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E. D. Sontag

# Mathematical Control Theory

Deterministic  
Finite Dimensional Systems



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# Mathematical Control Theory Deterministic Finite Dimensional Systems

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## **Mathematical Control Theory Deterministic Finite Dimensional Systems:**

**Mathematical Control Theory** Eduardo D. Sontag, 2013-11-21 Mathematics is playing an ever more important role in the physical and biological sciences provoking a blurring of boundaries between scientific disciplines and a resurgence of interest in the modern as well as the classical techniques of applied mathematics This renewal of interest both in research and teaching has led to the establishment of the series Texts in Applied Mathematics TAM The development of new courses is a natural consequence of a high level of excitement on the research frontier as newer techniques such as numerical and symbolic computer systems dynamical systems and chaos mix with and reinforce the traditional methods of applied mathematics Thus the purpose of this textbook series is to meet the current and future needs of these advances and to encourage the teaching of new courses TAM will publish textbooks suitable for use in advanced undergraduate and beginning graduate courses and will complement the Applied Mathematics Sciences AMS series which will focus on advanced textbooks and research level monographs v Preface to the Second Edition The most significant differences between this edition and the first are as follows Additional chapters and sections have been written dealing with nonlinear controllability via Lie algebraic methods variational and numerical approaches to nonlinear control including a brief introduction to the Calculus of Variations and the Minimum Principle time optimal control of linear systems feedback linearization single input case nonlinear optimal feedback controllability of recurrent nets and controllability of linear systems with bounded controls

**Mathematical Control Theory** Jerzy Zabczyk, 1992 This book is designed as a graduate text on the mathematical theory of deterministic control It covers a remarkable number of topics The book includes material on the realization of both linear and nonlinear systems impulsive control and positive linear systems subjects not usually covered in an introductory book To get so much material in such a short space the pace of the presentation is brisk However the exposition is excellent and the book is a joy to read A novel one semester course covering both linear and nonlinear systems could be given The book is an excellent one for introducing a mathematician to control theory The book presents a large amount of material very well and its use is highly recommended a Bulletin of the AMS Mathematical Control Theory An Introduction presents in a mathematically precise manner a unified introduction to deterministic control theory With the exception of a few more advanced concepts required for the final part of the book this presentation requires only a knowledge of basic facts from linear algebra differential equations and calculus In addition to classical concepts and ideas the author covers the stabilization of nonlinear systems using topological methods realization theory for nonlinear systems impulsive control and positive systems the control of rigid bodies the stabilization of infinite dimensional systems and the solution of minimum energy problems The book will be ideal for a beginning graduate course in mathematical control theory or for self study by professionals needing a complete picture of the mathematical theory that underlies the applications of control theory

**Mathematical Control Theory** John Baillieul, Jan C. Willems, 1999 This volume on mathematical control

theory contains high quality articles covering the broad range of this field The internationally renowned authors provide an overview of many different aspects of control theory offering a historical perspective while bringing the reader up to the very forefront of current research     *Mathematical Control Theory* Czesław Olech, Bronisław Jakubczyk, Jerzy Zabczyk, 1985

Mathematical Control Theory for Stochastic Partial Differential Equations Qi Lü, Xu Zhang, 2021-09-17 This is the first book to systematically present control theory for stochastic distributed parameter systems a comparatively new branch of mathematical control theory The new phenomena and difficulties arising in the study of controllability and optimal control problems for this type of system are explained in detail Interestingly enough one has to develop new mathematical tools to solve some problems in this field such as the global Carleman estimate for stochastic partial differential equations and the stochastic transposition method for backward stochastic evolution equations In a certain sense the stochastic distributed parameter control system is the most general control system in the context of classical physics Accordingly studying this field may also yield valuable insights into quantum control systems A basic grasp of functional analysis partial differential equations and control theory for deterministic systems is the only prerequisite for reading this book     **Open Problems in**

