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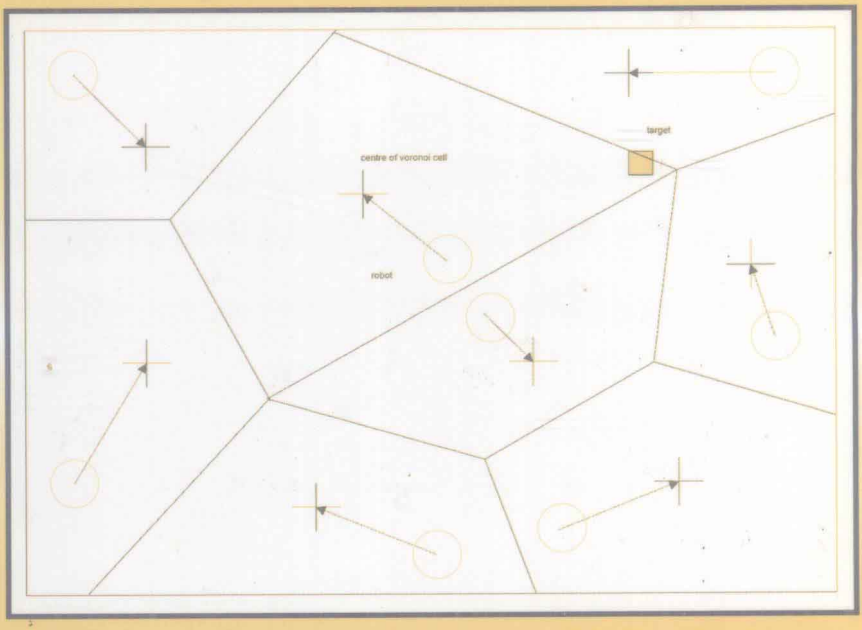
Modeling and Control of Complex Systems



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Modeling and Control of Complex Systems

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Modeling and Control of Complex Systems

AUTOMATION AND CONTROL ENGINEERING

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Preface

Broadly speaking, a complex system consists of a large number of interacting components, which may include molecules, cells, bacteria, electronic chips, computers, routers, automobiles, even people or business firms. Interactions among the elements of such systems are often nonlinear and lead to rich dynamics, with patterns and fluctuations on many scales of space and time. They are often hard to understand, model and control using traditional approaches. Recent developments in the area of electronics, computational speed, sensor and communication technologies and advances in areas such as microelectromechanical systems MEMS, nanotechnology and quantum electronics open the way for new approaches in dealing with systems far more complex than one could imagine a few years ago. System theory can play a significant role in understanding, modeling, and controlling such complex systems. There is a general understanding that complex system theory together with technological advances in materials, electronics, and sensors will help solve new nontraditional problems in addition to the traditional ones, push the performance envelope further, and open the way for new products and more efficient operations. As complex system and feedback control concepts penetrate different disciplines, new notation is generated and new techniques are developed, leading to many publications, with results and products scattered in different journals, books, conference proceedings, and so on. Given the multidisciplinary nature of complex systems the scattering of information across different areas creates a chaotic situation for the reader who is interested in understanding the complexity and possible solutions as they apply to different areas and applications.

The purpose of this book is to bring together a number of research experts working in different areas or disciplines to present some of their latest approaches and future research directions in the area of modeling and control of complex systems in a language that can be understood easily by system theorists. By bringing together different experts with different views and application areas the book provides a better picture of the issues involved in dealing with the modeling and control of complex systems in completely different areas. What works in one area may fail in another and an acceptable approach in one area may produce revolutionary results in another.

The book contains sixteen chapters covering an indicative spectrum of the different areas and disciplines that can be classed as complex systems. These include neural networks for modeling and control, modeling and control of civil structures, transportation systems, sensor networks, genomics, computer

networks, unmanned air vehicles, robots, biomedical systems, fluid flow systems, home automation systems, and so on. The focus is not only on the theoretical treatment of the topic but also on the application and future directions. Readers from different disciplines with interest in modeling and control of complex systems will benefit from the book as they will learn how complexity is dealt with in different disciplines by researchers of different backgrounds using different approaches. This feature of the book is very educational and will help researchers learn about methodologies in other areas that may be applicable to their area. In addition it will enable people to shift to other research areas within complex systems where their approach and methodology will lead to new solutions.

