Book Review

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Fuzzy Modeling and Fuzzy Control by Huaguang Zhang and Derong Liu, Boston, MA: Birkhauser, 200, pp. 416. ISBN: 978-0-8176-4491-8.

Fuzzy system research has attracted growing attention recently from both academia and industry. For instance, in the February 2007 issue of the *IEEE Computational Intelligence Magazine*, a set of feature articles dedicated for Type-2 fuzzy sets and their applications were presented to the world-wide research community. Over the past decades, fuzzy logic methodology has been proven to be effective in dealing with complex nonlinear systems with uncertainties that are otherwise difficult to model. Therefore, it has been widely applied to different application domains, such as robust control, chaos control, filter design, and many others. Meanwhile, with the development of science and technology, there emerge many new opportunities as well as challenges related to fuzzy system research. It is crucial to have a book that covers these emerging topics within a unified framework. I am delighted to find that the book written by Professor Zhang and Professor Liu fulfills these needs fairly well, which also presents the latest research achievements on fuzzy modeling and fuzzy control by the two authors, including a novel fuzzy model, named fuzzy hyperbolic model (FHM) and its various applications.

This book presents a systematic framework targeting at fuzzy modeling and fuzzy control of nonlinear systems with uncertainties. The entire book is organized into three major parts incorporating 13 chapters. The first part contains four chapters focusing on the modeling of nonlinear dynamical systems by using fuzzy logic. The second part includes five chapters in which fuzzy inference and control techniques are dealt with. The final part consists of four chapters, which covers several advanced topics in fuzzy control ranging from controller and filter design to chaotification of fuzzy systems and feedforward fuzzy control of nonlinear systems via Fourier integrals.

The first part includes Chapters 1–4. Chapter 1 starts with introducing fuzzy set theory and rough set theory. First, fundamental concepts and properties of classical fuzzy set theory are reviewed. After that, basic concepts of rough set theory are introduced, which provides introductory materials to be used throughout the book.

Chapter 2 introduces three methods for identifying multiple input single output (MISO) nonlinear dynamical systems by using the Takagi–Sugeno (T–S) fuzzy model, including an off-line identification method with high accuracy; an on-line identification method with fast convergence; and an identification method based on genetic algorithm (GA). This chapter provides systemic fuzzy modeling methods by T–S fuzzy model for three different system modeling problems, including transformation of the input-output process data to a fuzzy T–S model with high accuracy, on-line modeling of fast dynamic systems with time-delays, and deriving the optimal structure and parameters of T–S fuzzy model.

Chapter 3 addresses both structure and parameter identification problems by using a new data analysis method, the rough set data analysis (RSDA) method. The basic concepts are introduced first, and then a new rough information measure is defined to identify the input structure. Next, a novel input structure identification algorithm is developed based on this rough information measure. Furthermore, a fuzzy relation model is constructed by using the RSDA to search the optimal input space of fuzzy model. In this chapter, RSDA, data filtering, and fuzzy C-means clustering (FCM) are applied to the modeling procedure, which help readers find another data analysis and fuzzy modeling approach.

Chapter 4 is the most innovative part in whole book, which develops two new nonlinear state-space models, FHM and its generalized form GFHM. GFHM is proved to be a universal approximator. Moreover, this chapter gives a modeling process of FHM and a method for identification of the GFHM, which provides the readers with an alternative approach for fuzzy model design.

In Part II (Chapters 5–9), both the basic fuzzy inference and control techniques and several advanced fuzzy control

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approaches are introduced. These include fuzzy performance evaluator-based methods, generalized predictive fuzzy control methods, and adaptive control methods based on fuzzy basis functions.

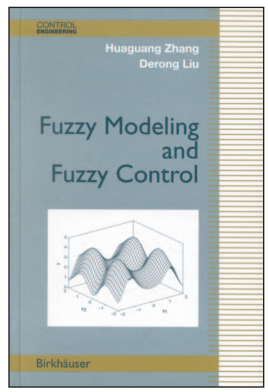
Chapter 5 discusses the basic methods of fuzzy inference and fuzzy control. First, major concepts of fuzzy rule-based model are introduced, and the relationship between controller parameters and control system's responses of the fuzzy self-tuning control system is addressed. Second, a method for automatic generation of fuzzy action table or look-up table is developed and analyzed in detail. Finally, the presented control methods are applied to a temperature control problem of steam power plant.