**Mathematical Systems and Control Theory** Vincent D. Blondel, Eduardo D. Sontag, Mathukumalli Vidyasagar, Jan C. Willems, 2012-12-06 System and Control theory is one of the most exciting areas of contemporary engineering mathematics From the analysis of Watt's steam engine governor which enabled the Industrial Revolution to the design of controllers for consumer items chemical plants and modern aircraft the area has always drawn from a broad range of tools It has provided many challenges and possibilities for interaction between engineering and established areas of pure and applied mathematics This impressive volume collects a discussion of more than fifty open problems which touch upon a variety of subfields including chaotic observers nonlinear local controllability discrete event and hybrid systems neural network learning matrix inequalities Lyapunov exponents and many other issues Proposed and explained by leading researchers they are offered with the intention of generating further work as well as inspiration for many other similar problems which may naturally arise from them With extensive references this book will be a useful reference source as well as an excellent addendum to the textbooks in the area     **A Course in Robust Control Theory** Geir E. Dullerud, Fernando

Paganini, 2013-03-14 Research in robust control theory has been one of the most active areas of mainstream systems theory since the late 70s This research activity has been at the confluence of dynamical systems theory functional analysis matrix analysis numerical methods complexity theory and engineering applications The discipline has involved interactions between diverse research groups including pure mathematicians applied mathematicians computer scientists and engineers This research effort has produced a rather extensive set of approaches using a wide variety of mathematical techniques and applications of robust control theory are spreading to areas as diverse as control of fluids power networks and the investigation of feedback mechanisms in biology During the 90s the theory has seen major advances and achieved a new

maturity centered around the notion of convexity The goal of this book is to give a graduate level course on robust control theory that emphasizes these new developments but at the same time conveys the main principles and ubiquitous tools at the heart of the subject Its pedagogical objectives are to introduce a coherent and unified framework for studying robust control theory to provide students with the control theoretic background required to read and contribute to the research literature and to present the main ideas and demonstrations of the major results of robust control theory The book will be of value to mathematical researchers and computer scientists wishing to learn about robust control theory graduate students planning to do research in the area and engineering practitioners requiring advanced control techniques

**Singular Trajectories and their Role in Control Theory** Bernard Bonnard, Monique Chyba, 2003-05-12 The role of singular trajectories in control theory is analysed in this volume that contains about 60 exercises and problems A section is devoted to the applications of singular trajectories to the optimisation of batch reactors The theoretical part based on the Martinet case concerns the singularity analysis of singular trajectories in sub Riemannian geometry An algorithm is given to evaluate conjugate points and a final chapter discusses open problems The volume will interest mathematicians and engineers

*Control Theory in the Plane* Otomar Hájek, 2014-03-12 This book introduces presents and illustrates the theory of control for systems governed by ordinary differential equations with special references to the two dimensional case These systems are continuous finite dimensional deterministic with a priori bounds on the admissible controls Its form is that of a graduate level textbook involving motivation a rather elementary level of exposition illustrative examples and extensive problem sections It is addressed to applied mathematicians and engineers system control electrical mechanical chemical who wish to acquire further mathematical background in order to treat the subject they already know is both fascinating and important Hopefully it might also serve those whose interest is in modeling bio mathematics and economics The special feature of this book is the focused study in the second part of control systems whose state space is the phase plane As with differential equations where specialisation to the plane provides a far richer theory the classical results of Poincaré and Bendixson control theory of two dimensional systems also has more intuitive and deeper results

**Optimal Control and Geometry: Integrable Systems** Velimir Jurdjevic, 2016-07-04 The synthesis of symplectic geometry the calculus of variations and control theory offered in this book provides a crucial foundation for the understanding of many problems in applied mathematics Focusing on the theory of integrable systems this book introduces a class of optimal control problems on Lie groups whose Hamiltonians obtained through the Maximum Principle of optimality shed new light on the theory of integrable systems These Hamiltonians provide an original and unified account of the existing theory of integrable systems The book particularly explains much of the mystery surrounding the Kepler problem the Jacobi problem and the Kovalevskaya Top It also reveals the ubiquitous presence of elastic curves in integrable systems up to the soliton solutions of the non linear Schrödinger equation Containing a useful blend of theory and applications this is an indispensable guide for graduates and researchers in

