Handbook of Research on

Advanced Intelligent Control Engineering and Automation

Ahmad Taher Azar and Sunddarapandian Vaidyanathan

IGI Global
DISSEMINATOR OF KNOWLEDGE

Handbook of Research on Advanced Intelligent Control Engineering and Automation

Ahmad Taher Azar
Benha University, Egypt

Sundarapandian Vaidyanathan
Vel Tech University, India

A volume in the Advances in Computational Intelligence and Robotics (ACIR) Book Series

ENGINEERING SCIENCE REFERENCE
An Imprint of IGI Global

Managing Director:	Lindsay Johnston
Managing Editor:	Austin DeMarco
Director of Intellectual Property & Contracts:	Jan Travers
Acquisitions Editor:	Kayla Wolfe
Production Editor:	Christina Henning
Typesetter:	Michael Brehm
Cover Design:	Jason Mull

Published in the United States of America by
Engineering Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA, USA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com

Library of Congress Cataloging-in-Publication Data

Handbook of research on advanced intelligent control engineering and automation / Ahmad Taher Azar and Sunddarapandian Vaidyanathan, editors.
pages cm
ISBN 978-1-4666-7248-2 (hardcover) -- ISBN 978-1-4666-7249-9 (ebook) -- ISBN 978-1-4666-7251-2 (print & perpetual access) 1. Automatic control. I. Azar, Ahmad Taher. II. Vaidyanathan, Sunddarapandian, 1967-
TJ213.H3145 2014
629.8'9563--dc23
2014037073

This book is published in the IGI Global book series Advances in Computational Intelligence and Robotics (ACIR) (ISSN: 2327-0411; eISSN: 2327-042X)

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

Advances in Computational Intelligence and Robotics (ACIR) Book Series

ISSN: 2327-0411
EISSN: 2327-042X

Mission

While intelligence is traditionally a term applied to humans and human cognition, technology has progressed in such a way to allow for the development of intelligent systems able to simulate many human traits. With this new era of simulated and artificial intelligence, much research is needed in order to continue to advance the field and also to evaluate the ethical and societal concerns of the existence of artificial life and machine learning.

The **Advances in Computational Intelligence and Robotics (ACIR) Book Series** encourages scholarly discourse on all topics pertaining to evolutionary computing, artificial life, computational intelligence, machine learning, and robotics. ACIR presents the latest research being conducted on diverse topics in intelligence technologies with the goal of advancing knowledge and applications in this rapidly evolving field.

Coverage

- Intelligent Control
- Cognitive Informatics
- Computational Logic
- Heuristics
- Robotics
- Computer Vision
- Automated Reasoning
- Adaptive and Complex Systems
- Evolutionary Computing
- Natural Language Processing

IGI Global is currently accepting manuscripts for publication within this series. To submit a proposal for a volume in this series, please contact our Acquisition Editors at Acquisitions@igi-global.com or visit: http://www.igi-global.com/publish/.

The Advances in Computational Intelligence and Robotics (ACIR) Book Series (ISSN 2327-0411) is published by IGI Global, 701 E. Chocolate Avenue, Hershey, PA 17033-1240, USA, www.igi-global.com. This series is composed of titles available for purchase individually; each title is edited to be contextually exclusive from any other title within the series. For pricing and ordering information please visit http://www.igi-global.com/book-series/advances-computational-intelligence-robotics/73674. Postmaster: Send all address changes to above address.

Titles in this Series

For a list of additional titles in this series, please visit: www.igi-global.com

Handbook of Research on Advancements in Robotics and Mechatronics
Maki K. Habib (The American University in Cairo, Egypt)
Engineering Science Reference • copyright 2015 • 953pp • H/C (ISBN: 9781466673878) • US $515.00 (our price)

Handbook of Research on Advanced Intelligent Control Engineering and Automation
Ahmad Taher Azar (Benha University, Egypt) and Sundarapandian Vaidyanathan (Vel Tech University, India)
Engineering Science Reference • copyright 2015 • 567pp • H/C (ISBN: 9781466672482) • US $335.00 (our price)

Handbook of Research on Artificial Intelligence Techniques and Algorithms
Pandian Vasant (Universiti Teknologi Petronas, Malaysia)
Information Science Reference • copyright 2015 • 694pp • H/C (ISBN: 9781466672581) • US $345.00 (our price)

