UNIVERSITI PUTRA MALAYSIA

DESIGN OF ROBUST PARTICLE SWARM OPTIMIZATION - TUNED FUZZY CONTROLLER FOR A SINGLE AXIS SMALL MAGNETIC LEVITATION SYSTEM

BASHEER NOAMAN HUSSEIN

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By

BASHEER NOAMAN HUSSEIN

Thesis submitted to the School of Graduate Studies of University Putra Malaysia in the fulfilment of the requirements for the Degree of Master of Science

OCTOBER 2010

DEDICATION

This thesis is dedicated to

My dearest Parents, Brother and Sisters, and Grandmother

The understanding and encouragement they provided during all these years of study

Also, this thesis is dedicated to

My fiancée Sara Ali and the memory of my cousin Yasir Kahtan

I love you

Abstract of the thesis presented to the School of Graduate Studies of University Putra Malaysia in the fulfilment of the requirement for the degree of Master of science

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Chairman: Nasri bin Sulaiman, PhD

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A control system is robust when it has low sensitivity, it is stable over the range of parameter variations and the performance continues to meet the specification in the presence of a set of changes in the system parameters and disturbances.

In this work the design of the robust linear and nonlinear controllers for Single Axis Magnetic Levitation System are presented. These controllers must overcome the problems of the high steady state error and robustness in the magnetic levitation system. The design of H_∞ robust controller is presented first and the system dynamics are linearized to be suitable for applying the H_∞ robust control technique. The magnetic force is regulated using this controller to achieve robust stability and performance, disturbance/noise rejection and asymptotic tracking with zero steady

state error. The plant with structured uncertainty is expressed in terms of unstructured multiplicative uncertainty to cover the overall change in system parameters. The unstructured multiplicative uncertainty is determined using curve fitting method.

The designed H_∞ controller has assured robust stability and robust performance of the single axis magnetic levitation system with parametric uncertainty. The parameters of the performance and control weighting functions that are obtained using trial and error lead to obtain a robust controller that achieves force control of magnetic levitation system.

The design of PD like fuzzy robust controller is presented secondly in this work. The Particle Swarm Optimization method (PSO) is used to find the optimal values of the Scalar gains and the membership functions subject to the robust control and minimum error constraints. The designed PD like fuzzy controller has assured robust stability and robust performance of the nonlinear model of single axis magnetic levitation system. This controller minimizes the rules from 64 rules to 16 rules and achieved zero steady state error without using the integral.

Finally, a comparison between the performances of the H_∞ controller and the optimal fuzzy logic controller has been made. It shows that the nonlinear optimal fuzzy logic controller achieve better performance than the linear H_∞ controller.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

REKABENTUK DARI TEGAP KAWANAN ZARAH PENGOPTIMUMAN PENYESUAIAN KAWALAN SAMAR BAGI SUATU UNTUK KECIL SISTEM MAGNET PENGANGKATAN

Oleh

BASHEER NOAMAN HUSSEIN

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Sistem kawalan adalah tegap apabila ia mempunyai kepekaan yang rendah, keseimbangan di dalam julat variasi pembolehubah dan mempunyai prestasi yang menepati spesifikasi walaupun terdapat perubahan pembolehubah dan gangguan di dalam sistem.

Di dalam kajian ini, rekaan alat kawalan lelurus dan tidak lelurus yang tegap untuk sistem magnet pengangkatan satu paksi dibentangkan. Alat kawalan ini mencapai tahap ketegapan untuk variasi di dalam pembolehubah sistem dalam julat yang luas. Rekaan alat kawalan yang kuat lagi tegap H_∞ dibentangkan dan dinamik sistem dileluruskan supaya teknik H_∞ sesuai diaplikasikan. Daya magnet diaturkan menggunakan alat kawalan ini untuk mencapai kekuatan dan ketegapan dari segi keseimbangan dan prestasi, menolak gangguan dan menjejak isyarat rujukan. Kilang

dengan ketidakpastian berstruktur dilahirkan dalam bentuk ketidakpastian pendaraban tidak berstruktur untuk melitupi perubahan keseluruhan di dalam pembolehubah sistem. Ketidakpastian pendaraban berstruktur diperolehi melalui kaedah garisan lengkungan yang sesuai.

Alat kawalan H_∞ dapat memastikan kekuatan dan ketegapan dari segi keseimbangan dan prestasi untuk sistem magnet pengangkatan satu paksi dengan ketidakpastian. Pembolehubah fungsi pemberat diperolehi kaedah cuba jaya seterusnya mendorong untuk mencapai alat kawalan yang kuat lagi tegap untuk system kawalan daya magnet pengangkatan.

Di samping itu, rekaan alat kawalan samar seperti PD turut dibentangkan di dalam penyelidikan ini. Kaedah yang dikenali sebagai Particle Swarm Optimization (PSO) digunakan untuk mendapatkan nilai keuntungan dan fungsi keahlian yang optimum, tertakluk pada kawalan yang kuat lagi tegap dan ralat yang kecil. Rekaan alat kawalan samar seperti PD memastikan kekuatan dan ketegapan dari segi keseimbangan dan prestasi bagi model sistem magnet pengangkatan satu paksi yang tidak lelurus. Alat kawalan ini meringkaskan peraturan dari 64 ke 16 peraturan.

Akhir sekali, perbandingan di antara alat kawalan H_∞ dan kawalan samar optimal dibuat. Ia menunjukkan alat kawalan samar optimal mencapai prestasi yang lebih baik berbanding alat kawalan H_∞.

ACKNOWLEDGEMENT

In the name of Allah SWT, the Most Gracious and the Most Merciful, I offer my humble thank gratitude You for giving me the strength to complete this thesis.

First and foremost, my sincere gratitude and appreciation goes to my supervisor, Dr. Nasri Sulaiman, and to my co-supervisors Dr. Raja Mohd Kamil and Associate Professor Dr. Mohammad Hamiruce for their constructive ideas, criticism, guidance and patience throughout the long duration of preparing this thesis. They have successfully guided me through some stressful times and were always willing to sharpen my understanding of this thesis and other academic activities.

I am also greatly indebted to Hazem I. Ali for his valuable insights, comments, ideas and suggestions in the course of improving and completing this thesis. I wish to thank Zeyad Assi Obaid for his kind assistance rendered to me in my study.

I wish to mention my beloved father, Noaman Hussein Ali who was instrumental in this accomplishment. My greatest pleasure would be to share this moment with him. Due appreciation is also extended to my mother, Amal Abed Shakir, my sisters and brother who have given me their prayers, encouragement, and unfailing support for me to go throughout this long journey.

Finally, I would like to extend my gratitude and affection to my Fiancée Sara Ali. Thank you for providing me the support with your patience, love, encouragement, and inspiration that has greatly facilitated the completion of this challenging effort.

I certify that a Thesis Examination Committee has met on __11/10/2010__ to conduct the final examination of **Basheer Noaman Hussein** on his thesis entitled "**Design of Robust Particle Swarm Optimization – Tuned Fuzzy Controller for Single Axis Small Magnetic Levitation System** " in accordance with the Universities and University Colleges Act 1971 and the Constitution of the University Putra Malaysia [P.U.(A)] 15 March 1998. The Committee recommends that the Student be awarded the relevant Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Date: December / 2010

DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

BASHEER NOAMAN HUSSEIN

Date: 11 / 10 / 2010

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