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Linear Systems **Linear Estimation Linear Systems A Linear Systems Primer Subspace Identification for Linear Systems** *Linear System Theory and Design* **Indefinite-Quadratic Estimation and Control Fast Reliable Algorithms for Matrices with Structure** *Modern Signal Processing* **State Space and Input-Output Linear Systems** *Linear State-Space Control Systems* **Optimal Filtering Control Theory for Linear Systems** Linear Systems Theory **Linear Control Systems** Identification of Linear Systems **Linear System Theory** Mastering System Identification in 100 Exercises I. Schur Methods in Operator Theory and Signal Processing Linear Systems and Signals Adaptive Filtering Prediction and Control **Piecewise Linear Control Systems Linear Optimal Control Systems Nonlinear System Theory Control System Design Stochastic Systems Periodic Systems Optimization and Dynamical Systems** *Discrete Random Signals and Statistical Signal Processing* **Bayesian Filtering and Smoothing The Theory of Linear Prediction** *VLSI and Modern Signal Processing* **Kalman Filtering** *Encyclopedia of Systems and Control Hybrid Systems: Computation and Control* **Lectures on Linear Least-squares Estimation** *Low Gain Feedback* Optimal Control Linear Multivariable Systems **State-space and Multivariable Theory**

This book enables readers to understand system identification and linear system modeling through 100 practical exercises without requiring complex theoretical knowledge. The contents encompass state-of-the-art system identification methods, with both time and frequency domain system identification methods covered, including the pros and cons of each. Each chapter features MATLAB exercises, discussions of the exercises, accompanying MATLAB downloads, and larger projects that serve as potential assignments in this learn-by-doing resource. A unified Bayesian treatment of the state-of-the-art filtering, smoothing, and parameter estimation algorithms for non-linear state space models. This work is aimed at mathematics and engineering graduate students and researchers in the areas of optimization, dynamical systems, control sys tems, signal processing, and linear algebra. The motivation for the results developed here arises from advanced engineering applications and the emer gence of highly parallel computing machines for tackling such applications. The problems solved are those of linear algebra and linear systems the ory, and include such topics as diagonalizing a symmetric matrix, singular value decomposition, balanced realizations, linear programming, sensitivity minimization, and eigenvalue assignment by feedback control. The tools are those, not only of linear algebra and systems theory, but also of differential geometry. The problems are solved via dynamical sys tems implementation, either in continuous time or discrete time , which is ideally suited to distributed parallel processing. The problems tackled are indirectly or directly concerned with dynamical systems themselves, so there is feedback in that dynamical systems are used to understand and optimize dynamical systems. One key to the new research results has been the recent discovery of rather deep existence and uniqueness results for the solution of certain matrix least squares optimization problems in geomet ric invariant theory. These problems, as well as many other optimization problems arising in linear algebra and systems theory, do not always admit solutions which can be found by algebraic methods. This text was developed over a three year period of time (1971- 1973) from a variety of notes and references used in the presentation of a senior/first year graduate level course in the Division of En gineering at Brown University titled Linear System Theory. The in tent of the course was not only to introduce students to the more modern, state-space approach to multivariable control system analysis and design, as opposed to the classical, frequency domain approach, but also to draw analogies between the two approaches whenever and wherever possible. It is therefore felt that the material presented will have broader appeal to practicing engineers than a text devoted exclusively to the state-space approach. It was assumed that students taking the course had also taken, as a prerequisite, an undergraduate course in classical control theory and also were familiar with certain standard linear algebraic notions as well as the theory of ordinary differential equations, although a substantial effort was expended to make the material as self-contained as possible. In particular, Chapter 2 is employed to familiarize the reader with a good deal of the mathematical material employed through out the remainder of the text. Chapters 3 through 5 were drawn, in part, from a number of contemporary state-space and matrix algebraic references, as well as some recent research of the author, especially those portions which deal with polynomial matrices and the differential operator approach. A text for a graduate course on linear system theory, with core material on the theory of time-varying linear systems in both continuous- and discrete-time and the time-invariant case. Chapters on subjects such as state equation, stability, and geometric theory include worked examples and some 400 exercises ranging from drill problems to extensions of the theory. This second edition contains expanded application examples, more drill exercises, and 10 new chapters on the theory of discrete-time, time-varying linear systems. Annotation copyright by Book News, Inc., Portland, OR 2. Piecewise Linear Modeling . . . . 9 2. 1 Model Representation . . . . 9 2. 2 Solution Concepts . . . . 2. 3 Uncertainty Models . . . . 2. 4 Modularity and Interconnections . . . . 