Handbook of Research on Synthesizing Human Emotion in Intelligent Systems and Robotics
Jordi Vallverdú (Universitat Autònoma de Barcelona, Spain)
Information Science Reference • copyright 2015 • 426pp • H/C (ISBN: 9781466672789) • US $245.00 (our price)

Recent Advances in Ambient Intelligence and Context-Aware Computing
Kevin Curran (University of Ulster, UK)
Information Science Reference • copyright 2015 • 376pp • H/C (ISBN: 9781466672840) • US $225.00 (our price)

Recent Advances in Intelligent Technologies and Information Systems
Vijayan Sugumaran (Oakland University, USA & Sogang University, Seoul, Korea)
Information Science Reference • copyright 2015 • 300pp • H/C (ISBN: 9781466666399) • US $200.00 (our price)

Emerging Research on Swarm Intelligence and Algorithm Optimization
Yuhui Shi (Xi'an Jiaotong-Liverpool University, China)
Information Science Reference • copyright 2015 • 341pp • H/C (ISBN: 9781466663282) • US $225.00 (our price)

Face Recognition in Adverse Conditions
Maria De Marsico (Sapienza University of Rome, Italy) Michele Nappi (University of Salerno, Italy) and Massimo Tistarelli (University of Sassari, Italy)
Information Science Reference • copyright 2014 • 480pp • H/C (ISBN: 9781466659667) • US $235.00 (our price)

Computer Vision and Image Processing in Intelligent Systems and Multimedia Technologies
Muhammad Sarfraz (Kuwait University, Kuwait)
Information Science Reference • copyright 2014 • 312pp • H/C (ISBN: 9781466660304) • US $215.00 (our price)

Editorial Advisory Board

Preface

Control engineering is concerned with the understanding and control of machines, processes, and industrial automation systems to provide useful economic products for society. Control engineering is based on foundations of feedback theory and linear systems analysis. The subject is multidisciplinary in nature since it deals with dynamic systems drawn from the disciplines of electrical, electronics, chemical, mechanical, aerospace, and instrumentation engineering.

Control and automation in its broadest sense plays a fundamental role in process industries. Automatic control systems involve mathematics more than it is usual in other engineering disciplines. Even though the subject has strong mathematical foundation, emphasis throughout the text is not on mathematical rigour or formal derivation (unless they contribute to understanding the concept), but instead, on the methods of application associated with the analysis and design of feedback system. This book presents a comprehensive analysis and design of various types of control systems such as intelligence control. The prerequisite for the reader is some elementary knowledge of differential equations, vector-matrix analysis, and mechanics.

This book is intended to be a major reference book for scientists and engineers interested in applying new computational and mathematical tools for solving the complicated problems of mathematical modeling, simulation, and control. This book presents a comprehensive analysis and design of various types of control systems such as adaptive control, nonlinear control, and intelligent control, which includes fuzzy logic, neural networks, and evolutionary algorithms.

The main advantage of this book that it is multi-disciplinary and it will attract a lot of researchers working in control, automation, simulations, modeling, and related fields. With a broad coverage of the contents essential for the analysis and design of various control problems in control engineering practice, this book can also be used as a handy desktop reference during control applications.

ORGANIZATION OF THE BOOK

This well-structured book consists of 25 full chapters. They are organized into 6 sections:

Section 1: Nonlinear Control Systems
Section 2: Chaos and Control Applications
Section 3: Intelligent Control Applications
Section 4: Robotics and Control Applications
Section 5: Time-Delay and Switched Control Systems
Section 6: Power Systems and Engineering Applications

BOOK FEATURES

- The book chapters deal with the recent research problems in the areas of computer science, information technology, automation, control engineering, intelligent control, and applications.
- The book chapters are well written with detailed theory and block diagrams.
- The book chapters are lucidly illustrated with numerical examples and simulations.
- The book chapters give a good literature survey with a long list of references.
- The book chapters discuss details of engineering applications and future research areas.

SUMMARY OF THE BOOK CHAPTERS

Section 1 contains Chapters 1-6 focusing on the area of Nonlinear Control Systems.

