# *Linear Optimal Control Systems*

Optimal control deals with the problem of finding a control law for a given system such that a certain optimality criterion is achieved. An optimal control is a set of differential equations describing the paths of the control variables that minimize the cost functional. This book, Continuous Time Dynamical Systems: State Estimation and Optimal Control with Orthogonal Functions, considers different classes of systems with quadratic performance criteria. It then attempts to find the optimal control law for each class of systems using orthogonal functions that can optimize the given performance criteria. Illustrated throughout with detailed examples, the book covers topics including: Block-pulse functions and shifted Legendre polynomials State estimation of linear time-invariant systems Linear optimal control systems incorporating observers Optimal control of systems described by integro-differential equations Linear-quadratic-Gaussian control Optimal control of singular systems Optimal control of time-delay systems with and without reverse time terms Optimal control of second-order nonlinear systems Hierarchical control of linear time-invariant and time-varying systems Successfully classroom-tested at the graduate level, Linear Control Theory: Structure, Robustness, and Optimization covers three major areas of control engineering (PID control, robust control, and optimal control). It provides balanced coverage of elegant mathematical theory and useful engineering-oriented results. The first part of the book develops results relating to the design of PID and first-order controllers for continuous and discrete-time linear systems with possible delays. The second section deals with the robust stability and performance of systems under parametric and unstructured uncertainty. This section describes several elegant and sharp results, such as Kharitonov's theorem and its extensions, the edge theorem, and the mapping theorem. Focusing on the optimal control of linear systems, the third part discusses the standard theories of the linear quadratic regulator, Hinfinity and l1 optimal control, and associated results. Written by recognized leaders in the field, this book explains how control theory can be applied to the design of real-world systems. It shows that the

techniques of three term controllers, along with the results on robust and optimal control, are invaluable to developing and solving research problems in many areas of engineering.

At present, in order to resolve problems of ecology and to save mineral resources for future population generations, it is quite necessary to know how to maintain nature arrangement in an efficient way. It is possible to achieve a rational nature arrangement when analyzing solutions to problems concerned with optimal control of distributed systems and with optimization of modes in which main ground medium processes are functioning (motion of liquids, generation of temperature fields, mechanical deformation of multicomponent media). Such analysis becomes even more difficult because of heterogeneity of the region that is closest to the Earth surface, and thin inclusions/cracks in it exert their essential influence onto a state and development of the mentioned processes, especially in the cases of mining. Many researchers, for instance, A.N. Tikhonov - A.A. Samarsky [121], L. Luckner - W.M. Shestakow [65], Tien-Mo Shih, K.L. Johnson [47], E. Sanchez-Palencia [94] and others stress that it is necessary to consider how thin inclusions/cracks exert their influences onto development of these processes, while such inclusions differ in characteristics from main media to a considerable extent (moisture permeability, permeability to heat, bulk density or shear strength may be mentioned). Xll An influence exerted from thin interlayers onto examined processes is taken into account sufficiently adequately by means of various constraints, namely, by the conjugation conditions [4, 8, 10, 15, 17-20, 22-26, 38, 44, 47, 52, 53, 68, 76, 77, 81, 83, 84, 90, 95, 96-100, 112-114, 117, 123].

This book is devoted to the development of optimal control theory for finite dimensional systems governed by deterministic and stochastic differential equations driven by vector measures. The book deals with a broad class of controls, including regular controls (vector-valued measurable functions), relaxed controls (measure-valued functions) and controls determined by vector measures, where both fully and partially observed control problems are considered. In the past few decades, there have been remarkable advances in the field of systems and control theory thanks to the unprecedented interaction between

mathematics and the physical and engineering sciences. Recently, optimal control theory for dynamic systems driven by vector measures has attracted increasing interest. This book presents this theory for dynamic systems governed by both ordinary and stochastic differential equations, including extensive results on the existence of optimal controls and necessary conditions for optimality. Computational algorithms are developed based on the optimality conditions, with numerical results presented to demonstrate the applicability of the theoretical results developed in the book. This book will be of interest to researchers in optimal control or applied functional analysis interested in applications of vector measures to control theory, stochastic systems driven by vector measures, and related topics. In particular, this self-contained account can be a starting point for further advances in the theory and applications of dynamic systems driven and controlled by vector measures.

