



Mathematical Problems of Control Theory

An Introduction

Gennady A. Leonov



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Mathematical Problems Of Control Theory An Introduction

Shlomo Engelberg



Mathematical Problems Of Control Theory An Introduction:

Mathematical Problems of Control Theory Gennadi? Alekseevich Leonov, 2001 This book shows clearly how the study of concrete control systems has motivated the development of the mathematical tools needed for solving such problems In many cases by using this apparatus far reaching generalizations have been made and its further development will have an important effect on many fields of mathematics In the book a way is demonstrated in which the study of the Watt flyball governor has given rise to the theory of stability of motion The criteria of controllability observability and stabilization are stated Analysis is made of dynamical systems which describe an autopilot spacecraft orientation system controllers of a synchronous electric machine and phase locked loops The Aizerman and Brockett problems are discussed and an introduction to the theory of discrete control systems is given Contents The Watt Governor and the Mathematical Theory of Stability of Motion Linear Electric Circuits Transfer Functions and Frequency Responses of Linear Blocks Controllability Observability Stabilization Two Dimensional Control Systems Phase Portraits Discrete Systems The Aizerman Conjecture The Popov Method Readership Applied mathematicians and mechanical engineers Optimal Control Theory Donald E. Kirk, 2012-04-26 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 *Mathematical Problems Of Control Theory: An Introduction* Gennady A. Leonov, 2001-11-28 This book shows clearly how the study of concrete control systems has motivated the development of the mathematical tools needed for solving such problems In many cases by using this apparatus far reaching generalizations have been made and its further development will have an important effect on many fields of mathematics In the book a way is demonstrated in which the study of the Watt flyball governor has given rise to the theory of stability of motion The criteria of controllability observability and stabilization are stated Analysis is made of dynamical systems which describe an autopilot spacecraft orientation system controllers of a synchronous electric machine and phase locked loops The Aizerman and Brockett problems are discussed and an introduction to the theory of discrete control systems is given **Mathematical Control Theory** Jerzy Zabczyk, 2020-07-28 This textbook 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 the 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 This second edition includes new chapters that introduce a variety of topics such as controllability with vanishing energy boundary control systems and delayed systems With additional proofs theorems results and a substantially larger index this new edition will be an invaluable resource for

students and researchers of control theory Mathematical Control Theory An Introduction 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 From reviews of the first edition At last We did need an introductory textbook on control which can be read understood and enjoyed by anyone Gian Carlo Rota The Bulletin of Mathematics Books It covers a remarkable number of topics 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 Bulletin of the AMS Indeed for mathematicians who look for the basic ideas or a general picture about the main branches of control theory I believe this book can provide an excellent bridge to this area IEEE Control Systems Magazine

Introduction to Optimal Control Theory Jack Macki, Aaron Strauss, 2012-12-06 This monograph is an introduction to optimal control theory for systems governed by vector ordinary differential equations It is not intended as a state of the art handbook for researchers We have tried to keep two types of reader in mind 1 mathematicians graduate students and advanced undergraduates in mathematics who want a concise introduction to a field which contains nontrivial interesting applications of mathematics for example weak convergence convexity and the theory of ordinary differential equations 2 economists applied scientists and engineers who want to understand some of the mathematical foundations of optimal control theory In general we have emphasized motivation and explanation avoiding the definition axiom theorem proof approach We make use of a large number of examples especially one simple canonical example which we carry through the entire book In proving theorems we often just prove the simplest case then state the more general results which can be proved Many of the more difficult topics are discussed in the Notes sections at the end of chapters and several major proofs are in the Appendices We feel that a solid understanding of basic facts is best attained by at first avoiding excessive generality We have not tried to give an exhaustive list of references preferring to refer the reader to existing books or papers with extensive bibliographies References are given by author s name and the year of publication e g Waltman 1974

An Introduction to Optimal Control Theory Aaron Strauss, 2012-12-06 This paper is intended for the beginner It is not a state of the art paper for research workers in the field of control theory Its purpose is to introduce the reader to some of the problems and results in control theory to illustrate the application of these results and to provide a guide for his further reading on this subject I have tried to motivate the results with examples especially with one canonical simple example described in 3 Many results such as the maximum principle have long and difficult proofs I have omitted these proofs In general I have included only the proofs which are either 1 not too difficult or 2 fairly enlightening as to the nature of the result I have however usually attempted to draw the strongest conclusion from a given proof For example many existing proofs in control theory for compact targets and uniqueness of solutions also hold for closed targets and non uniqueness Finally at the end of each section I have given references to generalizations and origins of the results discussed in that

section I make no claim of completeness in the references however as I have often been content merely to refer the reader either to an exposition or to a paper which has an extensive bibliography IV These lecture notes are revisions of notes I used for a series of nine lectures on control theory at the International Summer School on Mathematical Systems and Economics held in Varenna Italy June 1967

Mathematical Control Theory Czesław Olech, Bronisław Jakubczyk, Jerzy Zabczyk, 1985

