

UNIVERSITI TEKNOLOGI MARA

**AGARWOOD OIL QUALITY
GRADING MODEL USING SELF-
ORGANIZING MAP (SOM)**

MOHAMAD HUSHNIE BIN HARON

PhD

December 2020

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

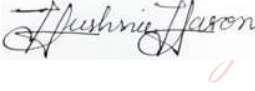
Name of Student : Mohamad Hushnie Bin Haron

Student I.D. No. : 2016353301

Programme : Doctor of Philosophy in electrical Engineering –
EE950

Faculty : Electrical Engineering

Thesis Title : Agarwood Oil Quality Grading Model Using Self-
Organizing Map (SOM)

Signature of Student :  Digitally signed by Hushnie Haron
DN: cn=Hushnie Haron, o, ou,
email=hushnieharon@gmail.com,
c=MY
Date: 2021.01.05 12:22:04 +08'00'

Date : December 2020

ABSTRACT

Agarwood is known as the resin impregnated duramen of the species *Aquilaria* that belongs to the Thymelaeaceae family. Extracted from the stem of Agarwood is a concentrated volatile aromatic compound called Agarwood oil. It is traded based on its quality, which is proportional to its price. The standard grading of Agarwood oil quality is carried out by skilled appraiser using their sensory organs based on its substantial appearances such as colour, odour, and user impression which is defined as customer awareness or opinions. The appraiser needs to include the user impression because it can affect the price of Agarwood oil. However, this method has limitations because human sensory organs are subject to fatigue and are also restricted in terms of unbiasedness, replicability, time utilization and workforce costs. To overcome these limitations, an Agarwood oil grading model were developed based on its chemical compounds using SOM to distinguish the Agarwood oil quality up to four grades. Three stages have been completed to achieve this goal, namely determination of significant chemical compounds of Agarwood oil, designation and confirmation of Agarwood oil grades, and establishment of Agarwood oil quality grading model. First, the raw data that were obtained from GC-MS analysis were pre-processed using techniques such as missing values ratio, natural logarithm, min. max normalization, MUNGE, winsorization, PCA and Pearson's correlation to determine significant chemical compounds. Then, these compounds were used as inputs for SOM and KNN to designate and confirm the Agarwood oil grades. Using independent Agarwood oil samples, the Agarwood oil quality grading model using SOM was established. The raw data consisted of 22 samples and 103 chemical compounds. At the end of pre-processing techniques, three chemical compounds in particular α -agarofuran, β -agarofuran and 10-epi- ϕ -eudesmol were determined. In the designation and confirmation of Agarwood oil grades, SOM obtained average silhouette indexes between reasonable and excellent and KNN achieved 100% accuracy, precision, sensitivity and specificity for $k=1$ to $k=2$. In the establishment of Agarwood oil grading model, SOM and KNN attained silhouette indexes of excellent and 100% accuracy, precision, sensitivity and specificity for $k=1$ to $k=5$ respectively. This thesis shows that the Agarwood oil quality grading model using SOM is able to determine significant chemical compounds that can be used for Agarwood oil grading and capable to distinguish the Agarwood oil quality into two to four grades based only on β -agarofuran, α -agarofuran and 10-epi- ϕ -eudesmol.

ACKNOWLEDGEMENT

Firstly, I wish to thank Allah for giving me the opportunity to embark on my PhD and for completing this long and challenging journey successfully. My gratitude and thanks go to my supervisor Prof. Ir. Dr. Mohd Nasir Taib for his tremendous guidance, encouragement and selfless support.

My appreciation also goes to my co-supervisors Ir. Dr. Nurlaila Ismail for her great mentorship and support, and Dr. Nor Azah Mohd Ali and Assoc. Prof Dr. Saiful Nizam Tajuddin who provided the facilities and assistance during data acquisition. Special thanks to my colleagues from Advance Signal Processing Research Group(ASPRG) and friends who are willingly sharing with me their knowledges and experiences during this study.

Finally, this thesis is dedicated to my dearest and loveable father and mother for their vision, determination and patience to educate me, and their pray to see me successful. This piece of victory is dedicated to both of you. Alhamdulillah.

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	ix
LIST OF FIGURES	xiii
LIST OF SYMBOLS	xvii
LIST OF ABBREVIATIONS	xviii
CHAPTER ONE INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	3
1.3 Objectives	4
1.4 Research Scopes	4
1.5 Significance of Study	5
1.6 Thesis Layout	5
CHAPTER TWO LITERATURE REVIEW	7
2.1 Introduction	7
2.2 Agarwood Oil	7
2.2.1 Agarwood Oil Analysis Techniques	8
2.2.2 Chemical Compounds of Agarwood Oil	9
2.2.3 Agarwood Oil Quality Grading Methods	11
2.3 Pre-Processing of Data	13
2.4 Machine Learning Algorithm	23
2.4.1 Self-Organizing Map (SOM)	24
2.4.2 K-Nearest Neighbour (KNN)	28
2.4.3 Confusion Matrix	30