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STABILITY AND CONTROL OF DYNAMICAL SYSTEMS WITH APPLICATIONS: A TRIBUTE TO ANTHONY N. MICHEL, edited by D. Liu and P. J. Antsaklis, Birkhäuser, Boston, 2003, 430pp, price $89.95, ISBN 0-8176-3233-6

1. THE SOURCE

This book is an extensive compilation of papers presented at the workshop held at the University of Notre Dame on 5 April 2003. The workshop honored Anthony N. Michel, who has made distinguished contributions in several areas of systems theory and control theory, on the occasion of his retirement, and was also a forum to explore topics and applications related to the stability and control of dynamical systems. The book presents recent research results on stability and control of dynamic systems by 41 of Michel's colleagues, friends, and former PhD students.

2. THE CONTENT

The book is organized into three major parts incorporating 21 chapters. The first part of the book contains seven chapters on stability analysis of dynamical systems. The second part of the book, comprising six chapters, is concerned with neural networks and signal processing. The final part of the book consists of eight chapters which cover power systems and control systems.

Part I of the book consists of Chapters 1–7. Chapter 1 (by A. Fettweis) starts with introducing the nonlinear passive Kirchhoff circuits, the wave-digital method, nonlinear relativistic mass and direct derivation of the alternative results. This chapter expands the wave-digital concepts and relativity theory through some modifications to Newton's Law. An unnecessary additional earlier requirement that had led to an unavoidable factor of $\frac{1}{2}$ in the expression for the equivalence between mass and energy is abandoned. The chapter clarifies some of the issues involved, by accurate and unequivocal measurements, to obtain results with the closest connection to reality.

Chapter 2 (by L. T. Gruyitch) studies the notion of time and defines the complete transfer function matrix for continuous-time MIMO time-invariant linear systems. This matrix is crucial for zero-pole cancelation, system minimal realization, stability analysis, and stabilizing, tracking and/or optimal control synthesis. A new Lyapunov methodology for nonlinear systems, called consistent Lyapunov methodology, enables us to establish the necessary and sufficient conditions for (1) asymptotic stability of $x=0$, (2) a set to be the exact domain of asymptotic stability and (3) a direct construction of a Lyapunov function for a given nonlinear dynamical system. Moreover, the extended concepts of vector Lyapunov function are introduced.

Chapter 3 (by J. Shen, A. K. Sanyal and N. H. Mc-Clamroch) develops a mathematical model for multibody attitude systems that expose the dynamic coupling between the rotational degree of freedom of the base body and the deformation or shape degree of freedom of the elastic subsystems. Furthermore, a number of results that guarantee asymptotic stability for this multibody attitude system are obtained. Finally, two examples including a system with elastic rotational degree of freedom and a system with elastic transnational degree of freedom are introduced.

Chapter 4 (by H. Lin and P. J. Antsaklis) concentrates on robust regulation of uncertain hybrid systems that affected by both parameter variations and exterior disturbances. In particular, a robust one-step predecessor operator for the uncertain linear hybrid systems serves as the basic tool for analysis. This chapter provides a method for checking the safety, reachability and attainability. Further, the authors apply the results to networked control systems (NCS) and formulate the ultimate boundedness control problem for the NCS with uncertain delay, package-dropout and quantization effects as a regulation problem for an uncertain hybrid system.

Chapter 5 (by K. M. Passino) gives stability properties of swarms, and analyses swarms' cohesion under very noisy measurements using Lyapunov stability theory. The author gives a simple example of how to consider the effect of sensor noise and noise in sensing the gradient of a 'resource profile'.

Chapter 6 (by M. L. Sichitiu and P. H. Bauer) presents a necessary and sufficient asymptotic stability condition for discrete time-varying uncertain delay systems, where the uncertainty set is finite and additional constraints on the time variance of the system exist, and applies the result to communication network control problems.

Chapter 7 (by G. Zhai) investigates the stability and the $\mathscr{L}_2$ gain properties for switched symmetric systems, and shows two results. The first result is that when all the subsystems are stable, the switched system is exponentially stable under arbitrary switching. Another one is that when all the subsystems have $\mathscr{L}_2$ gains less than a positive scalar γ, the switched system has $\mathscr{L}_2$ gains less than the same γ under arbitrary switching. The key idea is to establish a common Lyapunov function for all the subsystems in the switched systems.