Feedback Control Theory

Linear Systems and Optimal Control

State Estimation and Optimal Control with Orthogonal Functions

Examples and Algorithms

Optimal Control and Estimation

A unified approach is proposed for applied mechanics and optimal control theory. The Hamilton system methodology in analytical mechanics is used for eigenvalue problems, vibration theory, gyroscopic systems, structural mechanics, wave-guide, LQ control, Kalman filter, robust control etc. All aspects are described in the same unified methodology. Numerical methods for all these problems are provided and given in meta-language, which can be implemented easily on the computer. Precise integration methods both for initial value problems and for two-point boundary value problems are proposed, which result in the numerical solutions of computer precision. Key Features of the text include: -Unified approach based on Hamilton duality system theory and symplectic mathematics. -Gyroscopic system vibration, eigenvalue problems. -Canonical transformation applied to non-linear systems. -Pseudo-excitation method for structural random vibrations. -Precise integration of two-point boundary value problems. -Wave propagation along wave-guides, scattering. -Precise solution of Riccati differential equations. -Kalman filtering. -HINFINITY theory of control and filter.

"Covers design methods for optimal (or quasioptimal) control algorithms in the form of synthesis for deterministic and stochastic dynamical systems-with applications in aerospace, robotic, and servomechanical technologies. Providing new results on exact and approximate solutions of optimal control problems."

Balancing rigorous theory with practical applications, Linear Systems: Optimal and Robust Control explains the concepts behind linear systems, optimal control, and robust control and illustrates these concepts with concrete examples and problems. Developed as a two-course book, this self-contained text first discusses linear systems, including controllability, observability, and matrix fraction description. Within this framework, the author develops the ideas of state feedback control and observers. He then examines optimal control, stochastic optimal control, and the lack of robustness of linear quadratic Gaussian (LQG) control. The book subsequently presents robust control techniques and derives H? control theory from the first principle, followed by a discussion of the sliding mode control of a linear system. In addition, it shows how a blend of sliding mode control and H? methods can enhance the robustness of a linear system. By learning the theories and algorithms as well as exploring the examples in Linear Systems: Optimal and Robust Control, students will be able to better understand and ultimately better manage engineering processes and systems.

Designed for one-semester introductory senior-or graduate-level course, the authors provide the student with an introduction of analysis techniques used in the design of nonlinear and optimal feedback control systems. There is special emphasis on the fundamental topics of stability, controllability, and optimality, and on the corresponding geometry associated with these topics. Each chapter contains several examples and a variety of exercises.

Optimal Control Of Singularly Perturbed Linear Systems And Applications
An Algorithm for Linear Optimal Control Systems with State Space Constraints
Structure, Robustness, and Optimization
The Theory and Application of Linear Optimal Control
Linear Control Theory

While many books cover the theory of optimal design, few help readers to actually apply it. this volume is one of the first to aid readers in utilizing the theory of optimal control to solve practical problems in the face of uncertainty. Bryson covers random inputs and random errors in measurement, uncertainty in inputs from the environment, and uncertainty in the parameters of the dynamic model. He also addresses static and dynamic estimation, random processes, several types of controllers, smoothers, and filters.

Pedagogic features include hundreds of problems and worked examples, a CD-ROM supplement containing MATLAB codes of the OPTEST toolbox, and code for the examples, figures, and many of the problems.

For more than forty years, the equation y'(t) = Ay(t) + u(t) in Banach spaces has been used as model for optimal control processes described by partial differential equations, in particular heat and diffusion processes. Many of the outstanding open problems, however, have remained open until recently, and some have never been solved. This book is a survey of all results know to the author, with emphasis on very recent results (1999 to date). The book is restricted to linear equations and two particular problems (the time optimal problem, the norm optimal problem) which results in a more focused and concrete treatment. As experience shows, results on linear equations are the basis for the treatment of their semilinear counterparts, and techniques for the time and norm optimal problems can often be generalized to more general cost functionals. The main object of this book is to be a state-of-the-art monograph on the theory of the time and norm optimal controls for y'(t) = Ay(t) + u(t) that ends at the very latest frontier of research, with open problems and indications for future research. Key features: · Applications to optimal diffusion processes. · Applications to optimal heat propagation processes. · Modelling of optimal processes governed by partial differential equations. · Complete bibliography. · Includes the latest research on the subject. · Does not assume anything from the reader except basic functional analysis. · Accessible to researchers and advanced graduate students alike · Applications to optimal diffusion processes. · Applications to optimal heat propagation processes. · Modelling of optimal processes governed by partial differential equations. · Complete bibliography. · Includes the latest research on the subject. · Does not assume anything from the reader except basic functional analysis. · Accessible to researchers and advanced graduate students alike