26 2. 5 Piecewise Linear Function Representations . . . . 28 2. 6 Comments and References . . . . 30 3. 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Dissipativity Analysis . . . . 85 5. 1 Dissipativity Analysis via Convex Optimization . . . . . . 86 21 14 Contents Contents 5. 2 Computation of £2 induced Gain . . . . 88 5. 3 Estimation of Transient Energy . . . . 89 5. 4 Dissipative Systems with Quadratic Supply Rates . . . . . 91 5. 5 Comments and References . . . . 95 Controller Design . . . . 96 6. 1 Quadratic Stabilization of Piecewise Linear" Systems . . . 97 6. 2 Controller Synthesis based on Piecewise Quadratics . . . 98 6. 3 Comments and References . . . . 105 7. Selected Topics . . . . 107 7. 1 Estimation of Regions of Attraction . . . . The book blends readability and accessibility common to undergraduate control systems texts with the mathematical rigor necessary to form a solid theoretical foundation. Appendices cover linear algebra and provide a Matlab overivew and files. The reviewers pointed out that this is an ambitious project but one that will pay off because of the lack of good up-to-date textbooks in the area. Graduate-level text extends studies of signal processing, particularly regarding communication systems and digital filtering theory. Topics include filtering, linear systems, and estimation; discrete-time Kalman filter; time-invariant filters; more. 1979 edition. This unified survey focuses on linear discrete-time systems and explores natural extensions to nonlinear systems. It emphasizes discrete-time systems, summarizing theoretical and practical aspects of a large class of adaptive algorithms. 1984 edition. "A self-contained, highly motivated and comprehensive account of basic methods for analysis and application of linear systems that arise in signal processing problems in communications, control, system identification and digital filtering. Develops and exploits the structure of finite-dimensional linear systems; unifies state-space and transfer-function analysis; carefully develops and uses interrelations with state-space descriptions to illuminate both approaches; avoids the development of purely mathematical topics - all mathematical results are used in some significant systems problem; keeps the proofs as simple and direct as possible." --Descripción del editor. Linear prediction theory has had a profound impact in the field of digital signal processing. Although the theory dates back to the early 1940s, its influence can still be seen in applications today. The theory is based on very elegant mathematics and leads to many beautiful insights into statistical signal processing. Although prediction is only a part of the more general topics of linear estimation, filtering, and smoothing, this book focuses on linear prediction. This has enabled detailed discussion of a number of issues that are normally not found in texts. For example, the theory of vector linear prediction is explained in considerable detail and so is the theory of line spectral processes. This focus and its small size make the book different from many excellent texts which cover the topic, including a few that are actually dedicated to linear prediction. There are several examples and computer-based demonstrations of the theory. Applications are mentioned wherever appropriate, but the focus is not on the detailed development of these applications. The writing style is meant to be suitable for self-study as well as for classroom use at the senior and first-year graduate levels. The text is self-contained for readers with introductory exposure to signal processing, random processes, and the theory of matrices, and a historical perspective and detailed outline are given in the first chapter.Table of Contents: Introduction / The Optimal Linear Prediction Problem / Levinson's Recursion / Lattice Structures for Linear Prediction / Autoregressive Modeling / Prediction Error Bound and Spectral Flatness / Line Spectral Processes / Linear Prediction Theory for Vector Processes / Appendix A: Linear Estimation of Random Variables / B: Proof of a Property of Autocorrelations / C: Stability of the Inverse Filter / Recursion Satisfied by AR Autocorrelations The Encyclopedia of Systems and Control collects a broad range of short expository articles that describe the current state of the art in the central topics of control and systems engineering as well as in many of the related fields in which control is an enabling technology. The editors have assembled the most comprehensive reference possible, and this has been greatly facilitated by the publisher’s commitment continuously to publish updates to the articles as they become available in the future. Although control engineering is now a mature discipline, it remains an area in which there is a great deal of research activity, and as new developments in both theory and applications become available, they will be included in the online version of the encyclopedia. A carefully chosen team of leading authorities in the field has written the well over 250 articles that comprise the work. The topics range from basic principles of feedback in servomechanisms to advanced topics such as the control of Boolean networks and evolutionary game theory. Because the content has been selected to reflect both foundational importance as well as subjects that are of current interest to the research and practitioner communities, a broad readership that includes students, application engineers, and research scientists will find material that is of interest. Anyone seeking a gentle introduction to the methods of modern control theory and engineering, written at the level of a first-year graduate course, should consider this book seriously. It contains: A generous