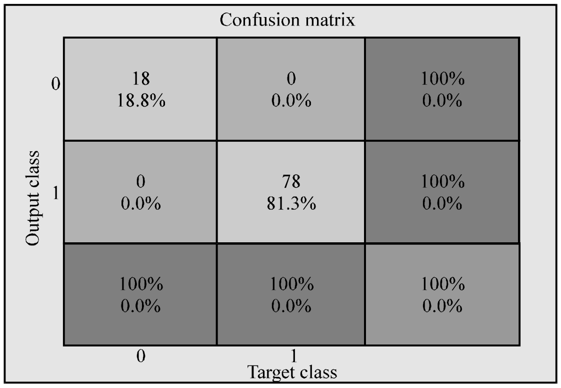
RESULTS AND DISCUSSION

Full hardware setup: Experiments were performed on a Toshiba Satellite L745 laptop with 8 GB memory and 2.5 GHz Intel i5 microprocessor. Windows 7 was installed as the operating system and MATLAB 2014a was used as the development environment.

Experiment results: The confusion matrix results for the Kernels are presented in Fig. 1 and 2 (linear) and (radial basis, polynomial and quadratic). The linear Kernel's best performance was 87.5% accuracy while the remaining Kernels managed to obtain 100% accuracy. The difference in results is attributed to the Kernel's effect on the hyperplane. The linear Kernel produces a linear hyperplane which managed to separate most of the data points.

However, this type of hyperplane was unable to differentiate data points in "grey areas" in which the data points near the hyperplane boundaries reside too close to each other and cannot be separated well.

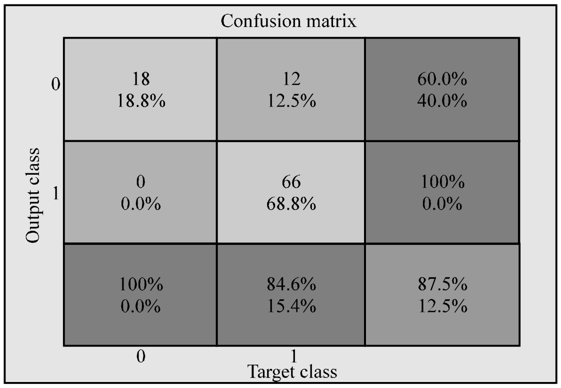
However, more complex Kernels (such as the radial basis, polynomial and quadratic Kernels) are able to modify the shape of the hyperplane to model more difficult decision boundaries hence, increasing the separation accuracy between the data classes.



Confusion matrix

Output class \ Target class	0	1	
0	18 18.8%	0 0.0%	100% 0.0%
1	0 0.0%	78 81.3%	100% 0.0%
	100% 0.0%	100% 0.0%	100% 0.0%

Fig. 1: Performance of SVM with linear Kernel on entire dataset



Confusion matrix

Output class \ Target class	0	1	
0	18 18.8%	12 12.5%	60.0% 40.0%
1	0 0.0%	66 68.8%	100% 0.0%
	100% 0.0%	84.6% 15.4%	87.5% 12.5%

Fig. 2: Performance of SVM with polynomial, radial basis and quadratic Kernels on entire dataset

CONCLUSION

A SVM-based Agarwood quality classification system has been presented in this study. The optimal Kernel function had been determined based on experiments performed with 100% classification accuracy. Based on the results it was determined that Agarwood quality determination is a non-linear problem which explains excellent classification performance by non-linear relative to linear classifiers.

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