Chapter 1 presents new results for the stabilization and control of mechanical systems with backlash. Backlash is one of the physical nonlinearities found in different types of actuators such as mechanical and hydraulic actuators. In Chapter 1, three different control approaches are derived for the stabilization and control of mechanical systems with backlash. As the first control approach, an independent joint control is designed from a SISO point of view, explaining how to deal with backlash in the actuator due to the interactions of gears. As the second control approach, a multivariable approach is considered. As the third control approach, the optimal control of mechanical systems with backlash is used, obtaining the optimal control law and frequency oscillations, when backlash is found in mechanical systems using a describing function.

Chapter 2 presents a family of kernel affine projection algorithms for nonlinear adaptive filtering. Linear adaptive filters have been widely used in a variety of applications such as mobile communications, video processing, etc. In system identification problems, the main goal is to identify an unknown system using an adaptive filer. As an extension of the linear counterparts, kernel adaptive filters have been proposed in the literature to identify nonlinear control systems. Chapter 2 explains the similarities between the linear algorithms and their corresponding kernel versions. Chapter 2 features a detailed discussion of several simulation results.

Chapter 3 presents new results on the advanced vibration control of atomic force microscope scanner. Atomic Force Microscopes (AFMs) are used in many nanopositioning applications in order to measure the topography of various specimens at an atomic level through surface imaging. The imaging of the samples in AFMs is carried out by using a three degree-of-freedom positioning unit called Piezoelectric Tube Scanner (PTS). The performance of the AFM mostly depends on the performance of the PTS. However, the PTS of the AFM is subject to the problem of vibration. Chapter 3 presents a design of a damping controller to compensate the vibration of the PTS. Chapter 3 gives details of the experimental results in order to show the effectiveness of the proposed damping controller.

Chapter 4 deals with the description, the parametric estimation, the state estimation, and the parametric and state estimation conjointly of nonlinear systems. Chapter 4 focuses on the class of nonlinear systems operating in a stochastic environment, which are described by Wiener state-space discrete-time mathematical models. Chapter 4 describes a new recursive parametric estimation algorithm, which is based on least squares techniques. The stability conditions of the developed parametric estimation scheme are analyzed using the Lyapunov method. The state estimation problem of nonlinear systems described by Wiener mathematical model is formulated. Chapter 4 details a new recursive state estimation algorithm, which is based on Kalman Filter, in order to estimate the unknown state variables. The new recursive algorithm permits to estimate conjointly the parameters and the state variables of nonlinear systems described by Wiener mathematical models, with unknown parameters and state variables.

Chapter 5 describes new results on the Proportional-Plus-Derivative (PD) state feedback H_2 control for descriptor systems. Chapter 5 gives a detailed study of the stabilization problem for singular system by proportional plus derivative feedback controller, which avoids developing the issue of admissibility (stable, regular, and impulse free) of singular systems and also to develop the H_2 control similarly to state space systems. Chapter 5 gives simulation results and illustrates the feasibility of the approaches followed in this chapter when an explicit expression of the desired proportional plus derivative state feedback controller is given.

Chapter 6 describes new results for the approximate input-output feedback linearization of non-minimum phase control systems using vanishing perturbation theory. Chapter 6 presents a new tracking control method for the nonlinear non-minimum phase system. Indeed, the main idea here is to dismiss a part of the system dynamics in order to make the approximate system input-state feedback linearizable. The neglected part is then considered as a perturbation part that vanishes at the origin. Finally, a linear controller is designed to control the approximate system. Stability is analyzed using the vanishing perturbation theory.

Section 2 contains Chapters 7-11 focusing on the area of Chaos and Control Applications.

Chapter 7 presents a novel Chaotic Random Bit Generator (CRBG), which is based on the Poincaré map of a non-autonomous chaotic dynamical system, viz. the Duffing-van der Pol system. As a result of the close relationship between cryptography and chaos theory in the last decade, several chaos-based cryptosystems, especially of using autonomous chaotic dynamical systems, have been put forward. Chapter 7 presents a novel Chaotic Random Bit Generator (CRBG), which is based on the Poincaré map of the Duffing-van der Pol system. The proposed CRBG also uses the X-OR function for improving the "randomness" of the produced bit streams, which are confirmed by using the four statistical tests, Monobit test, Poker test, Runs test, and Long run test, which are part of the FIPS-140-2 suite.

