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ACKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my main thesis supervisor, Professor Dr. Mohd Shariff Nabi Baksh, for encouragement, guidance, critics and friendship. I am also very thankful to my co-supervisor Professor Dr Awaluddin Mohd Shaharoun and Associate Professor Dr. Hishamuddin Jamaluddin for their guidance, advices and motivation. Without their continued support and interest, this thesis would not have been the same as presented here.

I am also indebted to Universiti Teknologi Malaysia (UTM) for funding my Ph.D study. Librarians at UTM, Cardiff University of Wales and the National University of Singapore also deserve special thanks for their assistance in supplying the relevant literatures.

My fellow postgraduate student should also be recognised for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family member.

ABSTRACT

The purpose of this study is to investigate the application of genetic algorithm (GA) in modelling linear and non-linear dynamic systems and develop an alternative model structure selection algorithm based on GA. Orthogonal least square (OLS), a gradient descent method was used as the benchmark for the proposed algorithm. A model structure selection based on modified genetic algorithm (MGA) has been proposed in this study to reduce problems of premature convergence in simple GA (SGA). The effect of different combinations of MGA operators on the performance of the developed model was studied and the effectiveness and shortcomings of MGA were highlighted. Results were compared between SGA, MGA and benchmark OLS method. It was discovered that with similar number of dynamic terms, in most cases, MGA performs better than SGA in terms of exploring potential solution and outperformed the OLS algorithm in terms of selected number of terms and predictive accuracy. In addition, the use of local search with MGA for fine-tuning the algorithm was also proposed and investigated, named as memetic algorithm (MA). Simulation results demonstrated that in most cases, MA is able to produce an adequate and parsimonious model that can satisfy the model validation tests with significant advantages over OLS, SGA and MGA methods. Furthermore, the case studies on identification of multivariable systems based on real experiment t al data from two systems namely a turbo alternator and a continuous stirred tank reactor showed that the proposed algorithm could be used as an alternative to adequately identify adequate and parsimonious models for those systems. Abstract must be bilingual. For a thesis written in Bahasa Melayu, the abstract must first be written in Bahasa Melayu and followed by the English translation. If the thesis is written in English, the abstract must be written in English and followed by the translation in Bahasa Melayu. The abstract should be brief, written in one paragraph and not exceed one (1) page. An abstract is different from synopsis or summary of a thesis. It should states the field of study, problem definition, methodology adopted, research process, results obtained and conclusion of the research. The abstract can be written using single or one and a half spacing. Example can be seen in Appendix 1 (Bahasa Melayu) and Appendix J

ABSTRAK

Kajian ini dilakukan bertujuan mengkaji penggunaan algoritma genetik (GA)

dalam pemodelan sistem dinamik linear dan tak linear dan membangunkan kaedah alternatif bagi pcmilihan struktur model menggunakan GA. Algorithma kuasa dua terkecil ortogon (OLS), satu kaedah penurunan kecerunan digunakan sebagai bandingan bagi kaedah yang dicadangkan. Pcmilihan struktur model mengunakan kaedah algoritma genetik yang diubahsuai (MGA) dicadangkan dalam kajian ini bagi

mengurangkan masalah konvergens pramatang dalam algoritma genetik mudah (SGA). Kesan penggunaan gabungan operator MGA yang berbeza ke atas prestasi model yang terbentuk dikaji dan keberkesanan serta kekurangan MGA diu t arakan. Kajian simulasi dilakukan untuk membanding SGA, MGA dan OLS. Dengan meggunakan bilangan parametcr dinamik yang setara kajian ini mendapati, dalam kebanyakan kes, prestasi MGA adalah lebih baik daripada SGA dalam mencari penyelesaian yang berpotensi dan lebih berkebolehan daripada OLS dalam menentukan bilangan sebutan yang dipilih dan ketcpatan ramalan. Di samping itu, penggunaan carian tcmpatan dalam MGA untuk menambah baik algorithma tersebut dicadang dan dikaji, dinamai sebagai algoritma mcmetic (MA). Hasil simulasi menunjukkan, dalam kebanyakan kes, MA berkeupayaan menghasilkan model yang bersesuaian dan parsimoni dan mcmenuhi ujian pengsahihan model di samping mcmperolehi beberapa kelebihan dibandingkan dengan kaedah OLS, SGA dan MGA. Tambahan pula, kajian kes untuk sistcm berbilang pcmbolehubah menggunakan data eksperimental sebenar daripada dua sistem iaitu sistem pengulang-alik turbo dan reaktor teraduk berterusan menunjukkan algoritma ini boleh digunakan sebagai alternatif untuk mcmperolehi model termudah yang memadai bagi sistcm tersebut.

