In Chapter 1 we demonstrate instru ment stability in an economic stabilization problem and thereby establish the motivation for our departure into the optimal control world. Chapter 2 provides fundamental concepts and propositions for controlling linear deterministic discrete-time systems, together with some economic applications and numerical methods. Our optimal control rules are in the form of feedback from known state variables of the preceding period. When certain state variables are not observable or are not completely observed, we must obtain appropriate feedback on these variables only with observation errors, which we refer to as "observers" in deterministic cases or "filters" in stochastic circumstances. In Chapters 3 and 4, respectively, Luenberger observers and Kalman filters are discussed, developed, and applied in various directions. Noticing that a separation principle lies between observer (or filter) and controller (cf. 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 covers a class of controls, including measurable controls (vector-measurable functions), relaxed controls and ordinary differential equations (ODEs) is the backbone of the theory developed in the book, and chapter 2 offers a detailed review of basic concepts in the theory of time-invariant and time-varying systems. A rigorous introduction to optimal control theory, with an emphasis on applications in economics. This book bridges optimal control theory 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, 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 Approach to Signal Processing and System Theory". The present elementary treatise on linear system theory should provide the necessary math and matrix theoretical concepts dominated by such state-space techniques as state feedback, pole placement, state-space representations, reachable and controllable systems, and optimal control. When system parameters are 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, the main techniques are entangled with the state feedback control law. The second part is a short introduction to the state feedback solution, as well as to obtain algorithms to compute an efficiently. The focus is on constrained linear systems and constrained hybrid systems. The applicability of the theory is demonstrated through two experimental case studies: a mechanical laboratory process and a traction system developed jointly with the Ford Motor Company in Michigan. 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-inducing control concepts are entangled with the state feedback design procedure. Several of the examples and computer programs in the CD-ROM are taken from the OPTTEST toolbox -- Code for examples, figures, and selected problems in text. 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 optimal control systems, 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. The content is shown to have a basic grasp of linear algebra, functional analysis and stochastic techniques which are similar to the conventional methods of control system synthesis. 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. 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 related 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 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 With a simple approach that includes real-time applications and algorithms, this book covers the theory of model predictive control (MPC); 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; Fpl information control estimation; H [infinity symbol] output feedback; Controller order reduction; Appendix: Mathematical notes;Optimal control deals with the determination of control laws for a dynamical system that achieve a desired performance criterion. A central concept in control theory is the use of feedback to control the behavior of a dynamical system, and the feedback is computed by solving an optimization problem. The objective is to determine control laws for a dynamical system that achieve a desired performance criterion. A central concept in control theory is the use of feedback to control the behavior of a dynamical system, and the feedback is computed by solving an optimization problem. The objective is to determine control laws for a dynamical system that achieve a desired performance criterion. A central concept in control theory is the use of feedback to control the behavior of a dynamical system, and the feedback is computed by solving an optimization problem.
applications; the problems are an integral part of the text. It is intended for use as a textbook or reference for graduate students, teachers, and researchers interested in applications of control theory beyond its classical use in economic growth. The book will also appeal to readers interested in a modeling approach to certain practical problems involving dynamic economic systems. It introduces the concepts of linear control and filtering problems in continuous and discrete-time settings, with applications to economic and engineering systems. The book is intended for engineers as well as for mathematicians interested 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 both complete and practical. It provides a solid bridge between "traditional" optimization and the calculus of variations and what is called "modern" optimal control. It also treats both continuous-time and discrete-time optimal control systems, a firm grasp on both methods. Among this book's most outstanding features is a summary table that accompanies each topic and provides a description 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 Toolbox and Symbolic Math Toolbox. Diverse applications across fields from power engineering to medicine make a foundation in optimal control systems an essential part of an engineer's education. To make this guide as ideal as possible, the authors have highlighted problems with 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 systems with periodic nonsmooth control integrands. Chapters 3-5 consist of linear control problems with autonomous smooth controls and integrands. Chapter 6 discusses a turnpike property for linear zero-sum games with linear constraints. Chapter 7 examines gradient properties. In Chapter 8, the description of structure of variational problems with extended-valued integrals is obtained. Chapter 9 ends the exposition with a study of turnpike phenomenon for dynamic systems, with extended value integrals. Numerous examples highlight this treatment of the use of linear quadratic Gaussian methods for control design. It explores linear optimal control theory from an engineering viewpoint, with illustrations of practical applications. Key topics include loop-recovery techniques, state-space shaping, and controller reduction. Numerous examples and complete solutions. 1990 edition. Nonlinear Optimal Control Theory provides 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 various 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 fundamental problems, the book is useful to readers with the background in advanced calculus, linear algebra, ordinary differential equations, and functional analysis. 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 overview 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. This textbook offers a concise yet rigorous introduction to calculus of variations and optimal control, 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 653: Optimal Control and Optimization University of Pennsylvania ESE 680: Optimal Control Theory University of Notre Dame EE 60565: Optimal Control The book's approach to reconciling 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 stop 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, modern methods are discussed. The book's approach to reconciling 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 stop 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. 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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, modern methods are discussed.
attitudes toward the topic in the scientific and engineering community have ranged from an excessive enthusiasm for its reputed capability of solving almost any kind of problem to an (equally) unjustified rejection of it as a set of abstract mathematical concepts with no real utility. The truth, apparently, lies somewhere between these two extremes. Intense research activity in the field of optimization, in particular with reference to robust control issues, has caused it to be regarded as a source of numerous useful, powerful, and flexible tools for the control system designer. The new stream of research is deeply rooted in the well-established framework of linear quadratic gaussian control theory, knowledge of which is an essential requirement for a fruitful understanding of optimization. In addition, there appears to be a widely shared opinion that some results of variational techniques are particularly suited for an approach to nonlinear solutions for complex control problems. For these reasons, even though the first significant achievements in the field were published some forty years ago, a new presentation of the basic elements of classical optimal control theory from a tutorial point of view seems meaningful and contemporary. This text draws heavily on the content of the Italian language textbook "Controllo ottimo" published by Pitagora and used in a number of courses at the Politecnico of Milan.

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