APPLICATION OF ARTIFICIAL IMMUNE SYSTEM IN DESIGNING POWER SYSTEMS STABILIZER

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A project report submitted in partial fulfillment of the requirements
for the award of the degree of
Master of Engineering (Electrical – Mechatronics and Automatic Control)

Faculty of Electrical Engineering
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MAY, 2007

Dedicated to my beloved parents, for their everlasting support and encouragement to complete the course of this study.

ACKNOWLEDGEMENT

Alhamdullillah, I am grateful to ALLAH SWT for His blessing and mercy in
making this project successful.

I wish to express my sincere appreciation to my project supervisor Dr. Hj. Mohd. Fauzi Othman for his effort, encouragement and guidance. In preparing this project report, I did a lot of reading and research on past projects, thesis and journals for my reference. They have given me tips and useful information in order for me to complete my analysis and research.

To all the lecturers who have taught me, thank you for the lessons you have delivered. I would also like to thank my friends, thank you for their useful ideas, information and moral support during the course of study.

Last but not least, I would like to express my heartiest appreciation to my parents, who are always there when it matters most.

Abstract

Biological Immune system is a control system that has strong robusticity and self-adaptability in complex disturbance and indeterminacy environments. This thesis proposes an appropriate artificial immune system algorithm to develop an immune controller. The idea of immune controller is adept and derived from biological vertebrate immune system. Mimicking and imitating of biological immune system or better known as the artificial immune system is thus developed. Applying and implementing of the algorithm of the artificial immune system is to develop an immune controller. There are various model of artificial immune controller but only the most suitable will be selected. The selected artificial immune controller has the resemblance and similarity of a proportional integral derivative controller. The selected immune controller is to be implemented into the power systems stabilizer. The immune controller is to obtain and achieve system goals in enhancing the performance and stability of power systems. The approach is to prove that an immune controller using artificial immune system algorithm can be used as a controller to obtain steady state output response.

Abstrak

Sistem kekebalan biologi merupakan sistem kawalan yang mempunyai kebolehgunaan dan penyesuaian diri yang kuat dalam menghadapi gangguan yang kompleks dan persekitaran yang tidak diduga. Tesis ini mencadangkan algoritma sistem kekebalan tiruan untuk membangunkan kawalan kekebalan. Idea kawalan kekebalan diperolehi daripada sistem kekebalan biologi daripada haiwan vetebrata. Meniru gaya sistem kekebalan biologi atau lebih dikenali sebagai sistem kekebalan tiruan boleh dicipta. Menggunakan algoritma daripada sistem kekebalan tiruan untuk membangun kawalan kekebalan. Terdapat pelbagai jenis kawalan kekebalan tiruan tetapi hanya yang paling sesuai akan dipilih. Kawalan kekebalan tiruan yang dipilih mempunyai ciri-ciri dan persamaan dengan kawalan pengkamilan, pembezaan dan pendaraban. Kawalan kekebalan yang terpilih akan digunakan kedalam sistem penstabilan kuasa. Kawalan kekebalan bertujuan untuk mencapai matlamat dalam meningkatkan keupayaan dan menstabilkan sistem kuasa. Capaian ini adalah untuk membuktikan bahawa kawalan kekebalan menggunakan algoritma sistem kekebalan tiruan boleh digunakan sebagai kawalan untuk mencapai tindak balas keluaran yang stabil.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Ti	-	quantity of the antibody
Bi	-	quantity of B cell
K1	-	mortality of the antibody which is caused by the antibody interaction
K2	-	natural mortality of the antibody
K3	-	reproduction rate of antibody which is caused by the mature B cell
K4	-	mortality of the B cell
K5	-	reproduction rate of B cell which is caused by the B cell itself
K6	-	new reproduction rate of B cell which is caused by the bone marrow
M(σi)	-	mature function of the Bi cell
P(σi)	-	reproduction function of which the Bi cells reproduce the Ti antibody
Q	-	reproduction rate of the antigen when the immune process doesn't exist
Ke	-	approximate rate of antigen's being specially eliminate
Ag	-	the reproduction of antigen
e(t)	-	error of the control system
u(t)	-	output of the immune controller
f(e,u)	-	immune controller
G(s)	-	object controlled by the immune controller
r(t)	-	input signal
y(t)	-	output response