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LIST OF ABBREVIATIONS

|  |  |  |
| --- | --- | --- |
| ANN | - | Artificial Neural Network |
| GA | - | Genetic Algorithm |
| PSO | - | Particle Swarm Optimization |
| MTS | - | Mahalanobis Taguchi System |
| MD | - | Mahalanobis Distance |
| TM | - | Taguchi Method |
| UTM | - | Universiti Teknologi Malaysia |
| XML | - | Extensible Markup Language |
| ANN | - | Artificial Neural Network |
| GA | - | Genetic Algorithm |
| PSO | - | Particle Swarm Optimization |
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LIST OF SYMBOLS

|  |  |  |
| --- | --- | --- |
| δ | - | Minimal error |
|  | - | Diameter |
|  | - | Force |
|  | - | Velocity |
|  | - | Pressure |
|  | - | Moment of Inersia |
|  | - | Radius |
|  | - | Reynold Number |
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# INTRODUCTION

## Introduction

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## Problem Background

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## Problem Statement

## Research Goal

### Research Objectives

The objectives of the research are :

1. To estimate the parameters
2. Item 1
3. Item 2
4. To define the best parameter estimate.

## Captions



Figure 1.1 Trends leading to the problem using MZJ Formatting Method

*(If the caption is written in a single line, use Caption for Figure UTM)*



Figure 1.2 Design and development phases of the proposed scheme (Muhamad, 2018)

*(If the caption is written more than one line, use Caption for Figure UTM 2 line)*

Table 1.1 The role of statistical quality engineering tools and methodologies

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Table 1.2 Basic ANN models used for control chart pattern recognition

*(If the caption is written more than one line, use Caption for Table UTM 2 line)*

## Quotation

After deliberating on doctoral education in Australia in the 1990s, one observer I Australia writes:

The lack of any significant formal course work within our Ph.D. and master degrees by research has continued for three decades. The focus of our Ph.D. research type degrees continues to be the research project, and this is almost the only medium by which education is accomplished.

(Stranks, 1984:171)

## Equation

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# LITERATURE REVIEW

## Introduction

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Figure 2.1 Continuous variability reduction using SPC chart (Revelle and Harrington, 1992)

Figure 2.2 Typical fully developed patterns on Shewhart control chart (Cheng, 1989)

Table 2.1 Regression analysis for the results of preliminary feature screening

Table 2.2 Estimated effects and regression coefficients for the recogniser's performance (reduced model)

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### State-of-the-Arts

## Limitation

## Research Gap

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# RESEARCH METHODOLOGY

## Introduction

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### Proposed Method

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#### Research Activities

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## Tools and Platforms



Figure 3.1 Example of Formatting Method

## Chapter Summary

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# PROPOSED WORK

## The Big Picture



Figure 4.1 This is MZJ original idea

## Analytical Proofs

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## Result and Discussion



Figure 4.2 The method for hig performance formatting

## Chapter Summary

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# CONCLUSION AND RECOMMENDATIONS

## Research Outcomes

## Contributions to Knowledge

## Future Works

Video provides a powerful way to help you prove your point. When you click Online Video, you can paste in the embed code for the video you want to add. You can also type a keyword to search online for the video that best fits your document.

Table 5.1 Example Repeated Header Table

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Video provides a powerful way to help you prove your point. When you click Online Video, you can paste in the embed code for the video you want to add. You can also type a keyword to search online for the video that best fits your document. To make your document look professionally produced, Word provides header, footer, cover page, and text box designs that complement each other.

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Appendix A Mathematical Proofs

Appendix B Psuedo Code

Appendix C Time-series Results Long Long Long Long Long Long Long Long Long Long

LIST OF PUBLICATIONS

**Journal Articles**

Qasem, S. N., Shamsuddin, S. M., Hashim, S. Z. M., Darus, M., & AlShammari, E. (2013). Memetic multiobjective particle swarm optimization based radial basis function network for classification problems. Information Sciences, 239, 165–190. https://doi.org/10.1016/j.ins.2013.03.021. (Q1, IF: 4.305)

Qasem, S. N., & Shamsuddin, S. M. (2011). Radial basis function network based on time variant multi-objective particle swarm optimization for medical diseases diagnosis. Applied Soft Computing, 11(1), 1427–1438. https://doi.org/10.1016/j.asoc.2010.04.014. (Q1, IF:3.907)

Shen, L. W., Asmuni, H., & Weng, F. C. (2015). A modified migrating bird optimization for university course timetabling problem. Jurnal Teknologi, 72(1), 89–96. https://doi.org/10.11113/jt.v72.2949. (Indexed by SCOPUS)

**Conference Proceedings**

Muhamad, W. Z. A. W., Jamaludin, K. R., Ramlie, F., Harudin, N., & Jaafar, N. N. (2017). Criteria selection for MBA programme based on the mahalanobis Taguchi system and the Kanri Distance Calculator. In 2017 IEEE 15th Student Conference on Research and Development (SCOReD) (pp. 220–223). IEEE. https://doi.org/10.1109/SCORED.2017.8305390. (Indexed by SCOPUS).

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