Chapter 8 proposes a novel nonlinear time-delayed system having a saturation function, which can exhibit chaotic behavior. Motivated by attract features and potential applications of time-delay models, Chapter 8 proposes a new chaotic system with a single scalar time delay and a nonlinearity described by a saturation function. Chapter 8 exhibits that the novel time-delayed chaotic system shows double-scroll chaotic attractors for some suitable chosen system parameters. The novel time-delayed chaotic system is also implemented with analog electronic circuit using off-the-shelf circuit components.

Chapter 9 deals with the control of chaos exhibited in the behavior of a one-degree-of-freedom impact mechanical oscillator with a single rigid constraint. First, an analytical expression of a constrained controlled Poincaré map is derived. Secondly, the linearized controlled Poincaré map around the fixed point is determined. Relying on this linearized map, a state feedback controller to stabilize the desired identified fixed point is designed. Chapter 9 shows that the proposed control strategy is efficient for the control of chaos for the desired fixed point and for the fixed parameter. Chapter 9 also shows that by changing the system parameter the oscillatory behavior of the mechanical system changes radically and becomes chaotic. Thus, the drawback of the developed OGY control method is revealed and some remedies are provided.

Chapter 10 presents some new investigations into the period-three route to chaos exhibited in the passive dynamic walking of the compass-gait biped robot as it goes down an inclined surface. This discovered kind of route in the passive bipedal locomotion was found to coexist with the conventional period-1 passive hybrid limit cycle. The further analysis on the period-three route chaos is realized by means of the Lyapunov exponents and the fractal dimension. Calculation method of the spectrum of Lyapunov exponents and the associated fractal dimension for the impulsive hybrid nonlinear dynamics is presented. Different attractive structures of the chaotic attractor in the phase plane are illustrated. Its first return Poincaré map and its basin of attraction are also presented. Furthermore, the further study of the period-three passive gait is also realized. The analysis of the period-three hybrid limit cycle is given. In addition, the basin of attraction of the period-three passive gait is also presented.

Chapter 11 investigates the bifurcation, quasi-periodicity, chaos, and co-existence of different behaviors in the controlled H-bridge inverter. Chapter 11 deals with the analysis of the dynamic behavior of a controlled single phase H-bridge inverter. Most of the control methods used to create the AC signal out of the DC source are based on the Pulse Width Modulation (PWM) with a switching period T.

Section 3 contains Chapters 12-14 focusing on the area of Intelligent Control Applications.

Chapter 12 presents two fuzzy adaptive variable structure controllers for a class of uncertain Multi-Input Multi-Output (MIMO) nonlinear systems with actuator nonlinearities (i.e. with sector nonlinearities and dead-zones). The design of the first controller concerns systems with symmetric and positive definite control-gain matrix, while the design of the second controller is extended to the case of non-symmetric control-gain matrix with the help of an appropriate matrix decomposition, namely the product of a symmetric positive-definite matrix, a diagonal matrix with diagonal entries +1 or -1 and a unity upper triangular matrix. An appropriate adaptive fuzzy-logic system is used to reasonably approximate the uncertain functions.

Chapter 13 investigates the fault detection and localization in the case of uncertain nonlinear systems. The multiple model approach is used to model nonlinear systems. This method uses the Takagi-Sugeno fuzzy systems principle to obtain a nonlinear system named multiple models. To model the system uncertainties, the interval approach is used in Chapter 13 because the faults or disturbances are generally unknown, but it is possible to know their upper and lower bounds. The main contribution in this work is to use the approach of the interval analysis to model the measurement uncertainties and propose a method to detect and locate faults in the case of non-linear uncertain systems described by Takagi-Sugeno multiple models. The proposed technique is insensitive to measurement uncertainties and highly reliable in case of a fault affecting the outputs system.

Chapter 14 presents a novel system for controlling intelligent building systems using natural user interfaces. In recent years, intelligent building systems have become standard in residential buildings as well as commercial buildings. A control system for an intelligent building system consists of a set of depth cameras installed in buildings rooms and a central processing computer, which analyses that depth data. Due to advanced logic, it is capable of identifying people occupying defined areas and recognizing their gestures. The system cooperates with a Domatiq System – Intelligent Building Management System, to provide an overall control of the building. Together with the Domatiq, users can associate specific gestures with Domatiq actions and events to realize specialized scenarios. This allows the user to control particular building components in a more natural way. Embedded feedback mechanism enhances the overall performance by informing users about current state of their commands and actions.

