UNIVERSITI TEKNIKAL MALAYSIA MELAKA

LOAD CLASSIFICATION USING SELF-ORGANIZING MAP (SOM) AND CORRELATION ANALYSIS FOR OPTIMIZATION

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Power) with Honours.

by

FATIN NABILA BINTI AZMAN

B071510349

960218-43-5006

FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING TECHNOLOGY

2019

© Universiti Teknikal Malaysia Melaka

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: LOAD CLASSIFICATION USING SELF-ORGANIZING MAP (SOM) AND CORRELATION ANALYSIS FOR OPTIMIZATION

Sesi Pengajian: 2019

Saya **FATIN NABILA BINTI AZMAN** mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (X)

© Universiti Teknikal Malaysia Melaka

☐ SULIT* Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972.

☐ TERHAD* Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.

☒ TIDAK TERHAD

Yang benar,

.....

FATIN NABILA BINTI AZMAN

Alamat Tetap:

Lot 1418 Jalan Manggis,

Batu 9 Kg Medan,

42500 Telok Panglima Garang,

Selangor, Darul Ehsan.

Tarikh:

Disahkan oleh penyelia:

.....

ZUL HASRIZAL BIN BOHARI

Cop Rasmi Penyelia

Tarikh:

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini

© Universiti Teknikal Malaysia Melaka

DECLARATION

I hereby, declared this report entitled LOAD CLASSIFICATION USING SELF-ORGANIZING MAP (SOM) AND CORRELATION ANALYSIS FOR OPTIMIZATION is the results of my own research except as cited in references.

Signature: ……

Author : FATIN NABILA BINTI AZMAN

Date:

© Universiti Teknikal Malaysia Melaka

APPROVAL

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

Signature: …….

Supervisor : ZUL HASRIZAL BIN BOHARI

© Universiti Teknikal Malaysia Melaka

ABSTRAK

Sektor elektrik Malaysia dikawal selia bagi bekalan kuasa dan dilihat sebagai pengeluar kuasa bebas (IPP). Kelemahan semula jadi yang berkaitan dengan pengelasan beban mendapat lebih kuat apabila ia benar-benar dikehendak menyediakan tempoh yang dicirikan oleh perubahan pantas dan bertenaga bagi pengukuran yang tidak ternilai kepada proses membuat keputusan. Dalam kajian ini, pendekatan rangkaian neural yang dicadangkan bagi klasifikasikan beban di Malaysia. Kajian ini membentangkan beban penggugusan menggunakan pendekatan berdasarkan gabungan Peta Penyusun Sendiri (SOM) dan Analisis Korelasi bagi tujuan mengoptimumkan data beban. Tujuan utama projek ini adalah untuk memahami keupayaan analisis korelasi dan SOM klasifikasi beban, melatih data beban melalui analisis korelasi dan SOM dengan menggunakan ciri-ciri yang terpilih. Projek ini memberi tumpuan kepada kelompok data pada Januari 2016 sehingga awal Febuari 2016. Data dari tahun sebelumnya telah dilatih untuk mengumpulkan data bagi perancangan masa depan. Hubungan data beban adalah kolerasi dan menggunakan kelompok pengiraan analisis korelasi dan SOM Toolbox dalam perisian MATLAB. Kemudian, saiz peta, masa latihan, ralat kuantitasi dan ralat topografi punya konsep untuk menentukan prestasi hasil.

© Universiti Teknikal Malaysia Melaka

ABSTRACT

The Malaysian electricity sector was regulated to power supply and has seen as the independent power producers (IPPs). The natural vulnerabilities related with load classification end up more intense when it actually required providing a period characterized by quick and energetic changes for priceless measurement to the decision-making process. In this research, a neural network approach is proposed for load classification in Malaysia. This research presents the clustering load using an approach based on the combination of Self-Organizing Maps (SOM) and Correlation Analysis for optimization. The main purpose in this project is to understand the ability of correlation analysis and SOM in load classification, and to relate and train the load data via correlation analysis and SOM method using selected features. This project focused on clustering data in January 2016 until early February 2016. The data from previous year was trained to cluster the data for the future planning. The relation of load data was correlated and cluster using calculated correlation analysis and SOM Toolbox in MATLAB software. After that, the map size, training time, quantization error and topographic error is compute to determine the performance of the result.

© Universiti Teknikal Malaysia Melaka

DEDICATION

To my beloved parents *Azman bin Salihan @ Hj Ismail* and *Arifah binti Tajul*. Not forgotten my siblings *Muhammad Azri*, *Nora Azmira*, *Muhammad Azanizam* and *Siti Asiah*.