Graduate-level text provides introduction to optimal control theory for stochastic systems, emphasizing application of basic concepts to real problems.

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.

Duality System in Applied Mechanics and Optimal Control

Optimal Control Theory

with Real-Time Applications

Stochastic and Deterministic Problems (Pure and Applied Mathematics: A Series of Monographs and Textbooks/221)

Linear Optimal Control Systems

*Individual turnpike results are of great interest due to their numerous applications in engineering and in economic theory; in this book the study is focused on new results of turnpike phenomenon in linear optimal control problems. The book is intended for engineers as well as for mathematicians interested in the calculus of variations, optimal control and in applied functional analysis. Two large classes of problems are studied in*

*more depth. The first class studied in Chapter 2 consists of linear control problems with periodic nonsmooth convex integrands. Chapters 3-5 consist of linear control problems with autonomous convex smooth integrands. Chapter 6 discusses a turnpike property for dynamic zero-sum games with linear constraints. Chapter 7 examines genericity results. In Chapter 8, the description of structure of variational problems with extended-valued integrands is obtained. Chapter 9 ends the exposition with a study of turnpike phenomenon for dynamic games with extended value integrands.*

*Upper-level undergraduate text introduces aspects of optimal control theory: dynamic programming, Pontryagin's minimum principle, and numerical techniques for trajectory optimization. Numerous figures, tables. Solution guide available upon request. 1970 edition.*

*This textbook offers a concise yet rigorous introduction to calculus of variations and optimal control theory, and is a self-contained resource for graduate students in engineering, applied mathematics, and related subjects. Designed specifically for a one-semester course, the book begins with calculus of variations, preparing the ground for optimal control. It then gives a complete proof of the maximum principle and covers key topics such as the Hamilton-Jacobi-Bellman theory of dynamic programming and linear-quadratic optimal control. Calculus of Variations and Optimal Control Theory also traces the historical development of the subject and features numerous exercises, notes and references at the end of each chapter, and suggestions for further study. Offers a concise yet rigorous introduction Requires limited background in control theory or advanced mathematics Provides a complete proof of the maximum principle Uses consistent notation in the exposition of classical and modern topics Traces the historical development of the subject Solutions manual (available only to teachers) Leading universities that have adopted this book include: University of Illinois at Urbana-Champaign ECE 553: Optimum Control Systems Georgia Institute of Technology ECE 6553: Optimal Control and Optimization University of Pennsylvania ESE 680: Optimal Control Theory University of Notre Dame EE 60565: Optimal Control*

*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.*

*Continuous Time Dynamical Systems*

*Optimal Control of Distributed Systems with Conjugation Conditions*

*Stochastic Linear-Quadratic Optimal Control Theory: Open-Loop and Closed-Loop Solutions*

*Optimal and Robust Control*

*Parallel Algorithms for Optimal Control of Large Scale Linear Systems*

Many practical control problems are dominated by characteristics such as state, input and operational constraints, alternations between different operating regimes, and the interaction of continuous-time and discrete event systems. At present no methodology is available to design controllers in a systematic manner for such systems. This book introduces a new design theory for controllers for such constrained and switching dynamical systems and leads to algorithms that systematically solve control synthesis problems. The first part is a self-contained introduction to multiparametric programming, which is the main technique used to study and compute state feedback optimal control laws. The book's main objective is to derive properties of the state feedback solution, as well as to obtain algorithms to compute it efficiently. The focus is on constrained linear systems and constrained linear hybrid systems. The applicability of the theory is demonstrated through two experimental case studies: a mechanical laboratory process and a traction control system developed jointly with the Ford Motor Company in Michigan.