Section 4 contains Chapters 15-17 focusing on the area of Robotics and Control Applications.

Chapter 15 provides a practical and intuitive way of cooperative task planning and execution for complex robotic systems using multiple robots in automated manufacturing applications. Based on hierarchical representation of discrete event robotic activities, independent and cooperative robotic actions are represented by extended Petri nets. Net models representing inter-robot cooperation with synchronized interaction are presented to achieve distributed autonomous coordinated activities in an example multi-robot cell. An implementation of control software on hierarchical and distributed architecture for two-robot task planning, and execution is also presented using Web service on an Internet environment, where the higher level controller executes an activity-based global net model of task plan representing cooperative behaviors performed by the robots, and the transitions of parallel activities of the robots are synchronously coordinated through the transmission of requests and the reception of status through gate arcs connecting between the net based controllers.

Chapter 16 investigates the problem of fault estimation using a fast adaptive fault diagnosis observer. A new form of the estimator bloc considered for this purpose is an Unknown Input Observer (UIO), which is subsequently used for a robust fault detection scheme and also as an adaptive detection design for an additive actuator fault. This observer is designed for an unknown input and fault free system, which is obtained by coordinate transformations of original systems with unknown inputs (disturbance) and faults. The observer information is devoted to the fault estimation for fault detection and isolation. The fault estimates can be used to form an additional control input to accommodate the fault. Stability of the adaptive estimation is provided by a Lyapunov function ending with solving the Linear Matrix Inequalities (LMI).

Chapter 17 proposes a fuzzy controller for a two-wheeled mobile robot that moves following a Genetic Algorithmic-based plan in its configuration space. The fuzzy controller aims at giving the accurate acceleration so that the controlled robot can move efficiently from one position to another in a limited time window frame. First, a fuzzy motion control structure starts with two-input-and-one-output in which the fuzzy systems are proposed. Then a Genetic Algorithmic-based plan is examined where a path solution is obtained with the combination of the Genetic Algorithms and the Constraint Satisfaction Problem techniques.

Section 5 contains Chapters 18-20 focusing on the area of Time-Delay and Switched Control Systems.

Chapter 18 focuses on the stability analysis problem for a class of continuous-time switched time-delay systems modelled by delay differential equations under arbitrary switching. By using a constructed Lyapunov function, the aggregation techniques, the Kotelyanski lemma associated with the *M*-matrix proprieties, and the vector norms notion, new delay-dependent sufficient conditions are derived for the considered system to be asymptotically stable. The obtained results corresponding to the Lyapunov vector function provide a solution to one of the basic problems in continuous-time switched time-delay systems. The results presented in Chapter 18 are explicit, simple to use, and allow us to avoid the problem of searching a common Lyapunov function. On the other hand, this proposed approach could be further used as a constructive solution to the problems of state and static output feedback stabilization. Chapter 18 provides two examples with numerical simulations to demonstrate the effectiveness of the proposed method.

Chapter 19 provides new results on the discrete-time approximation of multi-variable continuous-time delay systems. The major tools used in Chapter 19 are state-transition method and a method based on the trapezoidal rule for integration. Chapter 19 presents two methods of the effective discretization approach for the continuous-time systems with input and output delays. Sampled-data time-delay systems with internal and external point delays are described by approximate discrete time-delay systems in the discrete domain. These approximate discrete systems allow the hybrid control of time-delay systems. Chapter 19 provides two numerical examples in order to illustrate the correctness of the discretization process.

Chapter 20 provides a brief survey of the recent research results on robust iterative learning control for linear discrete-time switched systems. First, the problem of stability analysis and robust exponential stabilization for a class of switched linear systems with polytopic uncertainties is reviewed. A sufficient condition based on the average dwell time that guarantees the exponential stability of uncertain switched linear systems is given. Next, the Iterative Learning Control (ILC) is presented to build a formulation ensuring the exponential stability of the given system. The integrated design of this ILC scheme is transformed into a robust control problem of an uncertain 2D Roesser system. The results are obtained through original connection with the notion of stability along the pass for 2D repetitive systems. After a brief review of the stability analysis under restricted switching and the multiple Lyapunov function theory, the switching stabilization problem is studied, and a variety of switching stabilization methods found in the literature are outlined. Then the switching stabilizability problem is investigated.