Chapter 6 gives the definition of similarity measures, pattern matching of rules, composition of confirmation strength, and reasoning of combined rules. A fuzzy controller design scheme is also developed in which the above inference methods concerning two kinds of uncertainties are applied, and then applied to a real system. The development and design principle of this chapter can be extended to a variety of engineering applications.

In Chapter 7, a novel fuzzy adaptive control scheme and a fuzzy static feedback control scheme are developed based on fuzzy performance evaluator (FPE). First, a fuzzy model is employed to represent a nonlinear system. Then, based on the fuzzy model, a FPE is developed to predict and overcome the matching errors and disturbances. Finally, an H_∞ controller is obtained via FPE.

Chapter 8 presents an effective multivariable fuzzy model-based generalized predictive control (FGPC) approach. The advantages of this method are that the design procedure and the tuning of the controller parameters are simple to understand and implement for a multivariable nonlinear plant, especially with large time-delay and time-varying parameters. The stability, robustness and other properties of fuzzy generalized predictive control systems are analyzed in detail, and comparison of fuzzy predictive control and conventional control is also proposed.

Chapter 9 proposes an adaptive control scheme based on fuzzy basis function vector (FBFV) method for both MIMO square and MIMO nonsquare nonlinear systems, in which the FBFV is used to learn the MIMO nonlinear system uncertainty bounds, and an adaptive hybrid controller based on FBFV is designed to eliminate the effects of dynamical uncertainties and guarantee that the output tracking errors converge asymptotically to zero. The advantages of this method are strong robustness, fast convergence, and simple design procedure.



The final part covers several advanced topics in fuzzy control, including Chapters 10–13. In Chapter 10, the availability of FHM is enough showed. The well-known pole-placement method in linear control system theory is first extended to the fuzzy hyperbolic case, and then to stable controller design in the fuzzy hyperbolic function form. Furthermore, based on optimal control theory, H_∞ theory and nonlinear control system theory, a new nonlinear H_2 optimal controller and a novel H_∞ controller are developed. The main advantages of the proposed controllers are that the structures of controller are simple and the design can easily be performed. This chapter also studies fuzzy hyperbolic control law with guaranteed cost for nonlinear continuous-time systems with parameter uncertainties and its conclusion is given in terms of the feasibility of linear matrix inequalities (LMIs).

Chapter 11 deals with the fuzzy filter design problem for nonlinear discrete-time systems with time delays in the state variables. The analysis results and design methods of fuzzy H_∞ filters based on the T–S fuzzy model are expanded to a class of nonlinear discrete-time systems with multiple time delays and uncertainties. Also, the fuzzy H_∞ problem is converted to a linear matrix inequality (LMI) problem, while the LMI problem can efficiently be solved by the convex optimization techniques with global convergence.

In Chapter12, based on FHM, the chaotification of a nonlinear system is achieved by two approaches, i.e., the impulsive control method and the inverse optimal control method. The effectiveness and merit of the FHM are further demonstrated.

In Chapter 13, the Fourier integral is used for the function mapping and a novel Fourier integral-based adaptive method is used for the feedforward controller, while the fuzzy sliding mode control (FSMC) method is used for the feedback controller.

I would like to summarize several major significant contributions and characteristics of this book. First, the materials in this book are organized in a very systematic way. The fuzzy modeling, fuzzy control and applications are organized within a unified framework. The differences between every fuzzy model are presented in detail, and each fuzzy model is applied in wide control aspect throughout the book so that readers can easily penetrate proposed fuzzy models and catch the key of applications.

Second, this book presents the latest original research developments in this field. This includes identification problems by using the RSDA, fuzzy modeling and control based on FHM or GFHM, chaos control based on FHM, the novel Fourier integral-based adaptive method, and so on. These novel ideas provide the readers with an alternative approach for fuzzy modeling and controller design.

Third, besides the emphasis upon theoretical analyses and derivations, rich examples have been given so as to bridge the gaps between control system theory and practical applications by approaches and issues proposed in this book, such as temperature control problem of a steam power plant, the real inverted pendulum, mass-spring system, stirred tank reactor, and so on.

