

OPTIMAL CONTROL SYSTEMS

Optimal Control Systems

Michael J. Grimble



Optimal Control Systems:

Optimal Control Systems D. Subbaram Naidu, 2018-10-03 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

Nonlinear and Optimal Control Systems Thomas L. Vincent, Walter J. Grantham, 1997-06-23 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

Linear Optimal Control Systems Huibert Kwakernaak, Raphael Sivan, 1972-11-10 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

Industrial Control Systems Design Michael J. Grimble, 2001-03-30 Bridging the gap between research and industry this volume systematically and comprehensively presents the latest advances in control and estimation With emphasis on applications industrial problems illustrate the use of transfer function and state

space methods for modelling and design Combining theory with practice Industrial Control Systems Design will appeal to practising engineers and academic researchers in control engineering This unique reference spans fundamental state space and polynomial systems theory and introduces quantitative feedback theory Includes design case studies with illustrative problem descriptions and analysis from the steel marine process control aerospace and power generation sectors Focuses on the challenges in predictive optimal control now an indispensable method in advanced control applications Provides an introduction to safety critical control systems design and combined fault monitoring and control techniques Discusses the design of LQG and H controllers with several degrees of freedom including feedback tracking and feedforward functions

Optimal Sampled-Data Control Systems Tongwen Chen, Bruce A. Francis, 2012-12-06 Among the many techniques for designing linear multivariable analogue controllers the two most popular optimal ones are H_2 and H_∞ 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

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

Constrained Optimal Control of Linear and Hybrid Systems Francesco Borrelli, 2003-09-04 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

Optimal Control of Systems Governed by Partial Differential Equations Jacques-Louis Lions,1971 Mathematical Theory of Control Systems

Design V.N. Afanasiev,V. Kolmanovskii,V.R. Nosov,2013-04-17 Give and it shall be given unto you ST LUKE VI 38 The book is based on several courses of lectures on control theory and applications which were delivered by the authors for a number of years at Moscow Electronics and Mathematics University The book originally written in Russian was first published by Vysshaya Shkola Higher School Publishing House in Moscow in 1989 In preparing a new edition of the book we planned to make only minor changes in the text However we soon realized that we like many scholars working in control theory had learned many new things and had had many new insights into control theory and its applications since the book was first published Therefore we rewrote the book especially for the English edition So this is substantially a new book with many new topics The book consists of an introduction and four parts Part One deals with the fundamentals of modern stability theory general results concerning stability and instability sufficient conditions for the stability of linear systems methods for determining the stability or instability of systems of various type theorems on stability under random disturbances

Nonlinear Industrial Control Systems Michael J. Grimble,Paweł Majecki,2020-05-19 Nonlinear Industrial Control Systems presents a range of mostly optimisation based methods for severely nonlinear systems it discusses feedforward and feedback control and tracking control systems design The plant models and design algorithms are provided in a MATLAB toolbox that enable both academic examples and industrial application studies to be repeated and evaluated taking into account practical application and implementation problems The text makes nonlinear control theory accessible to readers having only a background in linear systems and concentrates on real applications of nonlinear control It covers different ways of modelling nonlinear systems including state space polynomial based linear parameter varying state dependent and hybrid design techniques for nonlinear optimal control including generalised minimum variance model predictive control quadratic Gaussian factorised and H design methods design philosophies that are suitable for aerospace automotive marine process control energy systems robotics servo systems and manufacturing steps in design procedures that are illustrated in design studies to define cost functions and cope with problems such as disturbance rejection uncertainties and integral wind up and baseline non optimal control techniques such as nonlinear Smith predictors feedback linearization sliding mode control and nonlinear PID Nonlinear Industrial Control Systems is valuable to engineers in industry dealing with actual nonlinear systems It provides students with a comprehensive range of techniques and examples for solving real nonlinear control design

problems **Control Systems** Jitendra R. Raol, Ramakalyan Ayyagari, 2019-07-12 Control Systems Classical Modern and AI Based Approaches provides a broad and comprehensive study of the principles mathematics and applications for those studying basic control in mechanical electrical aerospace and other engineering disciplines The text builds a strong mathematical foundation of control theory of linear nonlinear optimal model predictive robust digital and adaptive control systems and it addresses applications in several emerging areas such as aircraft electro mechanical and some nonengineering systems DC motor control steel beam thickness control drum boiler motional control system chemical reactor head disk assembly pitch control of an aircraft yaw damper control helicopter control and tidal power control Decentralized control game theoretic control and control of hybrid systems are discussed Also control systems based on artificial neural networks fuzzy logic and genetic algorithms termed as AI based systems are studied and analyzed with applications such as auto landing aircraft industrial process control active suspension system fuzzy gain scheduling PID control and adaptive neuro control Numerical coverage with MATLAB is integrated and numerous examples and exercises are included for each chapter Associated MATLAB code will be made available *Optimal Control Systems* by AA Fel'Dbaum ,1966-01-01 In this book we study theoretical and practical aspects of computing methods for mathematical modelling of nonlinear systems A number of computing techniques are considered such as methods of operator approximation with any given accuracy operator interpolation techniques including a non Lagrange interpolation methods of system representation subject to constraints associated with concepts of causality memory and stationarity methods of system representation with an accuracy that is the best within a given class of models methods of covariance matrix estimation methods for low rank matrix approximations hybrid methods based on a combination of iterative procedures and best operator approximation and methods for information compression and filtering under condition that a filter model should satisfy restrictions associated with causality and different types of memory As a result the book represents a blend of new methods in general computational analysis and specific but also generic techniques for study of systems theory and its particular branches such as optimal filtering and information compression Best operator approximation Non Lagrange interpolation Generic Karhunen Loeve transform Generalised low rank matrix approximation Optimal data compression Optimal nonlinear filtering **Optimal Networked Control Systems with MATLAB** Jagannathan Sarangapani, Hao Xu, 2018-09-03 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 **Continuous Time Dynamical Systems** B.M. Mohan,S.K.

