Book Review

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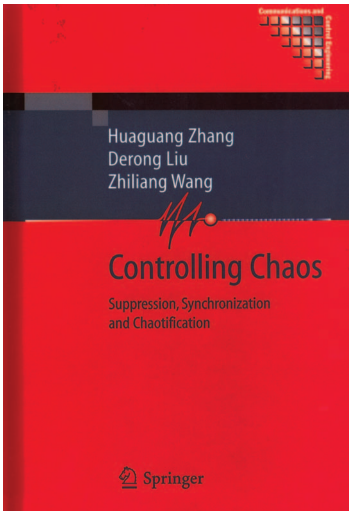
Controlling Chaos: Suppression, Synchronization and Chaotification, by Huaguang Zhang, Derong Liu, and Zhiliang Wang (Springer, London, 2009)

One of the interests of the IEEE Computational Intelligence Society is the study of non-linear dynamical systems, such as fuzzy systems and neural networks. As many non-linear dynamical systems exhibit chaotic phenomena, the study of chaotic systems has drawn a lot of attention from the IEEE Computational Intelligence Community. From practical viewpoints, controlling chaos, such as suppressions of chaos, synchronizations of chaotic systems and chaotifications of nonchaotic systems, are important to our daily life. For a long time, it was expected to have a book covering these topics. I am delighted to find that the book written by Prof. Zhang, Prof. Liu and Prof. Wang addresses the above issues and presents the latest research results in this field.

This book presents a systematic framework on controlling chaos. The entire book is organized into four major parts incorporating nine chapters. The first part of the book contains the first two chapters covering basics and introductions on non-linear dynamical systems and chaos. The second part of the book contains two consecutive chapters presenting the latest research results on suppressions of chaos. The third part of the book contains four consecutive chapters discussing the state of arts on the synchronization of chaotic systems. Finally, the last part of the book contains the final chapter presenting recent techniques on chaotifications of nonchaotic systems.



Chapter 1 reviews the history of chaos theory and chaos control. Results from major contributors, such as Poincaré, Birkhoff, van de Pol, Littlewood, Andoronov, Lorenz, Smale, Kolmogorov, Arnol'd, Feigenbaum, Li, Yorke and May, are summarized. In addition, developments of controlling chaos from the suppression aspects of chaos, synchronizations of chaotic systems and chaotifications of non-chaotic systems are reviewed. Some representative methods, such as Ott-Grebogi-Yorke (OGY) control methods, entrainment and migration control methods, time delay feedback control methods and state feedback control methods are discussed.

Chapter 2 reviews essential mathematical backgrounds for non-linear dynamical systems and chaos. Mathematical concepts and definitions on non-linear dynamical systems, such as concepts on non-linear ordinary equations, dynamical systems, flows, fixed points, equilibrium states, invariant sets, attractors, stable and unstable manifolds, Floquet index, Lyapunov exponents and Smale horseshoeare are presented. Following on these concepts and definitions, mathematical theorems, such as theorems about existence and uniqueness of solutions, the Hartman-Grobman theorems and the Lyapunov stability theorems are presented.

Chapter 3 starts from the backgrounds of entrainment and migration control techniques. Then, a modified entrainment and migration control technique based on the open-plus-closed-loop (OPCL) control method is discussed. An improved open-plus-non-linear-closed-loop (OPNCL) control method is proposed so that restrictions of the OPCL control method are relaxed. The proposed method is illustrated through controlling various chaotic systems.

Chapter 4 discusses how adaptive control methods and inverse optimal control methods are applied for the suppression of chaos. Two new methods based on parametric adaptive controls are developed for controlling chaotic systems with multiple parameters. The

Digital Object Identifier 10.1109/MCI.2010.939582
Date of publication: 17 January 2011

1556-603X/11/$26.00©2011IEEE

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proposed control method could avoid solving complicated Hamilton-Jacobi-Bellman (HJB) equations.

Chapter 5 proposes a method to synchronize the single output signal of a response system with a drive system via a scalar controller based on the non-linear geometric control theory and an exact linearization technique. This method is further generalized to synchronize multiple output signals. An adaptive method is also proposed to synchronize two different continuous time chaotic systems. Finally, an adaptive controller is designed to synchronize discrete time chaotic systems with parametric perturbations.

Chapter 6 proposes impulsive control methods for synchronizations of chaotic systems. A complete synchronization of chaotic systems is discussed. Then, these methods are applied for synchronizing unified systems with channel time delays. Following on that, robust synchronization schemes are presented for synchronizing chaotic systems with parametric uncertainty and parametric mismatch.

Chapter 7 investigates synchronizations of chaotic systems with unknown time delays and various structures with unknown parameters. This chapter starts with the discussion of synchronizations of drive systems and response systems having the same structures but different parameters. Then, the chapter extends to the discussion of synchronizations of different chaotic systems. Finally, a synchronization of two different time delay chaotic neural networks with known and unknown parameters is illustrated.

Chapter 8 first introduces fuzzy modeling methods for synchronizations of chaotic systems via the Takagi-Sugeno (T-S) fuzzy model. Then, some hyperchaotic systems are modeled based on the proposed fuzzy models. Following on that, an $H\infty$ synchronization method for two different hyperchaotic systems is developed. Finally, time delayed chaotic systems are synchronized based on the proposed T-S fuzzy model.

Chapter 9 first develops a simple non-linear state feedback control scheme to chaotify a discrete time fuzzy hyperbolic model (FHM) with uncertain parameters. Then, an impulsive control and non-linear feedback control method is applied to chaotify a continuous time FHM. Chaotifying continuous time linear systems is illustrated via a sampled data control approach.

I would like to summarize several major contributions and characteristics of this book. First, the types of chaotic systems discussed in this book, such as Lorenz systems, Rössler systems, Hénon maps, Liu hyperchaotic systems, Liao chaotic systems, Chen chaotic systems and Lü chaotic systems are rather extensive. Second, the methods discussed in this book for stabilizing, synchronizing and generating chaos cover basic approaches to recent advanced techniques which could serve a wide range of readers. Last but not the least, this book combines the fuzzy logic and chaos control together. In particular, this book explores the FHM which is a new type of fuzzy chaotic models. Overall, this book is a valuable resource for general readers and for those researchers working in the field of chaos control.