In addition to making a number of minor corrections and updating the references, we have expanded the section on "real-time system identification" in Chapter 10 of the first edition into two sections and combined it with Chapter 8. In its place, a very brief introduction to wavelet analysis is included in Chapter 10. Although the pyramid algorithms for wavelet decompositions and reconstructions are quite different from the Kalman filtering algorithms, they can also be applied to time-domain filtering, and it is hoped that splines and wavelets can be incorporated with Kalman filtering in the near future. College Station and Houston Charles K. Chui September 1990 Guanrong Chen Preface to the First Edition Kalman filtering is an optimal state estimation process applied to a dynamic system that involves random perturbations. More precisely, the Kalman filter gives a linear, unbiased, and minimum error variance recursive algorithm to optimally estimate the unknown state of a dynamic system from noisy data taken at discrete real-time. It has been widely used in many areas of industrial and government applications such as video and laser tracking systems, satellite navigation,

ballistic missile trajectory estimation, radar, and fire control. With the recent development of high-speed computers, the Kalman filter has become more use ful even for very complicated real-time applications.

Preface; List of symbols; Introduction; Analysis of control systems; Multivariable systems; Vector random processes; Performance; Robustness; The linear quadratic regulator; The Kalman filter; Linear quadratic Gaussian control; Control; Ful information control estimation; H [infinity symbol] output feedback; Controller order reduction; Appendix: Mathematical notes.

A knowledge of linear systems provides a firm foundation for the study of optimal control theory and many areas of system theory and signal processing. State-space techniques developed since the early sixties have been proved to be very effective. The main objective of this book is to present a brief and somewhat complete investigation on the theory of linear systems, with emphasis on these techniques, in both continuous-time and discrete-time settings, and to demonstrate an application to the study of elementary (linear and nonlinear) optimal control theory. An essential feature of the state-space approach is that both time-varying and time-invariant systems are treated systematically. When time-varying systems are considered, another important subject that depends very much on the state-space formulation is perhaps real-time filtering, prediction, and smoothing via the Kalman filter. This subject is treated in our monograph entitled "Kalman Filtering with Real-Time Applications" published in this Springer Series in Information Sciences (Volume 17). For time-invariant systems, the recent frequency domain approaches using the techniques of Adamjan, Arov, and Krein (also known as AAK), balanced realization, and oo H theory via Nevanlinna-Pick interpolation seem very promising, and this will be studied in our forthcoming monograph entitled "Mathematical Ap proach to Signal Processing and System Theory". The present elementary treatise on linear system theory should provide enough engineering and mathe of these two subjects.

Equivalence of Quadratic Performance Indices for Linear Optimal Control Systems

H2 and H[infinity] Methods

Design criterion for improving the sensitivity of linear optimal control systems

Linear Optimal Control

Linear State-Space Control Systems

**A NEW EDITION OF THE CLASSIC TEXT ON OPTIMAL CONTROL THEORY As a superb introductory text and an indispensable reference, this new edition of Optimal Control will serve the needs of both the professional engineer and the advanced student in mechanical, electrical, and aerospace engineering. Its coverage encompasses all the fundamental topics as well as the major changes that have occurred in**

recent years. An abundance of computer simulations using MATLAB and relevant Toolboxes is included to give the reader the actual experience of applying the theory to real-world situations. Major topics covered include: Static Optimization Optimal Control of Discrete-Time Systems Optimal Control of Continuous-Time Systems The Tracking Problem and Other LQR Extensions Final-Time-Free and Constrained Input Control Dynamic Programming Optimal Control for Polynomial Systems Output Feedback and Structured Control Robustness and Multivariable Frequency-Domain Techniques Differential Games Reinforcement Learning and Optimal Adaptive Control

Among the many techniques for designing linear multivariable analogue controllers, the two most popular optimal ones are H2 and H-infinity optimization. The fact that most new industrial controllers are digital provides strong motivation for adapting or extending these techniques to digital control systems. This book, now available as a corrected reprint, attempts to do so. Part I presents two indirect methods of sampled-data controller design: These approaches include approximations to a real problem, which involves an analogue plant, continuous-time performance specifications, and a sampled-data controller. Part II proposes a direct attack in the continuous-time domain, where sampled-data systems are time-varying. The findings are presented in forms that can readily be programmed in, e.g., MATLAB.