© Universiti Teknikal Malaysia Melaka

ACKNOWLEDGEMENTS

Praise to Allah S.W.T The Most Gracious and The Most Merciful for His Blessing granted me to finish the Final Year Project 2. First of all, I would like to take this opportunity to thank my supervisor, Mr. Zul Hasrizal bin Bohari for all the guidance and encouragement for me in completing my Final Year Project.

I would like to extend my thankfulness to the most cherished person in my life, my parents (Azman bin Salihan @ Hj Ismail and Arifah binti Tajul) for all the moral support, financial and for never ending reminding me to always be responsible and trustworthy.

In addition, I would like to thank you all my friends for the helps and moral support during my studies in Universiti Teknikal Malaysia Melaka.

© Universiti Teknikal Malaysia Melaka

TABLE OF CONTENTS

		PAGE
TABLE OF CONTENTS		**x**
LIST OF TABLES		**xiii**
LIST OF FIGURES		**xv**
LIST OF APPENDICES		**xviii**
LIST OF ABBREVIATIONS		**xix**
CHAPTER 1	**INTRODUCTION**	**20**
1.1	Background	20
1.2	Problem Statement	21
1.3	Objectives	21
1.4	Scope of work	22
CHAPTER 2	**LITERATURE REVIEW**	**23**
2.1	Introduction	23
2.2	Theoretical Background	23
2.2.1	Load Classification	23
2.2.2	Types of load classification	24
2.2.3	Process model of load classification	24
2.3	Correlation Analysis	26

© Universiti Teknikal Malaysia Melaka

2.3.1 Correlation coefficient 26

2.4 Artificial Neural Network 28

2.5 Self-Organizing Maps 31

2.5.1 Sequential training of SOMs 32

2.5.2 Visual analysis of SOMs 34

2.6 Review from Previous Related Work 35

2.7 Summary and Discussion of the Review 38

CHAPTER 3 METHODOLOGY 39

3.1 Introduction 39

3.2 Flow of the Progress Report 39

3.2.1 Data Collection 42

3.2.2 Data Organizing 42

3.2.3 Calculate correlation between input and output 43

3.2.4 Correlation coefficient 43

3.2.5 Data organizing for SOM 43

3.2.6 Training using SOM 46

3.2.7 Data grouping 47

3.2.8 Result analysis 47

3.3 Gantt chart and Milestone of Research 48

3.4 Summary 50

© Universiti Teknikal Malaysia Melaka

CHAPTER 4 RESULT 51

4.1 Introduction 51

4.2 Data Organizing 51

4.3 Correlation Analysis 54

4.4 SOM Load Classification for January 2016 at MSB1 56

4.4.1 Training for the January 2016 at MSB1 56

4.4.2 SOM Clustering at MSB 1 for January 2016 64

4.5 SOM Load Classification for January 2016 at MSB2 67

4.5.1 Training for the January 2016 at MSB2 67

4.5.2 SOM Clustering at MSB 2 for January 2016 75

4.6 Commercialization Relevancy 78

4.7 Summary 78

CHAPTER 5 CONCLUSION 79

5.1 Conclusion 79

REFERENCES 81

APPENDIX 84

© Universiti Teknikal Malaysia Melaka

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1:	Review work from past researchers	35
Table 3.1:	List of holiday for January 2016 to early February 2016	44
Table 3.2:	Input data as assigned input	45
Table 3.3:	The Gantt chart for project activities	49
Table 3.4:	The milestone of the project	50
Table 4.1:	Correlation analysis of input data and week at MSB 1 in January 2016	54
Table 4.2:	Correlation analysis of input data and week at MSB 2 in January 2016	54
Table 4.3:	Correlation analysis of I/O data by week at MSB 1 in January 2016	55
Table 4.4:	Correlation analysis of I/O data by week at MSB 2 in January 2016	55
Table 4.5:	Training data using *range* normalization	57
Table 4.6:	Training data using *var* normalization	58
Table 4.7:	Training data using *log* normalization	60
Table 4.8:	Training data using *logistic* normalization	61
Table 4.9:	The comparison between 4 types of normalization method	63
Table 4.10:	The importance load that has been classified	65
Table 4.11:	Training data using *range* normalization	68

© Universiti Teknikal Malaysia Melaka

Table 4.12:	Result from the training of data using *var* normalization	69
Table 4.13:	Result from the training of data using *log* normalization	71
Table 4.14:	Result from the training of data using *logistic* normalization	72
Table 4.15:	Result from the training of data using *logistic* normalization	74
Table 4.16:	The importance load that has been classified	77

