Recent Progress in Controlling Chaos

SERIES ON STABILITY, VIBRATION AND CONTROL OF SYSTEMS

Founder and Editor: Ardéshir Guran

Co-Editors: M. Cloud & W. B. Zimmerman

About the Series

Rapid developments in system dynamics and control, areas related to many other topics in applied mathematics, call for comprehensive presentations of current topics. This series contains graduate level textbooks, monographs, and a collection of thematically organized research or pedagogical articles addressing key topics in applied dynamics.

The material is ideal for a general scientific and engineering readership, and is also mathematically precise enough to be a useful reference for research specialists in mechanics and control, nonlinear dynamics, and in applied mathematics and physics.

Reporting on academic/industrial research from institutions around the world, the SVCS series reflects technological advances in mechanics and control. Particular emphasis is laid on emerging areas such as modeling of complex systems, bioengineering, mechatronics, structronics, fluidics, optoelectronic sensors, micromachining techniques, and intelligent system design.

Selected Volumes in Series A

- Vol. 12 The Calculus of Variations and Functional Analysis: With Optimal Control and Applications in Mechanics
Authors: L. P. Lebedev and M. J. Cloud
- Vol. 13 Multiparameter Stability Theory with Mechanical Applications
Authors: A. P. Seyranian and A. A. Mailybaev
- Vol. 14 Stability of Stationary Sets in Control Systems with Discontinuous Nonlinearities
Authors: V. A. Yakubovich, G. A. Leonov and A. Kh. Gelig
- Vol. 15 Process Modelling and Simulation with Finite Element Methods
Author: W. B. J. Zimmerman
- Vol. 16 Design of Nonlinear Control Systems with the Highest Derivative in Feedback
Author: V. D. Yurkevich
- Vol. 17 The Quantum World of Nuclear Physics
Author: Yu. A. Berezchnoy

Selected Volume in Series B

- Vol. 14 Impact and Friction of Solids, Structures and Intelligent Machines
Editor: A. Guran
- Vol. 15 Advances in Mechanics of Solids: In Memory of Prof. E. M. Haseganu
Editors: A. Guran, A. L. Smirnov, D. J. Steigmann and R. Vaillancourt

SERIES ON STABILITY, VIBRATION AND CONTROL OF SYSTEMS

Series B

Volume 16

Founder & Editor: **Ardéshir Guran**

Co-Editors: **M. Cloud & W. B. Zimmerman**

Recent Progress in Controlling Chaos

Miguel A F Sanjuán

Universidad Rey Juan Carlos, Spain

Celso Grebogi

University of Aberdeen, UK

World Scientific

NEW JERSEY • LONDON • SINGAPORE • BEIJING • SHANGHAI • HONG KONG • TAIPEI • CHENNAI

Published by

World Scientific Publishing Co. Pte. Ltd.

5 Toh Tuck Link, Singapore 596224

USA office: 27 Warren Street, Suite 401-402, Hackensack, NJ 07601

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

Series on Stability, Vibration and Control of Systems, Series B

RECENT PROGRESS IN CONTROLLING CHAOS — Vol. 16

Copyright © 2010 by World Scientific Publishing Co. Pte. Ltd.

All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system now known or to be invented, without written permission from the Publisher.

For photocopying of material in this volume, please pay a copying fee through the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA. In this case permission to photocopy is not required from the publisher.

ISBN-13 978-981-4291-69-9

ISBN-10 981-4291-69-2

Printed in Singapore.

Preface

The field of Nonlinear Dynamics and Complex Systems is a very active research field in which many scientists from many different fields are contributing to its growth and development.