Chapters 8–13 constitutes Part II of the book. Chapter 8 (by I. W. Sandberg) researches the approximation capabilities of Gaussian radial basis functions and the concept of locally compact metric spaces. It is shown that the members of some interesting families of shift-varying input–output maps can be uniformly approximated in certain special way. The proposed results have theoretical guidance to many aspects of system identification and adaptive systems.

Chapter 9 (by K. Waheed and F. M. Salem) provides a generalized state-space blind source recovery framework based on the theory of multivariable optimization and the Kullback–Lieblar divergence as the performance functional. The multivariable optimization technique is used to derive update laws for nonlinear time-varying dynamical systems. Moreover, the various possible state-space demixing network structures are exploited to develop learning rules. In particular, linear state-space algorithms are presented for the minimum phase and non-minimum phase mixing environment models.

Chapter 10 (by L. Yang, R. Enns, Y. T.Wang and J. Si) discusses the theme of approximate dynamic programming (ADP). It presents direct neural dynamic programming (NDP) and applies it to a challenging continuous state control problem of helicopter command tracking. It is noted that direct NDP mechanism for helicopter control is probably the first time that an ADP type of algorithm has been applied to a complex real-life continuous state problem.

In Chapter 11 (by J. Farrell, M, Sharma and M. Polycarpo), algorithms for estimating the aircraft state vector and for approximating the nonlinear forces and moments acting on the aircraft are proposed. First, the authors give aircraft dynamics and model structure, and then discuss the unknown forces and moments and their representation as 'non-dimensional coefficient' functions over an operating envelope denoted by Δ. Finally, a Lyapunov-like function is used to prove the convergence of the estimator state and to discuss sufficient conditions for the convergence of the approximated force and moment functions.

Chapter 12 (by G. G. Yen) presents some results about dynamic multiobjective evolutionary algorithm (DMOEA). In the proposed DMOEA, a cell-based rank and density estimation strategy, a population growing strategy, a population declining strategy, and an objective space compression strategy are designed. In order to validate the proposed DMOEA, its performance is compared to five other advanced MOEAs. Moreover, DMOEA with different parameter settings is exploited by the chosen test function to show its robustness in converging to an optimal population size independent of the initial population.

Chapter 13 (by Y. F. Huang) is focused on set-membership adaptive filtering (SMAF). One unique feature of the proposed SMAF is data-dependent selective update of parameter estimates, and thus the SMAF could offer performance comparable to what can be achieved with conventional algorithms such as RLS and LMS.

The final part of the book contains Chapters 14–21. Chapter 14 (by M. A. Pai and T. B. Nguyen) is concerned with trajectory sensitivity theory and practical application to power systems. It also discusses the technique to compute critical values of any parameter that induces stability in the system using trajectory sensitivity.

Chapter 15 (by V. Vittal) investigates the design of a corrective control strategy after large disturbances in large electric power systems. An analytical approach by which the system is separated into smaller islands at a slightly reduced capacity is developed. The basis for forming the islands is to minimize the generation-load imbalance in each island, thereby facilitating the restoration process. Then, a carefully designed load-shedding scheme based on the rate of frequency decline is explored.

Chapter 16 (by A. Bose) expands control methods of maintaining the stability of the electric power generation-transmission-distribution grid. It presents a roadmap for the development of new controls for power system stability.

Chapter 17 (by D. W. Porter) introduces data fusion modelling (DFM) for groundwater systems identification. It is shown that DFM is a spatial and temporal state estimation and system identification methodology that uses three sources of information: measured data, physical laws and statistical models for uncertainty in spatial heterogeneities and for temporal variation in driving terms. DFM provides predictive modeling to help close the management control loop. Kalman-filtering methods are generalized using information filtering methods coupled with a Markov random field representation for spatial variations.