Section 6 contains Chapters 21-25 focusing on the area of Power Systems and Engineering Applications.

In Chapter 21, two computational algorithms are proposed and applied on an estimation algorithm in order to improve the global performance of the estimation phase. The proposed system is studied based on the Model Reference Adaptive System (MRAS). In this chapter, the MRAS technique is proposed as the software algorithm, for replacing the Tesla meter and the other measurement components for online estimate the overall characteristic PMSM parameters. In the conventional MRAS, the specific PI parameters are manually tuned, due to the complicated mathematical expressions. Here, the approach aims to ameliorate the MRAS technique with intelligent optimization methods. Thereby, a comparative analysis between two intelligent optimization methods is achieved to define the best one. These two methods esteemed the natural bacterial and insect movement and called, respectively, BFO and PSO algorithms. This novel MRAS technique is applied in the PMSM motor type to approximate the three main parameters deviation, in terms of stator resistance, inductance, and the permanent magnet flux.

Chapter 22 focuses on the design of a robust H∞ controller for the power flow between the stator of the Doubly-Fed Induction Generator (DFIG) and the grid. The robust H∞ controller design is formulated as a mixed-sensitivity problem. A mathematical model of the DFIG written in an appropriate d-q reference frame is established to carry out simulations. The proposed power control scheme is elaborated and compared with a conventional Proportional- Integral (PI) controller based on vector control technique.

Chapter 23 describes the design of a controller with time response specifications on STM32 microcontroller. The basic idea of this work is to implement a fixed low order controller on a real electronic system by using the STM32 microcontroller. The principal aim of this controller is to guarantee some time response specifications such as the settling time and the overshoot. In this work, the Generalized Geometric Programming (GGP) method is exploited as a global optimization method. The key concept of this method is to transform an optimization problem originally non-convex to a convex one by mean of some mathematical transformations. The practical implementation, on a fast electronic system characterized by a little constant time, of the proposed control law and a Proportional Integral (PI) controller illustrates the effectiveness of the proposed algorithm.

Chapter 24 develops a new control strategy, for the grid side converter, based on symmetrical components theory. This strategy named Symmetrical Components Control Strategy (SCCS) aims to isolate the hybrid system of the adverse impact of the grid fault while fulfilling all necessary interconnection requirements. Dynamic modeling and simulations of the studied power system have been accomplished using MATLAB/Simulink. The results point out thoroughly the applicability of the proposed control scheme under unbalanced grid conditions.

Chapter 25 discusses modelling and control of a Neutral Point Clamped (NPC) inverter that operates with the PWM switching pattern using a DSP. The mathematical model of the NPC inverter is carried out using conversion and connection functions for an easier understanding of the system operation. Simulation results using MATLAB program are reported in this chapter. It is shown that the performances obtained for driving an asynchronous motor using this inverter are very promising. Finally, analysis of the theoretical and the experimental results is carried out in order to validate the effectiveness of the proposed control solution.

AUDIENCE

This book will serve as a reference handbook for scientists and engineers who are interested in applying new computational and mathematical tools for solving recent research problems in Computer Science, Information Technology, Engineering, Automation, and Chaos and Control Engineering. This book can also be used at the graduate or advanced undergraduate level as a textbook or major reference for courses such as Mathematical Modeling, Computational Science, Numerical Simulation, Nonlinear Dynamical Systems and Chaos, Control Systems, Applied Artificial Intelligence, and many others.

Ahmad Taher Azar
Benha University, Egypt

Sundarapandian Vaidyanathan
Vel Tech University, India

Acknowledgment

As the editors, we hope that the chapters in this book will stimulate further research into control systems and be utilized in real-world applications. We hope that this book, covering so many different aspects, will be of value for all readers.

We would like to thank also the reviewers for their diligence in reviewing the chapters.

Special thanks go to IGI Global, especially the book editorial team.

Ahmad Taher Azar
Benha University, Egypt

Sunddarapandian Vaidyanathan
Vel Tech University, India

Section 1

Nonlinear Control Systems

List of Contributors