LIST OF ABBREVIATIONS

AI	-	Artificial Intelligence
AIS	-	Artificial Immune System
ANNPSS	-	Artificial Neural Network Power Systems Stabilizer
APCs	-	Antigen Presenting Cells
APSS	-	Adaptive Power Systems Stabilizer
AVR	-	Automatic Voltage Regulator
BVINM	-	Basic Varela Immune Network Model
CPSS	-	Conventional power System Stabilizer
DARS	-	Distributed Autonomous Robotic System
FLCPSS	-	Fuzzy Logic Controller Power System Stabilizer
GA	-	Genetic Algorithm
NFPSS	-	Neuro Fuzzy Power Systems Stabilizer
PSS	-	Power Systems Stabilizer
IVINC	-	Improved Varela Immune Network Controller
IVINM	-	Improved Varela Immune Network Model
VINM	-	Varela Immune Network Model

CHAPTER 1

INTRODUCTION

1.1 Introduction

The successful operation of a power system depends largely on the engineer's ability to provide reliable and uninterrupted service to load. The reliability of the power supply implies much more than merely being available. Ideally, the loads must be fed at constant voltage and frequency at all times. In practical terms this means that both voltage and frequency must be held within close tolerances so that the consumer's equipment may operate satisfactorily. For example, a drop in voltage of 10-15% or a reduction of the system frequency of only a few hertz may lead to stalling of the motor loads on the system. Thus it can be accurately stated that the power system operator must maintain a very high standard of continuous electrical service.

Electrical power systems are among the largest structural achievement of man. Some transcend international boundaries, but others supply the local needs of a ship or an aero-plane. The generators within an interconnected power system usually produce alternating current and are synchronized to operate at the same frequency. In a synchronized system, the power is naturally shared between generators in the ratio of the rating of the generators, but this can be modified by the operator. Systems which operate at different frequencies can also be interconnected, either through a frequency converter or through a direct tie. A direct current tie is also used between system that, while operating at the same nominal frequency, have difficulty in remaining in synchronism if interconnected.

Conventional power systems stabilizers contain a phase lag/lead network for phase compensation has played a very significant role in enhancing the stability of power systems. There are various new approaches based on modern control and artificial intelligence techniques to improve the performance of the power systems stabilizer being proposed during the past 30 years. Although it is feasible to develop a satisfactory stabilizer using any one of these techniques, each has its unique strengths and drawbacks. One of the proposed techniques is the application of artificial immune system to power system stabilizer. This paper proposes an optimization algorithm imitating the immune system to design power systems stabilizer in enhancing the stability of power and to improve damping of low frequency oscillations using a suitable artificial immune algorithm.

1.2 Objectives

The objectives of this thesis are to study and analyze for the mathematical model and algorithm of artificial immune system. Here are various types of mathematical mode of immune algorithm can be found from books, journals, thesis papers, internet etc. The artificial immune algorithm to be chosen in this analysis must have the similarity or heuristic between the artificial immune controller and the control system itself. By using a selected artificial immune algorithm an immune controller is to be developed. The immune controller is then tested and simulated using MATLAB Simulink to observe its output response and performance. Once the desired immune controller is obtained, the immune controller is implemented to a power systems stabilizer. The application of this immune controller is to design a power systems stabilizer which optimizes the performance of power systems and enhances the stability of power. The main objective of the immune controller is to enhance the quality of the control system and the damping of low frequency oscillations in the power systems stabilizer.

From the various parameters of the IVINC controller, we can conduct analysis from the simulation results to obtain steady state output response. These parameters will be the guideline or reference for the implementation of further test and analysis of IVINC controllers. The IVINC controller will be implemented into the two area test system of the power systems stabilizer. The IVINC controller will be pair with other conventional controller using various combinations to analyze the systems output response. The purpose of the analysis is to compare between the IVINC and the conventional controller in obtaining stable output response. Different combinations of controllers produce different output response, stability, settling time and peak.

1.3 Scope of Work

The scope of work is to study and analyze various mathematical model of immune algorithm in order to design immune controller. The mathematical model of the immune algorithm must have the quality or other relation or characteristics of the control system. With a selected artificial immune system elements and algorithm the purpose of the project is to design an artificial immune controller. The controller then has to be tested and simulated using a MATLAB Simulink. Once the appropriate immune algorithm has been obtained, we can use it to design a power systems stabilizer. The artificial immune system algorithm technique can be used to develop a satisfactory stabilizer so as to enhance the stability of the power system. The immune controller is to be implemented into the power system transfer function using MATLAB Simulink. From there we can observe the output response. Improvement and adjustment of the immune controller variables need to be conducted from time to time in order to obtain a good result and performance of the output response of the power system.

1.4 Expected Contribution

The artificial immune controller is the first method to be implemented to the two test area system of the power systems stabilizer. Through analysis and simulation it is observed that IVINC controller can perform as well as other controllers in achieving stability. The IVINC Controller is able to produce good simulation result in damping low frequency oscillation in power systems just like other conventional controllers. Furthermore, IVINC controllers can be implemented and applied in other control system applications.