Chapter 18 (by M. K. Sain and B. F. Wyman) provides a tutorial study of the nominal design problem (NDP) and results for feedback synthesis in an algebraic framework. The NDP can be understood as an abstract kernel problem on localized modules and the design freedom amounts to the choice of a single morphism in this chapter. It is important that model matching does not determine the design morphism associated with total synthesis problem.

Chapter 19 (by J. J. Murray, C. J. Cox and R. E. Saeks) proposes the adaptive dynamic programming algorithm, and gives detailed four step proof of the adaptive dynamic programming theorem.

Chapter 20 (by K. T. Erickson, E. K. Stanek, E. Cetinkaya, S. Dunn-Norman and A. Miller) analyses the reliability of the supervisory control and data acquisition (SCADA) system used in offshore oil and gas platforms. A fault tree is constructed to show the effect of contributing events on system-level reliability. Probability methods provide a unifying method to assess physical faults, contributing effect, human actions and other events having a high degree of uncertainty. Results of the reliability study indicate that communication system failures are the predominant failure modes in the SCADA systems.

Chapter 21 (by D. Liu, Y. Zhang and S. Hu) develops call admission control algorithms for signal-to-interference ratio-based power-controlled CDMA cellular networks based on calculated power control set-points for all users in the network. The proposed call admission control algorithms are derived from the viewpoint of controlling the SIR levels for all users at a base station. In particular, it gives several admission control algorithms when necessary and sufficient conditions under which the power control algorithm will have a feasible solution.

3. COMMENTS

One feature of the book is that each chapter gives a detailed introduction and a concise conclusion so that readers could easily penetrate the proposed methods. Moreover, an abstract at the beginning of each chapter helps the readers capture the topic of each chapter. Every chapter is a helpful guide for anyone engaged in research for analysis and applications of dynamical systems, providing the readers with all necessary references to relevant bibliography, thus offering ample opportunity for further exploration on the algorithms covered in the book.

The book reads very well. The mathematical descriptions are quite rigorous, derivations are logical, the main ideas presented are original and results stated in the book are accurate and appropriate. The book emphasizes theoretical analyses and derivations, but no lack of rich examples. The many examples bridge the gap between control system theory and practical applications by approaches and issues proposed in this book, such as swarm dynamics, blind source recovery, direct NDP-based tracking control and so on.

Last, but not least, this book provides breadth to the methods/techniques used, depth to literature review, and reviews on the current status and future developments of several research and application areas.

This book is a valuable resource for researchers and practitioners interested in expanding their knowledge of dynamical systems research and applications. The book is different from textbooks of a graduate course. It is light on link of the whole book and heavy on consistency and depth of each chapter, which discusses currently very active research topics. It provides an excellent extension to a graduate course in dynamical systems. 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.

4. SUMMARY

In summary, this is a very well-written book, and it is clear that the authors have made important research contributions in the area of researches and applications of dynamical systems and presented a very special tribute to Anthony N. Michel who has made significant contributions to the systems and control community.

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Relay feedback: analysis, identification and control, Qing-Guo Wang, Tong Heng Lee and Chong Lin, Springer, London, 2003, 383pp

The relay feedback test proposed by Åström and Hägglund [1] has received considerable attention of process control practitioners for almost two decades. Luyben [2] is among the first to employ the relay feedback test for the identification of highly nonlinear processes. Based on the relay feedback, the autotune variation (ATV) identification method has become a standard practice in process control community. Åström and Hägglund [3] discuss the relay feedback identification and PID controller design and Yu [4] provides updated summary on relay feedback identification up to 1999.

The book intends to present a fairly comprehensive, up-to-date, and detailed treatment of relay feedback theory, use of relay feedback for process identification, and use of identified models for general control design. The materials are based on research results of the authors and his co-workers in the domain. For presentation, the technical development of the results is quite self-contained with fundamental knowledge of the linear system theory is assumed. Illustrative examples of different degrees of complexity are given to facilitate understanding. Therefore, the book can be accessed by graduate students, researchers and practicing engineers. This book covers three areas: (1) analysis of relay feedback system (RFS), and (2) identification using RFS, and (3) controller design (PID controllers in particular).