historical overview of automatic control, from Ancient Greece to the 1970s, when this discipline matured into an essential field for electrical, mechanical, aerospace, chemical, and biomedical engineers, as well as mathematicians, and more recently, computer scientists; A balanced presentation of the relevant theory: the main state-space methods for description, analysis, and design of linear control systems are derived, without overwhelming theoretical arguments; Over 250 solved and exercise problems for both continuous- and discrete-time systems, often including MATLAB simulations; and Appendixes on MATLAB, advanced matrix theory, and the history of mathematical tools such as differential calculus, transform methods, and linear algebra. Another noteworthy feature is the frequent use of an inverted pendulum on a cart to illustrate the most important concepts of automatic control, such as: Linearization and discretization; Stability, controllability, and observability; State feedback, controller design, and optimal control; and Observer design, reduced order observers, and Kalman filtering. Most of the problems are given with solutions or MATLAB simulations. Whether the book is used as a textbook or as a self-study guide, the knowledge gained from it will be an excellent platform for students and practising engineers to explore further the recent developments and applications of control theory. This book deals with the combined issues of speed and numerical reliability in algorithm development. This book offers a comprehensive treatment of the theory of periodic systems, including the problems of filtering and control. It covers an array of topics, presenting an overview of the field and focusing on discrete-time signals and systems. This book constitutes the refereed proceedings of the 8th International Workshop on Hybrid Systems: Computation and Control, HSCC 2005, held in Zurich, Switzerland in March 2005. The 40 revised full papers presented together with 2 invited papers and the abstract of an invited talk were carefully reviewed and selected from 91 submissions. The papers focus on modeling, analysis, and implementation of dynamic and reactive systems involving both discrete and continuous behaviors. Among the topics addressed are tools for analysis and verification, control and optimization, modeling, engineering applications, and emerging directions in programming language support and implementation. Based on a streamlined presentation of the authors’ successful work Linear Systems, this textbook provides an introduction to systems theory with an emphasis on control. Initial chapters present necessary mathematical background material for a fundamental understanding of the dynamical behavior of systems. Each chapter includes helpful chapter descriptions and guidelines for the reader, as well as summaries, notes, references, and exercises at the end. The emphasis throughout is on time-invariant systems, both continuous- and discrete-time. Control Theory for Linear Systems deals with the mathematical theory of feedback control of linear systems. It treats a wide range of control synthesis problems for linear state space systems with inputs and outputs. The book provides a treatment of these problems using state space methods, often with a geometric flavour. Its subject matter ranges from controllability and observability, stabilization, disturbance decoupling, and tracking and regulation, to linear quadratic regulation, H2 and H-infinity control, and robust stabilization. Each chapter of the book contains a series of exercises, intended to increase the reader's understanding of the material. Often, these exercises generalize and extend the material treated in the regular text. "There are three words that characterize this work: thoroughness, completeness and clarity. The authors are congratulated for taking the time to write an excellent linear systems textbook!" —IEEE Transactions on Automatic Control Linear systems theory plays a broad and fundamental role in electrical, mechanical, chemical and aerospace engineering, communications, and signal processing. A thorough introduction to systems theory with emphasis on control is presented in this self-contained textbook, written for a challenging one-semester graduate course. A solutions manual is available to instructors upon adoption of the text. The book’s flexible coverage and self-contained presentation also make it an excellent reference guide or self-study manual. For a treatment of linear systems that focuses primarily on the time-invariant case using streamlined presentation of the material with less formal and more intuitive proofs, please see the authors’ companion book entitled A Linear Systems Primer. Uses simple and efficient methods to develop results and design procedures, thus creating a non-exhaustive approach to presenting the material; Enables the reader to employ the results to carry out design. Thus, most results are discussed with an eye toward numerical computation; All design procedures in the text can be carried out using any software package that includes singular-value decomposition, and the solution of linear algebraic equations and the Lyapunov equation; All examples are developed for numerical computation and are illustrated using MATLAB, the most widely available software package. Subspace Identification for Linear Systems focuses on the theory, implementation and applications of subspace identification algorithms for linear time-invariant finite- dimensional dynamical systems. These algorithms allow for a fast, straightforward and accurate determination of linear multivariable models from measured input-output data. The theory of subspace identification algorithms is presented in detail. Several chapters are