# Mathematical Problems of Control Theory

## An Introduction

### Gennady A. Leonov

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# Mathematical Problems Of Control Theory An Introduction

John B. Baillieul,J.C. Willems

**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 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 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 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 systemsa 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     <u>An Introduction to Optimal Control Problems in Life Sciences and Economics</u> Sebastian Aniţa,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     **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     **A Mathematical Introduction to Control Theory** Shlomo Engelberg,2005     *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 controlability 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   *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 re sults and to provide a guide for his further reading on this subject I have tried to motivate the results with examples especial ly 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 1ecture notes are revisions of notes I used for aseries of nine 1ectures on contro1 theory at the International Summer Schoo1 on Mathematica1 Systems and Economics held in Varenna Ita1y June 1967   *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   *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 **Mathematical Control Theory** Eduardo D. Sontag,2013-11-21 Mathematics is playing an ever more important role in the physical and biologi cal 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 rein force 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 Sci ences 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 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 **Introduction to Mathematical Control Theory** Stephen Barnett,R. G. Cameron,1985 In this new edition of a successful text Professor Barnett now joined in the authorship by Dr Cameron has concentrated on adding material where topics have developed since the first edition and they have also taken advantage of the extensive classroom testing that has

been possible in the intervening years The book remains the concise readable account of some basic mathematical aspects of control concentrating on state space methods and emphasizing points of mathematical interest As far as the additional material is concerned the new chapter on multivariable theory reflects some of the significant developments in that field during the past decade and there is also now an appendix on Kalman filtering All references have been updated and a large number of new problems for student use have been incorporated    <u>Stability of Stationary Sets in Control Systems with Discontinuous Nonlinearities</u> Vladimir Andreevich I?A?kubovich,Gennadi? Alekseevich Leonov,Arkadi? Kha?movich Gelig,2004 This book presents a development of the frequency domain approach to the stability study of stationary sets of systems with discontinuous nonlinearities The treatment is based on the theory of differential inclusions and the second Lyapunov method Various versions of the Kalman Yakubovich lemma on solvability of matrix inequalities are presented and discussed in detail It is shown how the tools developed can be applied to stability investigations of relay control systems gyroscopic systems mechanical systems with a Coulomb friction nonlinear electrical circuits cellular neural networks phase locked loops and synchronous machines    **New Perspectives and Applications of Modern Control Theory** Julio B. Clempner,Wen Yu,2017-09-30 This edited monograph contains research contributions on a wide range of topics such as stochastic control systems adaptive control sliding mode control and parameter identification methods The book also covers applications of robust and adaptice control to chemical and biotechnological systems This collection of papers commemorates the 70th birthday of Dr Alexander S Poznyak    **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    <u>Infinite Dimensional Optimization and Control Theory</u> Hector O. Fattorini,1999-03-28 Treats optimal problems for systems described by ODEs and PDEs using an approach that unifies finite and infinite dimensional nonlinear programming    **Sensitivity Methods in Control Theory** L. Radanović,2014-06-28 Sensitivity Methods in Control Theory is a collection of manuscripts presented as the Third International Symposium of Sensitivity Analysis held at Dubrovnik Yugoslavia on August 31 September 5 1964 sponsored by The Theory Committee of International Federation of Automatic Control Sensitivity theory or sensitivity analysis concerns the solution of problems associated with parameter variations within the general scope of control theory This book is organized into five parts

encompassing 30 chapters Part I presents some basic approaches of sensitivity analysis such the Lyapunov s theory of stability invariant imbedding nonlinear sampled data and linear time varying systems This part also looks into the preliminary steps towards the development of game theory and some general applications of sensitivity analysis Part II treats the problem of accuracy reliability self adjustment and optimization of sensitivity of automatic control systems while Part III deals with the functional derivative technique of sensitivity analysis and its applications for designing self adjusting control systems Part IV describes the task of synthesizing control systems for linear plants with variable parameters satisfying specified performance criteria Part V considers the association between sensitivity and optimality in various control systems This book will prove useful to design and other specialized fields in engineering

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