An excellent introduction to feedback control system design, this book offers a theoretical approach that captures the essential issues and can be applied to a wide range of practical problems. Its explorations of recent developments in the field emphasize the relationship of new procedures to classical control theory, with a focus on single input and output systems that keeps concepts accessible to students with limited backgrounds. The text is geared toward a single-semester senior course or a graduate-level class for students of electrical engineering. The opening chapters constitute a basic treatment of feedback design. Topics include a detailed formulation of the control design program, the fundamental issue of performance/stability robustness tradeoff, and the graphical design technique of loopshaping. Subsequent chapters extend the discussion of the loopshaping technique and connect it with notions of optimality. Concluding chapters examine controller design via optimization, offering a mathematical approach that is useful for multivariable systems.

This book develops original results regarding singular dynamic systems following two different paths. The first consists of generalizing results from classical state-space cases to linear descriptor systems, such as dilated linear matrix inequality (LMI) characterizations for descriptor systems and performance control under regulation constraints. The second is a new path, which considers descriptor systems as a powerful tool for conceiving new control laws, understanding and deciphering some controller's architecture and even homogenizing different—existing—ways of obtaining some new and/or known results for state-space systems. The book also highlights the comprehensive control problem for

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descriptor systems as an example of using the descriptor framework in order to transform a non-standard
control problem into a classic stabilization control problem. In another section, an accurate solution
is derived for the sensitivity constrained linear optimal control also using the descriptor framework.
The book is intended for graduate and postgraduate students, as well as researchers in the field of
systems and control theory.
Kalman Filtering
Optimal Control Systems
Nonlinear Optimal Control Theory
Calculus of Variations and Optimal Control Theory
Applied Linear Optimal Control Hardback with CD-ROM
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Nonlinear Optimal Control Theory presents a deep, wide-ranging introduction to the mathematical theory of the optimal control of processes governed by ordinary differential equations and certain types of differential equations with memory. Many examples illustrate the mathematical issues that need to be addressed when using optimal control techniques in diverse areas. Drawing on classroom-tested material from Purdue University and North Carolina State University, the book gives a unified account of bounded state problems governed by ordinary, integrodifferential, and delay systems. It also discusses Hamilton-Jacobi theory. By providing a sufficient and rigorous treatment of finite dimensional control problems, the book equips readers with the foundation to deal with other types of control problems, such as those governed by stochastic differential equations, partial differential equations, and differential games.

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. Parallel Algorithms for Optimal Control of Large Scale Linear Systems is a comprehensive presentation for both linear and bilinear systems. The parallel algorithms presented in this book are applicable to a wider class of practical systems than those served by traditional methods for large scale singularly perturbed and weakly coupled systems based on the power-series expansion methods. It is intended for scientists and advance graduate students in electrical engineering and computer science who deal with parallel algorithms and control systems, especially large scale systems. The material presented is both comprehensive and unique.

Linear optimal control theory has produced an important synthesis technique for the design of linear multivariable systems. In the present study, efficient design procedures, based on the general optimal theory, have been developed. These procedures make use of design techniques which are similar to the conventional methods of control system analysis. Specifically, a scalar expression is developed which relates the closed-loop poles of the multi- controller, multi-output optimal system to the weighting parameters of a

quadratic performance index. Methods analogous to the root locus and Bode plot techniques are then developed for the systematic analysis of this expression. Examples using the aircraft longitudinal equations of motion to represent the object to be controlled are presented to illustrate design procedures which can be carried out in either the time or frequency domains. Both the model-in -the-performance-index and model-following concepts are employed in several of the examples to illustrate the model approach to optimal design.

