NEW TYPES OF KNOWLEDGE ABOUT SYSTEM DYNAMICS FOR INTELLIGENT CONTROL SYSTEM DESIGN

BY

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Abstract

This is a thesis by publication. This thesis comprises ten published/submitted journal articles including eight research articles and two review articles. Five of these journal papers have been already published or finally accepted for publication. This thesis, based on research undertaken in the area of intelligent and non-model-based control, aims at broadening knowledge about system dynamics applicable for control system design. Currently, mathematical models of systems, experimental input-output data and experts' knowledge in the form of fuzzy rules (linguistic expressions) are three types of knowledge about systems dynamics which are employed in control system design. These types of knowledge are used to define the number and the positions of controllers in the control system (architecture of control systems) and/or the mathematical form of controllers (controllers' structure) and/or controllers' parameters. Defining control systems at these three levels (architecture, controllers' structure and parameters) forms the process of control design.

In the area of non-model-based control, some cases of unexpected poor control performance were observed by the author. For instance, neuro-predictive method controls process plants very well. This method is based on input-output data. Thus, this control technique seems to promise a good control performance in general. However, attempts to use this technique in yaw angle control of a model helicopter were unsuccessful regardless of the effort spent on tuning the controller parameters (see Chapter 3); similarly, unsuccessful outcomes resulted for feedback fuzzy control of model helicopter pitch angle (see Chapter 4). This thesis has two main contributions: firstly, this thesis provides explanation for the aforementioned unexpected poor performances through introduction of two new concepts:

Control Inertia (see Chapter 3) and Generalized-Type-Zero (GTZ) Systems (see Chapter 7). It is shown here that high control inertia systems witness a considerable repeating overshoot, and GTZ systems need consistent control input to maintain their desirable control output. Secondly, based on these two new concepts, this thesis offers new control methods with developing new control ideas: fuzzy brakes and steady state control laws which can improve the performance, energy consumption and suitability for implementation of control systems. The proposed methods are shown to be usable for a wide range of systems. The merits of the proposed control approaches were indicated theoretically and practically. As a result, being/not being high control inertia and being/not being GTZ were used as new types of knowledge about system dynamics applicable in control system design.

Statement of originality

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution. To the best of my knowledge and belief it contains no material previously published or written by another person, except where due reference has been made in the text.

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I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Morteza Mohammadzaheri 2/09/2010

Declaration regarding receipt of editorial advice

I, Morteza Mohammadzaheri, declare that I have received editorial advice in the writing of this thesis. This advice was restricted to the suitability for purpose of the language and illustrations in the publication and to completeness and consistency of English expression in this publication. This nature of this advice was in accordance with Sections D and E of the Australian Standards for Editing Practice. The editor's current or former area of academic specialisation is unrelated to my own.

Morteza Mohammadzaheri 2/09/2010

Statement of authorship

A Critical Review on Fuzzy Control
Text in manuscript.

A Critical Review on Neuro Control
Submitted to Asian Journal of Control, 28 June 2010.

Intelligent Predictive Control of Model Helicopter's Yaw Angle
Asian Journal of Control, Volume 12, No. 6, Pages 1-13, November 2010.

Design and Stability Discussion of a Hybrid Intelligent Controller for an Unordinary System
Asian Journal of Control, Volume 11, No. 5, Pages 476-488, September 2009.

Double Command Fuzzy Control of a Nonlinear CSTR
Korean Journal of Chemical Engineering, Volume 27, Number 1, Pages 19-31, January 2010.

Intelligent Control of a Nonlinear Tank Reactor
Asian Journal of Control (in press), finally accepted for publication on 11 December 2009.

A Design Approach for Feedback-feedforward Control Systems
Text in manuscript.

Double Command Feedforward-Feedback Control of a Nonlinear Plant
Korean Journal of Chemical Engineering, Volume 27, No. 5, Pages 1-13, September 2010.

Model-Free Double Command Hybrid Control of a Non-thermic CSTR
Text in manuscript.

Hybrid Intelligent Control of an Infrared Dryer
Submitted to Control Engineering Practice, 2 September 2010.

Mr. Morteza Mohammadzaheri (Candidate)

Statement of contribution (in terms of the conceptualization of the work, its realization and its documentation)

Proposed ideas, performed analysis, interpreted data, wrote manuscript and acted as corresponding author
Certification that the statement of contribution is accurate

Signed : .....*Date*..21/FEB/2011

Dr. Lei Chen (Supervisor)

Statement of contribution (in terms of the conceptualization of the work, its realization and its documentation)

Supervised development of work, helped in manuscript evaluation

Certification that the statement of contribution is accurate and permission is given for the inclusion of the paper in the thesis

Signed ... .*Date*..2/02/2011

Thesis by Publication

This thesis comprises a portfolio of publications that have been published and/or submitted for publication and/or text in manuscripts in accordance with the 'Academic Program Rules 2008' approved by the Research, Education and Development Committee of the University of Adelaide. Five of the research journal articles, presented here, have already been published or finally accepted for publication. All journals to which the articles have been submitted are indexed in the lists of internationally and nationally most reputable research databases: ISI, JSR and ERA.

This thesis is based on the following publications (in the order of appearance in the thesis):

1. Morteza Mohammazaheri and Lei Chen, "A Critical Review on Fuzzy Control", text in manuscript.
2. Morteza Mohammazaheri and Lei Chen, "A Critical Review on Neuro Control", submitted.
3. Morteza Mohammazaheri and Lei Chen, "Intelligent Predictive Control of Model Helicopter's Yaw Angle" Asian Journal of Control, Volume 12, No. 6, Pages 1-13, November 2010.
4. Morteza Mohammazaheri and Lei Chen, "Design and Stability Discussion of a Hybrid Intelligent Controller for an Unordinary System", Asian Journal of Control, Volume 11, No. 5, Pages 476-488, September 2009.
5. Morteza Mohammazaheri and Lei Chen, "Double Command Fuzzy Control of a Nonlinear CSTR", Korean Journal of Chemical Engineering, Volume 27, Number 1, Pages 19-31, January 2010.
6. Morteza Mohammazaheri and Lei Chen, "Intelligent Control of a Nonlinear Tank Reactor", Asian Journal of Control (in press).
7. Morteza Mohammazaheri and Lei Chen, "A Design Approach for Feedback-feedforward Control Systems", text in manuscript.
8. Morteza Mohammazaheri and Lei Chen, "Double Command Feedforward-Feedback Control of a Nonlinear Plant" Korean Journal of Chemical Engineering, Volume 27, No. 5, Pages 1-13, September 2010.
9. Morteza Mohammazaheri and Lei Chen, "Model-Free Double Command Hybrid Control of a Non-thermic CSTR", text in manuscript.
10. Morteza Mohammazaheri and Lei Chen, "Hybrid Intelligent Control of an Infrared Dryer", submitted.

In addition, several conference papers have been presented from the research reported in this thesis. Two of them are included in this thesis as appendices:

1. Morteza Mohammadzaheri and Lei Chen, "Intelligent Modeling of MIMO Nonlinear Dynamic Process Plants for Predictive Control Purposes", 17th IFAC World Conference, 6-11 July 2008.
2. Morteza Mohammadzaheri and Lei Chen, "Anti-overshoot Control of Model Helicopter's Yaw Angle with Combination of Fuzzy Controller and Fuzzy Brake",

International Conference on Intelligent and Advanced Systems (IEEE sponsored), Kuala Lumpur, Malaysia, 25-28 November 2007.

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