Among the many different and interesting problems covered in this field, we mention those in chaotic dynamics, which manifest themselves in many different scenarios in the natural and technical sciences. And the attempts of scientists to control this chaotic dynamics has contributed to a research line known as chaos control. Research on chaos control was strongly influenced by the seminal paper of Edward Ott, Celso Grebogi and James Yorke. This paper was chosen by the American Physical Society as a milestone in the last fifty years. It opened up a whole new area of research, changing philosophically our way of thinking about chaos. Previously, it was strongly believed by scientists that chaos was intrinsically uncontrollable. We understand now that chaos not only can be controlled and manipulated but that chaos can give a great inherent flexibility in choosing a large number of controllable states by applying tiny perturbations to the system under consideration. Since that publication, a lot of progress has been done in this topic, through the implementation of different techniques and algorithms with a lot of applications as well.

This present book, *Recent Progress in Controlling Chaos*, contains 15 contributions of world-renowned scientists and experts in the field of controlling chaos, and the editors of this volume are well known scientists in the field of Nonlinear Dynamics, Chaos and Complex Systems, in particular, Chaos Control. Among the topics covered are techniques used for the reduction of chaotic transport in magnetized plasmas, methods of control applied to chaotic neural networks, different methods of adaptive feedback, pulsive and delayed feedback control techniques, phase control technique, applications of control techniques to traffic, mechanical structures and neuron networks, the method of partial control of chaos useful for

controlling transient chaos in presence of noise and certain applications to celestial mechanics.

Our main goal is to offer readers a broad view of the more recent progress in the field. Besides the progress in key techniques and concepts in the field of control, some of the contributions are also very useful for those who look for applications in Science and Technology. The contributors have been carefully selected and include researchers from different areas and background. Some authors come from a more fundamental and basic background while others, a more applied and engineering background.

The book will certainly be of much use for graduate students and scientists working in Nonlinear Dynamics, Chaos and Complex Systems, in general. It provides the attractiveness for the study of the complex nonlinear systems and it brings new results and ideas to students and researchers.

Miguel A. F. Sanjuán and Celso Grebogi
Editors

Móstoles, Madrid and Aberdeen, 5 May 2009

Contents

Preface	v
1. Reduction of the Chaotic Transport of Impurities in Turbulent Magnetized Plasmas	1
<i>C. Chandre, G. Ciraolo and M. Vittot</i>	
2. Controlling Chaos in a Chaotic Neural Network	21
<i>G. He, P. Zhu, J. Kuroiwa and K. Aihara</i>	
3. Adaptive Feedback Control of Periodic Orbits in Chaotic Systems	45
<i>H. Ando, S. Boccaletti and K. Aihara</i>	
4. Feedback Anti-control of Chaos	73
<i>Y. Shi and G. Chen</i>	
5. Delayed Feedback Control Techniques	103
<i>K. Pyragas and V. Pyragas</i>	
6. Phase Control in Nonlinear Systems	147
<i>S. Zambrano, J. M. Seoane, I. P. Mariño, M. A. F. Sanjuán and R. Meucci</i>	
7. Recent Advances in Control of Complex Dynamics in Mechanical and Structural Systems	189
<i>G. Rega and S. Lenci</i>	

8.	Clipping Chaos to Cycles	239
	<i>S. Sinha</i>	
9.	A Minimal Model of City Traffic: Chaos, Critical Behavior and Control	267
	<i>J. A. Valdivia, B. A. Toledo, V. Muñoz and J. Rogan</i>	
10.	Controlling Chaotic Bursting in Map-based Neuron Network Models	291
	<i>R. L. Viana, J. C. A. de Pontes, S. R. Lopes, C. A. S. Batista and A. M. Batista</i>	
11.	Partial Control of Chaotic Systems	315
	<i>S. Zambrano and M. A. F. Sanjuán</i>	
12.	Continuous and Pulsive Feedback Control of Chaos	337
	<i>G. Litak, L. M. Saha and M. Ali</i>	
13.	Chaos Control	371
	<i>L. F. R. Turci and E. E. N. Macau</i>	
14.	Chaos Stabilization in the Three Body Problem	395
	<i>A. R. Dzhanoev, A. Loskutov, J. E. Howard and M. A. F. Sanjuán</i>	
15.	Controlling the Chaos using Fuzzy Estimation in a Gyrostat Satellite	409
	<i>A. Guran</i>	
	Index	427