Optimal Sampled-Data Control Systems

Optimal Control of Dynamic Systems Driven by Vector Measures

Linear Quadratic Methods

A Concise Introduction

On the Design of Insensitive Linear Optimal Control Systems

*Optimal Networked Control Systems with MATLAB® discusses optimal controller design in discrete time for networked control systems (NCS). The authors apply several powerful modern control techniques in discrete time to the design of intelligent controllers for such NCS. Detailed derivations, rigorous stability proofs, computer simulation examples, and downloadable MATLAB® codes are included for each case. The book begins by providing background on NCS, networked imperfections, dynamical systems, stability theory, and stochastic optimal adaptive controllers in discrete time for linear and nonlinear systems. It lays the foundation for reinforcement learning-based optimal adaptive controller use for finite and infinite horizons. The text then: Introduces quantization effects for linear and nonlinear NCS, describing the design of stochastic adaptive controllers for a class of linear and nonlinear systems Presents two-player zero-sum game-theoretic formulation for linear systems in input–output form enclosed by a communication network Addresses the stochastic optimal control of nonlinear NCS by using neuro dynamic programming Explores stochastic optimal design for nonlinear two-player zero-sum games under communication constraints Treats an event-sampled distributed NCS to minimize transmission of state and control signals within the feedback loop via the communication network Covers distributed joint optimal network scheduling and control design for wireless NCS, as well as the effect of network protocols on the wireless NCS controller design An ideal reference for graduate students, university researchers, and practicing engineers, Optimal Networked Control Systems with MATLAB® instills a solid understanding of neural network controllers and how to build them.*

*"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.*

*The theory of optimal control systems has grown and flourished since the 1960's. Many texts, written on varying levels of sophistication, have been published on the subject. Yet even those purportedly designed for beginners in the field are often riddled with complex theorems, and many treatments fail to include topics that are essential to a thorough grounding in the various aspects of and approaches to optimal control. Optimal Control Systems provides a comprehensive but accessible treatment of the subject with just the right degree of mathematical rigor to be complete but practical. It provides a solid bridge between "traditional" optimization using the calculus of variations and what is called "modern" optimal control. It also treats both continuous-time and discrete-time optimal control systems, giving students a firm grasp on both methods. Among this book's most outstanding features is a summary table that accompanies each topic or problem and includes a statement of the problem with a step-by-step solution. Students will also gain valuable experience in using industry-standard MATLAB and SIMULINK software, including the Control System and Symbolic Math Toolboxes. Diverse applications across fields from power engineering to medicine make a foundation in optimal control systems an essential part of an engineer's background. This clear, streamlined presentation is ideal for a graduate level course on control systems and as a quick reference for working engineers.*

*This book gathers the most essential results, including recent ones, on linear-quadratic optimal control problems, which represent an important aspect of stochastic control. It presents the results in the context of finite and infinite horizon problems, and discusses a number of new and interesting issues. Further, it precisely identifies, for the first time, the interconnections between three well-known, relevant issues – the existence of optimal controls, solvability of the optimality system, and solvability of the associated Riccati equation. Although the content is largely self-contained, readers should have a basic grasp of linear algebra, functional analysis and stochastic ordinary differential equations. The book is mainly intended for senior undergraduate and graduate students majoring in applied mathematics who are interested in stochastic control theory. However, it will also appeal to researchers in other related areas, such as engineering, management, finance/economics and the social sciences.*

*Turnpike Theory of Continuous-Time Linear Optimal Control Problems*

*Optimal Networked Control Systems with MATLAB*

*An Introduction*

*The Zeros of Linear Optimal Control Systems and Their Role in High Feedback Gain Stability Design*

***Nonlinear and Optimal Control Systems***

Highlighing the Hamiltonian approach to singularly perturbed linear optimal control systems, this volume develops parallel algorithms in independent slow and fast time scales to solve various optimal linear control and filtering problems. Highlights the Hamiltonian approach to singularly perturbed linear optimal control systems. Develops parallel algorithms in independent slow and fast time scales for solving various optimal linear control and filtering problems in standard and nonstandard singularly perturbed systems, continuous- and discrete-time, deterministic and stochastic, mul

Optimal Design of Control Systems

Constrained Optimal Control of Linear and Hybrid Systems

With solved problems and MATLAB examples

The Time Optimal and Norm Optimal Problems

Infinite Dimensional Linear Control Systems