many fields from mathematical physics to space control      *Control and System Theory of Discrete-Time Stochastic Systems* Jan H. van Schuppen, 2021-08-02 This book helps students researchers and practicing engineers to understand the theoretical framework of control and system theory for discrete time stochastic systems so that they can then apply its principles to their own stochastic control systems and to the solution of control filtering and realization problems for such systems Applications of the theory in the book include the control of ships shock absorbers traffic and communications networks and power systems with fluctuating power flows The focus of the book is a stochastic control system defined for a spectrum of probability distributions including Bernoulli finite Poisson beta gamma and Gaussian distributions The concepts of observability and controllability of a stochastic control system are defined and characterized Each output process considered is with respect to conditions represented by a stochastic system called a stochastic realization The existence of a control law is related to stochastic controllability while the existence of a filter system is related to stochastic observability Stochastic control with partial observations is based on the existence of a stochastic realization of the filtration of the observed process      **Control Theory from the Geometric Viewpoint** Andrei A. Agrachev, Yuri Sachkov, 2004-04-15 This book presents some facts and methods of Mathematical Control Theory treated from the geometric viewpoint It is devoted to finite dimensional deterministic control systems governed by smooth ordinary differential equations The problems of controllability state and feedback equivalence and optimal control are studied Some of the topics treated by the authors are covered in monographic or textbook literature for the first time while others are presented in a more general and flexible setting than elsewhere Although being fundamentally written for mathematicians the authors make an attempt to reach both the practitioner and the theoretician by blending the theory with applications They maintain a good balance between the mathematical integrity of the text and the conceptual simplicity that might be required by engineers It can be used as a text for graduate courses and will become most valuable as a reference work for graduate students and researchers      **Control Theory from the Geometric Viewpoint** Andrei A. Agrachev, Yuri Sachkov, 2014-01-15      *Nonautonomous Linear Hamiltonian Systems: Oscillation, Spectral Theory and Control* Russell Johnson, Rafael Obaya, Sylvia Novo, Carmen Núñez, Roberta Fabbri, 2016-03-25 This monograph contains an in depth analysis of the dynamics given by a linear Hamiltonian system of general dimension with nonautonomous bounded and uniformly continuous coefficients without other initial assumptions on time recurrence Particular attention is given to the oscillation properties of the solutions as well as to a spectral theory appropriate for such systems The book contains extensions of results which are well known when the coefficients are autonomous or periodic as well as in the nonautonomous two dimensional case However a substantial part of the theory presented here is new even in those much simpler situations The authors make systematic use of basic facts concerning Lagrange planes and symplectic matrices and apply some fundamental methods of topological dynamics and ergodic theory Among the tools used in the analysis which include Lyapunov exponents Weyl matrices exponential dichotomy

and weak disconjugacy a fundamental role is played by the rotation number for linear Hamiltonian systems of general dimension The properties of all these objects form the basis for the study of several themes concerning linear quadratic control problems including the linear regulator property the Kalman Bucy filter the infinite horizon optimization problem the nonautonomous version of the Yakubovich Frequency Theorem and dissipativity in the Willems sense The book will be useful for graduate students and researchers interested in nonautonomous differential equations dynamical systems and ergodic theory spectral theory of differential operators and control theory Introduction to the Mathematical Theory of Control

Alberto Bressan, Benedetto Piccoli, 2007 *Optimal Control of Dynamic Systems Driven by Vector Measures* N. U.

Ahmed, Shian Wang, 2021-09-13 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 **Control Theory and Advanced Technology**, 1994 **Trends in Control Theory and**

**Partial Differential Equations** Fatiha Alabau-Boussouira, Fabio Ancona, Alessio Porretta, Carlo Sinestrari, 2019-07-04 This book presents cutting edge contributions in the areas of control theory and partial differential equations Over the decades control theory has had deep and fruitful interactions with the theory of partial differential equations PDEs Well known examples are the study of the generalized solutions of Hamilton Jacobi Bellman equations arising in deterministic and stochastic optimal control and the development of modern analytical tools to study the controllability of infinite dimensional systems governed by PDEs In the present volume leading experts provide an up to date overview of the connections between these two vast fields of mathematics Topics addressed include regularity of the value function associated to finite dimensional control systems controllability and observability for PDEs and asymptotic analysis of multiagent systems The book will be of interest for both researchers and graduate students working in these areas **SIAM Journal on Control**

**and Optimization** Society for Industrial and Applied Mathematics, 2006  
**Mathematics**, 2000

**Proceedings of the Steklov Institute of**



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