devoted to deterministic, stochastic and combined deterministic-stochastic subspace identification algorithms. For each case, the geometric properties are stated in a main 'subspace' Theorem. Relations to existing algorithms and literature are explored, as are the interconnections between different subspace algorithms. The subspace identification theory is linked to the theory of frequency weighted model reduction, which leads to new interpretations and insights. The implementation of subspace identification algorithms is discussed in terms of the robust and computationally efficient RQ and singular value decompositions, which are well-established algorithms from numerical linear algebra. The algorithms are implemented in combination with a whole set of classical identification algorithms, processing and validation tools in Xmath's ISID, a commercially available graphical user interface toolbox. The basic subspace algorithms in the book are also implemented in a set of Matlab files accompanying the book. An application of ISID to an industrial glass tube manufacturing process is presented in detail, illustrating the power and user-friendliness of the subspace identification algorithms and of their implementation in ISID. The identified model allows for an optimal control of the process, leading to a significant enhancement of the production quality. The applicability of subspace identification algorithms in industry is further illustrated with the application of the Matlab files to ten practical problems. Since all necessary data and Matlab files are included, the reader can easily step through these applications, and thus get more insight in the algorithms. Subspace Identification for Linear Systems is an important reference for all researchers in system theory, control theory, signal processing, automization, mechatronics, chemical, electrical, mechanical and aeronautical engineering. Since its origins in the 1940s, the subject of decision making under uncertainty has grown into a diversified area with application in several branches of engineering and in those areas of the social sciences concerned with policy analysis and prescription. These approaches required a computing capacity too expensive for the time, until the ability to collect and process huge quantities of data engendered an explosion of work in the area. This book provides succinct and rigorous treatment of the foundations of stochastic control; a unified approach to filtering, estimation, prediction, and stochastic and adaptive control; and the conceptual framework necessary to understand current trends in stochastic control, data mining, machine learning, and robotics. This book concentrates on the problem of accurate modeling of linear systems. It presents a thorough description of a method of modeling a linear dynamic invariant system by its transfer function. The first two chapters provide a general introduction and review for those readers who are unfamiliar with identification theory so that they have a sufficient background knowledge for understanding the methods described later. The main body of the book looks at the basic method used by the authors to estimate the parameter of the transfer function, how it is possible to optimize the excitation signals. Further chapters extend the estimation method proposed. Applications are then discussed and the book concludes with practical guidelines which illustrate the method and offer some rules-of-thumb. Presents a unified mathematical framework for a wide range of problems in estimation and control. This book gives a unified and unique presentation of low gain and high gain design methodologies. In particular the development of low gain feedback design methodology is discussed. The development of both low and high gain feedback enhances the industrial relevance of modern control theory, by providing solutions to a wide range of problems that are of paramount practical importance. This detailed monograph provides the reader with a comprehensive insight into these problems: research results are examined and solutions to the problems are considered. Compared to that of high gain feedback, the power and significance of low gain feedback is not as widely recognized. The purpose of this monograph is to present some recent developments in low gain feedback, and its applications. Several low gain techniques are examined, including the control of linear systems with saturating actuators, semi-global stabilization of minimum phase input-output linearizable systems and H2 suboptimal control. It is difficult for me to forget the mild sense of betrayal I felt some ten years ago when I discovered, with considerable dismay, that my two favorite books on linear system theory - Desoer's Notes for a Second Course on Linear Systems and Brockett's Finite Dimensional Linear Systems - were both out of print. Since that time, of course, linear system theory has undergone a transformation of the sort which always attends the maturation of a theory whose range of applicability is expanding in a fashion governed by technological developments and by the rate at which such advances become a part of engineering practice. The growth of the field has inspired the publication of some excellent books; the encyclopedic treatises by Kailath and Chen, in particular, come immediately to mind. Nonetheless, I was inspired to write this book primarily by my practical needs as a teacher and researcher in the field. For the past five years, I have taught a one semester first year gradu ate level linear system theory course in the School of Electrical Engineering at Cornell. The members of the class have always come from a variety of departments and backgrounds, and con sequently have entered the class with levels of preparation