An Introduction to Optimal Control Problems in Life Sciences and Economics Sebastian Anița, Viorel Arnăutu, Vincenzo Capasso, 2011-05-05 Combining control theory and modeling this textbook introduces and builds on methods for simulating and tackling concrete problems in a variety of applied sciences Emphasizing learning by doing the authors focus on examples and applications to real world problems An elementary presentation of advanced concepts proofs to introduce new ideas and carefully presented MATLAB programs help foster an understanding of the basics but also lead the way to new independent research With minimal prerequisites and exercises in each chapter this work serves as an excellent textbook and reference for graduate and advanced undergraduate students researchers and practitioners in mathematics physics engineering computer science as well as biology biotechnology economics and finance

An Introduction to Optimal Control Theory Onésimo Hernández-Lerma, Leonardo R. Laura-Guarachi, Saul Mendoza-Palacios, David González-Sánchez, 2023-02-21 This book introduces optimal control problems for large families of deterministic and stochastic systems with discrete or continuous time parameter These families include most of the systems studied in many disciplines including Economics Engineering Operations Research and Management Science among many others The main objective is to give a concise systematic and reasonably self contained presentation of some key topics in optimal control theory To this end most of the analyses are based on the dynamic programming DP technique This technique is applicable to almost all control problems that appear in theory and applications They include for instance finite and infinite horizon control problems in which the underlying dynamic system follows either a deterministic or stochastic difference or differential equation In the infinite horizon case it also uses DP to study undiscounted problems such as the ergodic or long run average cost After a general introduction to control problems the book covers the topic dividing into four parts with different dynamical systems control of discrete time deterministic systems discrete time stochastic systems ordinary differential equations and finally a general continuous time MCP with applications for stochastic differential equations The first and second part should be accessible to undergraduate students with some knowledge of elementary calculus linear algebra and some concepts from probability theory random variables expectations and so forth Whereas the third and fourth part would be appropriate for advanced undergraduates or graduate students who have a working knowledge of mathematical analysis derivatives integrals and stochastic processes

Mathematical Introduction to Control Theory, a (Third Edition) Shlomo Engelberg, 2024 The 3rd edition strikes a nice balance between mathematical rigor and engineering oriented applications helping students to understand the mathematical and engineering aspects of control theory The book

makes effective use of the tools provided by MATLAB R and includes material about using the tools provided by the Python R programming language in the design and analysis of control systems without allowing the computer based tools to substitute for knowledge of control theory The examples in the text are carefully designed to develop the student s intuition in both mathematics and engineering With over 90 solved homework problems and about 200 figures this invaluable title will benefit junior and senior level university students in engineering 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 **Mathematical**

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Introduction to Control Theory O. L. R. Jacobs, 1974 **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 **Optimal Control** Michael Athans, Peter L. Falb, 2013-04-26 Geared toward advanced undergraduate and graduate engineering students this text introduces the theory and applications of optimal control It serves as a bridge to the technical literature enabling students to evaluate the implications of theoretical control work and to judge the merits of papers on the subject Rather than presenting an exhaustive treatise Optimal Control offers a detailed introduction that fosters careful thinking and disciplined intuition It develops the basic mathematical background with a coherent formulation of the control problem and discussions of the necessary conditions for optimality based on the maximum principle of Pontryagin In depth examinations cover applications of the theory to minimum time minimum fuel and to quadratic criteria problems The structure properties and engineering realizations of several optimal feedback control systems also receive attention Special features include numerous specific problems carried through to engineering realization in block diagram form The text treats almost all current examples of control problems that permit analytic solutions and its unified approach makes frequent use of geometric ideas to encourage students intuition *Calculus of Variations and Optimal Control Theory* Daniel Liberzon, 2012-01-08 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 **Mathematical Control Theory** John B. Baillieul, J.C. Willems, 2012-12-06 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 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 *Introduction to the Mathematical Theory of Control Processes: Linear Equations and Quadratic Criteria v. 1* Bellman,1967-01-01 This work discusses the theory of control processes The extremely rapid growth of the theory associated intimately with the continuing trend toward automation makes it imperative that the courses of this nature rest upon a broad basis The work discusses the fundamentals of the calculus of variations dynamic programming discrete control processes use of the digital computer and functional analysis Introductory courses in control theory are essential for training the modern graduate student in pure and applied mathematics engineering mathematical physics economics biology operations research and related fields The work also describes the dual approaches of the calculus of variations and dynamic programming in the scalar case and illustrates ways to tackle the multidimensional optimization problems Optimal Control Leslie M. Hocking,1991 Systems that evolve with time occur frequently in nature and modelling the behaviour of such systems provides an important application of mathematics These systems can be completely deterministic but it may be possible too to control their behaviour by intervention through controls The theory of optimal control is concerned with determining such controls which at minimum cost either direct the system along a given trajectory or enable it to reach a given point in its state space This textbook is a straightforward introduction to the theory of optimal control with an emphasis on presenting many different applications Professor Hocking has taken pains to ensure that the theory is developed to display the main themes of the arguments but without using sophisticated mathematical tools Problems in this setting can arise across a wide range of subjects and there are illustrative examples of systems from as diverse fields as dynamics economics population control and medicine Throughout there are many worked examples and numerous exercises with solutions are provided

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