Kar,2018-10-08 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

Optimal Control Leonid T. Aschepkov,Dmitriy V. Dolgy,Taekyun Kim,Ravi P. Agarwal,2017-01-11 This book is based on lectures from a one year course at the Far Eastern Federal University Vladivostok Russia as well as on workshops on optimal control offered to students at various mathematical departments at the university level The main themes of the theory of linear and nonlinear systems are considered including the basic problem of establishing the necessary and sufficient conditions of optimal processes In the first part of the course the theory of linear control systems is constructed on the basis of the separation theorem and the concept of a reachability set The authors prove the closure of a reachability set in the class of piecewise continuous controls and the problems of controllability observability identification performance and terminal control are also considered The second part of the course is devoted to nonlinear control systems Using the method of variations and the Lagrange multipliers rule of nonlinear problems the authors prove the Pontryagin maximum principle for problems with mobile ends of trajectories Further exercises and a large number of additional tasks are provided for use as practical training in order for the reader to consolidate the theoretical material *Robust and Optimal Control* Mi-Ching

Tsai, Da-Wei Gu, 2014-01-07 A Two port Framework for Robust and Optimal Control introduces an alternative approach to robust and optimal controller synthesis procedures for linear time invariant systems based on the two port system widespread in electrical engineering The novel use of the two port system in this context allows straightforward engineering oriented solution finding procedures to be developed requiring no mathematics beyond linear algebra A chain scattering description provides a unified framework for constructing the stabilizing controller set and for synthesizing H_2 optimal and H_∞ sub optimal controllers Simple yet illustrative examples explain each step A Two port Framework for Robust and Optimal Control features a hands on tutorial style presentation giving the reader the opportunity to repeat the designs presented and easily to modify them for their own programs an abundance of examples illustrating the most important steps in robust and optimal design and end of chapter exercises To further demonstrate the proposed approaches in the last chapter an application case study is presented which demonstrates the use of the framework in a real world control system design and helps the reader quickly move on with their own challenges MATLAB codes used in examples throughout the book and solutions to selected exercise questions are available for download The text will have particular resonance for researchers in control with an electrical engineering background who wish to avoid spending excessive time in learning complex mathematical theoretical developments but need to know how to deal with robust and optimal control synthesis problems Please see <http://km.emotors.ncku.edu.tw/class/hw1.html> for solutions to the exercises provided in this book

Robust Industrial Control Systems Michael J. Grimble, 2006-05-01 Robust Industrial Control Systems Optimal Design Approach for Polynomial Systems presents a comprehensive introduction to the use of frequency domain and polynomial system design techniques for a range of industrial control and signal processing applications The solution of stochastic and robust optimal control problems is considered building up from single input problems and gradually developing the results for multivariable design of the later chapters In addition to cataloguing many of the results in polynomial systems needed to calculate industrial controllers and filters basic design procedures are also introduced which enable cost functions and system descriptions to be specified in order to satisfy industrial requirements Providing a range of solutions to control and signal processing problems this book Presents a comprehensive introduction to the polynomial systems approach for the solution of H_2 and H_∞ optimal control problems Develops robust control design procedures using frequency domain methods Demonstrates design examples for gas turbines marine systems metal processing flight control wind turbines process control and manufacturing systems Includes the analysis of multi degrees of freedom controllers and the computation of restricted structure controllers that are simple to implement Considers time varying control and signal processing problems Addresses the control of non linear processes using both multiple model concepts and new optimal control solutions Robust Industrial Control Systems Optimal Design Approach for Polynomial Systems is essential reading for professional engineers requiring an introduction to optimal control theory and insights into its use in the design of real industrial processes Students and

researchers in the field will also find it an excellent reference tool Linear Control Systems Branislav Kisić, Gyan C. Agarwal, 2012-12-06 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 *Optimal Control* Zoran Gajic, Myo-Taeg Lim, Dobrila Skataric, Wu-Chung Su, Vojislav Kecman, 2018-10-03 Unique in scope Optimal Control Weakly Coupled Systems and Applications provides complete coverage of modern linear bilinear and nonlinear optimal control algorithms for both continuous time and discrete time weakly coupled systems using deterministic as well as stochastic formulations This book presents numerous applications to real world systems from various industries including aerospace and discusses the design of subsystem level optimal filters Organized into independent chapters for easy access to the material this text also contains several case studies examples exercises computer assignments and formulations of research problems to help instructors and students **Essentials of Optimal Control** Pierre Naslin, 1969

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