ranging from first year calculus and a taste of transform theory on the one extreme to senior level real analysis and abstract algebra on the other. "This book attempts to reconcile modern linear control theory with classical control theory. One of the major concerns of this text is to present design methods, employing modern techniques, for obtaining control systems that stand up to the requirements that have been so well developed in the classical expositions of control theory. Therefore, among other things, an entire chapter is devoted to a description of the analysis of control systems, mostly following the classical lines of thought. In the later chapters of the book, in which modern synthesis methods are developed, the chapter on analysis is recurrently referred to. Furthermore, special attention is paid to subjects that are standard in classical control theory but are frequently overlooked in modern treatments, such as nonzero set point control systems, tracking systems, and control systems that have to cope with constant disturbances. Also, heavy emphasis is placed upon the stochastic nature of control problems because the stochastic aspects are so essential." --Preface. Introduction to state-space methods covers feedback control; state-space representation of dynamic systems and dynamics of linear systems; frequency-domain analysis; controllability and observability; shaping the dynamic response; more. 1986 edition. Incorporating new problems and examples, the second edition of Linear Systems and Signals features MATLAB® material in each chapter and at the back of the book. It gives clear descriptions of linear systems and uses mathematics not only to prove axiomatic theory, but also to enhance physical and intuitive understanding. This original work offers the most comprehensive and up-to-date treatment of the important subject of optimal linear estimation, which is encountered in many areas of engineering such as communications, control, and signal processing, and also in several other fields, e.g., econometrics and statistics. The book not only highlights the most significant contributions to this field during the 20th century, including the works of Wiener and Kalman, but it does so in an original and novel manner that paves the way for further developments. This book contains a large collection of problems that complement it and are an important part of piece, in addition to numerous sections that offer interesting historical accounts and insights. The book also includes several results that appear in print for the first time. FEATURES/BENEFITS Takes a geometric point of view. Emphasis on the numerically favored array forms of many algorithms. Emphasis on equivalence and duality concepts for the solution of several related problems in adaptive filtering, estimation, and control. These features are generally absent in most prior treatments, ostensibly on the grounds that they are too abstract and complicated. It is the authors' hope that these misconceptions will be dispelled by the presentation herein, and that the fundamental simplicity and power of these ideas will be more widely recognized and exploited. Among other things, these features already yielded new insights and new results for linear and nonlinear problems in areas such as adaptive filtering, quadratic control, and estimation, including the recent Hà theories. A fully updated textbook on linear systems theory Linear systems theory is the cornerstone of control theory and a well-established discipline that focuses on linear differential equations from the perspective of control and estimation. This updated second edition of Linear Systems Theory covers the subject's key topics in a unique lecture-style format, making the book easy to use for instructors and students. João Hespanha looks at system representation, stability, controllability and state feedback, observability and state estimation, and realization theory. He provides the background for advanced modern control design techniques and feedback linearization and examines advanced foundational topics, such as multivariable poles and zeros and LQG/LQR. The textbook presents only the most essential mathematical derivations and places comments, discussion, and terminology in sidebars so that readers can follow the core material easily and without distraction. Annotated proofs with sidebars explain the techniques of proof construction, including contradiction, contraposition, cycles of implications to prove equivalence, and the difference between necessity and sufficiency. Annotated theoretical developments also use sidebars to discuss relevant commands available in MATLAB, allowing students to understand these tools. This second edition contains a large number of new practice exercises with solutions. Based on typical problems, these exercises guide students to succinct and precise answers, helping to clarify issues and consolidate knowledge. The book's balanced chapters can each be covered in approximately two hours of lecture time, simplifying course planning and student review. Easy-to-use textbook in unique lecture-style format Sidebars explain topics in further detail Annotated proofs and discussions of MATLAB commands Balanced chapters can each be taught in two hours of course lecture New practice exercises with solutions included Numerous examples highlight this treatment of the use of linear quadratic Gaussian methods for control system design. It explores linear optimal control theory from an engineering viewpoint, with illustrations of practical applications. Key topics include loop-recovery techniques, frequency shaping, and controller reduction. Numerous examples and complete solutions. 1990 edition.

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