The book is intended for people who are interested in the theory and application of a system approach to handle complex systems in a very wide range of areas. Possible solutions to the modeling and control of complex systems may include, in addition to theory and simulation tools, the use of advanced sensor and communication technologies for implementation. This mix of theory simulation and technology becomes a strong educational vehicle for enlarging knowledge beyond the bounds of specific topics in which most researchers are often trapped. It encourages a multidisciplinary approach to deal with complexity, which has the potential of leading to new breakthroughs and advances.

We wish to thank all the authors for their valuable time and efforts in putting together this book, for their hard work, and for sharing their experiences so readily. We also thank the reviewers for their valuable comments in enhancing the contents of this book. Last, but not least, we would like to thank Frank Lewis, the series editor, B. J. Clark, Helen Redshaw, Nora Konopka, Catherine Giacari, Jessica Vakili, and the rest of the staff at CRC for their understanding, patience, and unwavering support in materializing this book.

We hope this book will be a useful reference and a source of inspiration for all the readers in this important and growing field of research, and will contribute to the effective modeling and design of complex systems, which form the pillar of today's society.

Petros Ioannou
Andreas Pitsillides

The Editors

Dr. Petros Ioannou is a professor in the Department of Electrical Engineering-Systems, University of Southern California and the director of the Center of Advanced Transportation Technologies. He also holds a courtesy appointment with the Department of Aerospace and Mechanical Engineering. His research interests are in the areas of adaptive control, neural networks, nonlinear systems, vehicle dynamics and control, intelligent transportation systems and marine transportation.

Dr. Ioannou is a fellow of IEEE, fellow of the International Federation of Automatic Control (IFAC), and the author or coauthor of 8 books and over 200 research papers in the areas of controls, vehicle automation, neural networks, nonlinear dynamical systems and intelligent transportation systems.

Andreas Pitsillides (IEEE M'89, SM'2005) received a B.Sc. (Honors) degree from the University of Manchester Institute of Science and Technology (UMIST) and Ph.D. from Swinburne University of Technology, Melbourne, Australia, in 1980 and 1993, respectively. He is an associate professor, Department of Computer Science, University of Cyprus, and heads the Networks Research Laboratory (NetRL). Andreas is also a founding member and chairman and scientific director of the Cyprus Academic and Research Network (CYNET) since its establishment in 2000. Prior to that he worked in industry for six years (Siemens 1980–1983, Asea-Brown Boveri, 1983–1986), and from 1987 to 1994 was with the Swinburne University of Technology (lecturer, senior lecturer 1990–1994, and foundation associate director of the Swinburne Laboratory for Telecommunications Research, 1992–1994). In 1992, he spent a six-month period as an academic visitor at the Telstra (Australia) Telecom Research Labs (TRL).

Andreas's research interests include fixed and wireless networks (ad hoc and sensor networks, TCP/IP, WLANs, UMTS third generation mobile networks and beyond), flow and congestion control, resource allocation and radio resource management, and Internet technologies and their application in mobile e-services, for example, in tele-healthcare and security issues. He has a particular interest in adapting tools from various fields of applied mathematics, such as nonlinear control theory and computational intelligence, to solve problems in computer networks. Andreas has published over 170 research papers and book chapters, presented invited lectures at major research organizations, and has given short courses at international conferences and short courses to industry.

His work has been funded by the European Commission IST program, the Cyprus National Research Promotion Foundation (RPF), the Cambridge Microsoft Research Labs, the University of Cyprus, the Swinburne University of Technology, and the Australian government research grants board, with total funding exceeding 9 million Euro. Current research projects include: IST FP 6 M-POWER, IST FP 6 C-MOBILE, IST FP 6 MOTIVE, RPF VIDEO, UCY ADAVIDEO, IST e-TEN FP 6 HEALTHSERVICE24, IST e-TEN LINKCARE, IST FP6 GEANT.

Andreas serves or has served on the executive committees of major conferences, such as INFOCOM, WiOpt, ISYC, MCCS, and ICT. He is a member of the International Federation of Automatic Control (IFAC) Technical Committee TC 1.5 on Networked Systems and TC 7.3 on Transportation Systems, and of the International Federation of Information Processing (IFIP) working group WG 6.3: Performance of Communications Systems. Andreas is also a member of the editorial board of *Computer Networks (COMNET) Journal*.

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Petros Ioannou and Andreas Pitsillides

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