© Universiti Teknikal Malaysia Melaka

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1:	Analysis Technique (Gasson & Cutler, 1990)	24
Figure 2.2:	Process model of load classification (Zhou et al., 2013)	25
Figure 2.3:	Clustering methods (Zhou et al., 2013)	26
Figure 2.4:	Example of correlation (Larson & Farber, 2009)	27
Figure 2.5:	The building blocks of neural networks (Kriesel, 2005)	28
Figure 2.6:	Feedforward ANNs (Schlesinger & Hlavác, 2011)	29
Figure 2.7:	Two-dimensional SOM (rectangular topology) (Stefanovič & Kurasova, 2011)	32
Figure 2.8:	(a) Data with cluster (Pölzlbauer et al., 2005), (b) U-matrix and clusters	34
Figure 3.1:	Methodology of correlation analysis	40
Figure 3.2:	Methodology of SOM for load classification	41
Figure 3.3:	Data organizing of correlation analysis	42
Figure 3.4:	Data organizing for SOM	44
Figure 4.1:	The graph of (a) Average line to neutral voltage, (b) Average line to line voltage, (c) Average line current, (d) Total system power, (e) Total system apparent power, (f) Total system reactive power, (g) Neutral current against hours in Friday for 6 consequence weeks in January 2016 to early February 2016	53

© Universiti Teknikal Malaysia Melaka

Figure 4.2: The U-matrix and plane representation for *range* normalization with 2520 numbers of neuron 58

Figure 4.3: The U-matrix and plane representation for *var* normalization with 2520 numbers of neuron 59

Figure 4.4: The U-matrix and plane representation for *log* normalization with 2560 numbers of neuron 61

Figure 4.5: The U-matrix and plane representation for *logistic* normalization with 2500 numbers of neuron 62

Figure 4.6: SOM clustering at MSB 1 for January 2016 64

Figure 4.7: The importance load for January 2016 66

Figure 4.8: The U-matrix and plane representation for *range* normalization with 2520 numbers of neuron 69

Figure 4.9: The U-matrix and plane representation for *var* normalization with 2560 numbers of neuron 70

Figure 4.10: The U-matrix and plane representation for *log* normalization with 2580 numbers of neuron 72

Figure 4.11: The U-matrix and plane representation for *logistic* normalization with 2500 numbers of neuron 73

Figure 4.12: SOM clustering at MSB 2 for January 2016 75

Figure 4.13: The importance load at MSB 2 for January 2016 77

Figure 6.1: Command for training 113

Figure 6.2: The U-matrix and plane representation in January 2016 to early February 2016 for *range* normalization with 2560 and 2580 numbers of neuron 122

© Universiti Teknikal Malaysia Melaka

Figure 6.3: The U-matrix and plane representation in January 2016 to early February 2016 for *var* normalization with 2580 numbers of neuron 122

Figure 6.4: The U-matrix and plane representation in January 2016 to early February 2016 for *logistic* normalization with 2560 and 2580 numbers of neuron 123

© Universiti Teknikal Malaysia Melaka

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
Appendix 1	Data for January 2016 at MSB1 and MSB2	84
Appendix 2	SOM command for training	113
Appendix 3	SOM Training for January 2016 to early February 2016 (MSB1)	118
Appendix 4	Poorly visualized data at MSB1	122
Appendix 5	SOM Training for January 2016 to early February 2016 (MSB2)	124

© Universiti Teknikal Malaysia Melaka

LIST OF ABBREVIATIONS

ANN	Artificial Neural Network
SOM	Self-Organizing Map
PSO	Particle Swarm Optimization
AI	Artificial Intelligence

© Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

1.1 Background

In Malaysia, the energy consumption has a difference pattern with different types of consumers such as domestic, commercial, industrial also in agricultural. The type of the consumers may be same but their energy consumption is different based on their load. Mining the energy consumption patterns with different consumer based on load data classification can not only support the production planning, the arrangement of more personalized energy services for power producers and makes a competitive market policies moreover it can help different electricity consumers to enhance the understanding of their energy consumption patterns. Therefore, consumers can manage a strategies for their energy consumption more economically and optimally based on the knowledge from the load classification. In addition, the cost for energy consumption for consumers can be reduced and the energy use efficiency improved more significantly (Zhou, Yang, & Shen, 2013).