Last, but not least, each chapter gives a detailed introduction and a concise conclusion so that readers can understand the background of the discussed problems and quickly capture the topic of each chapter. Every chapter is a helpful guide for anyone engaged in the research on analysis and applications of fuzzy modeling and fuzzy control. Moreover, it provides the readers with all necessary references to relevant bibliography, thus offering ample opportunity for further exploration on the algorithms covered in the book.

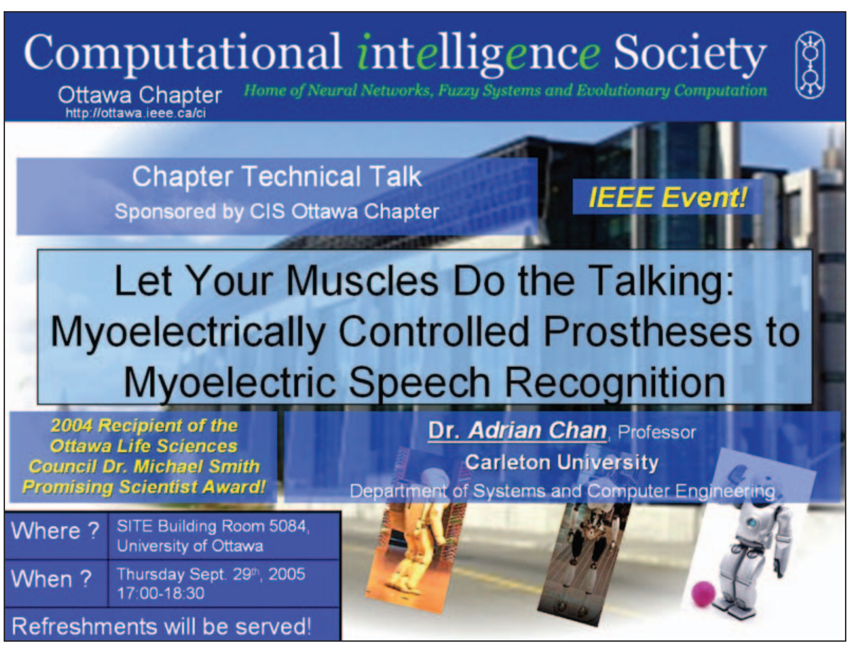
This book is a valuable resource for those researchers and practitioners interested in expanding their knowledge from fuzzy logic and application to nonlinear dynamical systems. It discusses a currently very active research topic and provides an excellent extension to a graduate course in nonlinear dynamic systems or fuzzy modeling and control. In any case, the book could be a valuable addition to a well-stocked academic or corporate library, particularly for universities or organizations that interested in the subject.

In summary, this is a well-written book, and it is clear that Professor Zhang and Professor Liu have made important research contributions in the area of fuzzy modeling and fuzzy control. This book provides the current status and future developments in the modeling and control for nonlinear dynamic systems. Integrated systematic framework, significant original research development, and balanced theoretical analyses and application research, are the major contributions of this book.

Editor's Remarks (continued from page 2)

exchange media but only if members from around the globe actively contribute. To ensure we are serving your needs, the success of this magazine relies heavily upon your active contribution, so submit your research, report your local chapter activities, and provide feedback and comments. As your Editor-in-Chief, I invite you to contact me at with encouragements as well as criticisms.

Family Corner (continued from page 7)



Poster for Prof. Adrian Chan's talk held on September 29, 2005 at the University of Ottawa.

In 2008, the chapter has already organized a lecture as mentioned above and is planning to organize a total of 5 talks. Two more talks will be organized in the summer of this year, and another two in the fall. The upcoming lectures will focus on applications (such as bioinformatics, circuits and systems design, financial analysis) and areas (such as fuzzy logic, granular computing, and evolutionary algorithms) of computational intelligence that have not been addressed in previous talks and from which our members can benefit. As a chapter objective, we continue to build up this chapter to become the meeting place of choice for the computational intelligence community in the Ottawa region. For more information please visit the chapter website at http://ottawa.ieee.ca/ci.