Within the energy areas, a desire to get a dependable and efficient energy is the main objective of all electric utilities. Since Malaysia is one of the fastest developing countries in the region, the certainty level and dependability related with these load classification are more vital in this fast growing region with fast growing demand of energy. As the country develops, there is nothing in the history backdrop of the world that has a greater effect on the quality of life than the change and utilization of electrical power.

© Universiti Teknikal Malaysia Melaka

1.2 Problem Statement

Load classification is an important component in the operation and arranging of consumer that led by Utilities Company. The impact of the up and down of oil and gas prices can also affect the energy consumption in Malaysia. Energy consumption can be considered in many factors such as temperature changes that will be difficult to do the classification. This difficulty can affect the planning, maintenance and others. As to conquer this issues a load classification model are used based on data collected. The data provided is test to give more accurate result of classification.

1.3 Objectives

The main objectives of this research are:

i. To study the ability of correlation analysis and Self-Organizing Map (SOM) in load classification.

ii. To understand the relationship between input and output by using correlation analysis.

iii. To train via Self-Organizing Map (SOM) method using selected features (line current, apparent power, reactive power and holiday list).

© Universiti Teknikal Malaysia Melaka

1.4 Scope of work

The project focus on developing correlation analysis and Self-Organizing Map (SOM) by implement it using MATLAB software. The software was conduct to run a simulation and analysed the load data. Therefore, mining and extracting valuable knowledge from load data is important research direction.

The data was provided considering parameter of voltage, current, apparent power, reactive power and holiday list. The focusing area for this project is at Hospital Port Dickson, Negeri Sembilan.

© Universiti Teknikal Malaysia Melaka

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter introduces a literature outline at the beginning of a research which aims to review the critical points of the research. Literature review has been conducted in order to obtain the information on the current load classification method that available from other researchers on the same field all around the world. This chapter provides the theoretical background for the load classification and the methods of load classification based on the past researches.

2.2 Theoretical Background

2.2.1 Load Classification

(Zhou et al., 2013) stated that load classification is a process that consist of numerous steps such as preparation of load classification, implementing load classification by utilizing clustering method and also understanding the applications of load classification.

(Zuhaimy, Fuad, & F. Azna, 1999) also claimed that the reliability and economic prerequisites can be made by consideration in arranging for the future establishment. Daily and future load classification arranging play an exceptionally vital part in each type of consumers.

© Universiti Teknikal Malaysia Melaka

2.2.2 Types of load classification

According to (Gasson & Cutler, 1990) in data mining the classification techniques are assembled in numerous categories based on the main task that are usually focused on such as artificial intelligence (neural networks and fuzzy logic), statistical techniques (linear regression and discriminant analysis), and visualization techniques (histograms and scatter plots). Figure 2.1 shows a synopsis of the techniques mentioned.

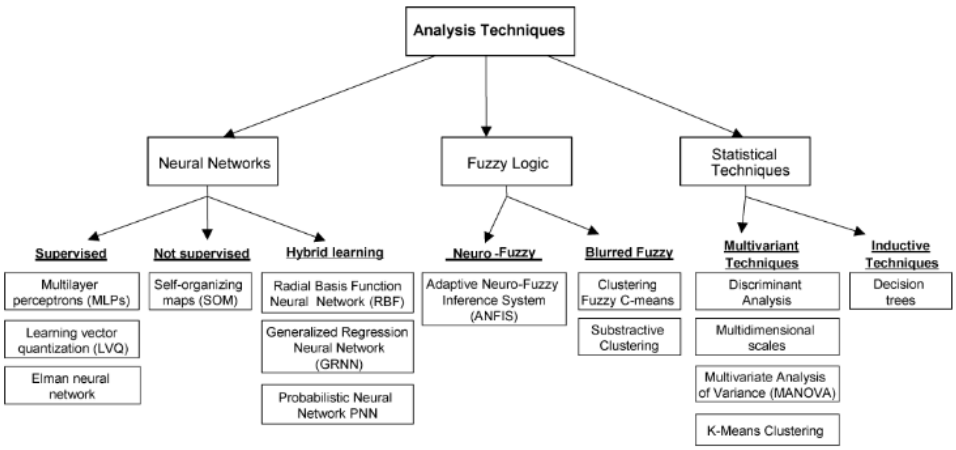

Figure 2.1: Analysis Technique (Gasson & Cutler, 1990)

2.2.3 Process model of load classification

(Zhou et al., 2013) stated that the process of load classification have five stages such as preparation of load data, clustering the preparation of load data, implementing clustering load data, understanding and evaluate load classification results and load classification results. Figure 2.2 shows the process model of load classification step by step.

© Universiti Teknikal Malaysia Melaka