

Advances in Industrial Control

Chunlei Zhang
Raúl Ordóñez

Extremum-Seeking Control and Applications

A Numerical Optimization-Based Approach

AIC

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Extremum Seeking Control And Applications A Numerical Optimization Based Approach Advances In Industrial Control

Jun Ma,Xiaocong Li,Kok Kiong Tan



Extremum Seeking Control And Applications A Numerical Optimization Based Approach Advances In Industrial Control:

Extremum-Seeking Control and Applications Chunlei Zhang, Raúl Ordóñez, 2011-10-26 Extremum seeking control tracks a varying maximum or minimum in a performance function such as output or cost. It attempts to determine the optimal performance of a control system as it operates thereby reducing downtime and the need for system analysis. Extremum seeking Control and Applications is divided into two parts. In the first, the authors review existing analog optimization based extremum seeking control including gradient perturbation and sliding mode based control designs. They then propose a novel numerical optimization based extremum seeking control based on optimization algorithms and state regulation. This control design is developed for simple linear time invariant systems and then extended for a class of feedback linearizable nonlinear systems. The two main optimization algorithms, line search and trust region methods, are analyzed for robustness. Finite time and asymptotic state regulators are put forward for linear and nonlinear systems respectively. Further design flexibility is achieved using the robustness results of the optimization algorithms and the asymptotic state regulator by which existing nonlinear adaptive control techniques can be introduced for robust design. The approach used is easier to implement and tends to be more robust than those that use perturbation based extremum seeking control. The second part of the book deals with a variety of applications of extremum seeking control: a comparative study of extremum seeking control schemes in antilock braking system design, source seeking, formation control, collision and obstacle avoidance for groups of autonomous agents, mobile radar networks and impedance matching. MATLAB Simulink code which can be downloaded from www.springer.com. ISBN helps readers to reproduce the results presented in the text and gives them a head start for implementing the algorithms in their own applications. Extremum seeking Control and Applications will interest academics and graduate students working in control and industrial practitioners from a variety of backgrounds: systems, automotive, aerospace, communications, semiconductor and chemical engineering.

Extremum Seeking Through Delays and PDEs Tiago Roux Oliveira, Miroslav Krstic, 2022-12-05 Extremum Seeking through Delays and PDEs: the first book on the topic expands the scope of applicability of the extremum seeking method from static and finite dimensional systems to infinite dimensional systems. Readers will find numerous algorithms for model free real time optimization are developed and their convergence guaranteed. Extensions from single player optimization to noncooperative games under delays and PDEs are provided. The delays and PDEs are compensated in the control designs using the PDE backstepping approach and stability is ensured using infinite dimensional versions of averaging theory and accessible and powerful tools for analysis. This book is intended for control engineers in all disciplines: electrical, mechanical, aerospace, chemical, mathematicians, physicists, biologists and economists. It is appropriate for graduate students, researchers and industrial users.

Robust Adaptive Control Iasson Karafyllis, Miroslav Krstic, 2025-06-11 This book presents a solution to a problem in adaptive control design that had been

open for 40 years robustification to disturbances without compromising asymptotic performance This original methodology builds on foundational ideas such as the use of a deadzone in the update law and nonlinear damping in the controller and advances the tools for and the theory behind designing robust adaptive controllers thus guaranteeing robustness properties stronger than previously achieved The authors present all stability notions old and new that are useful in adaptive control provide numerous examples and contrast their analysis to landmark approaches to robustification of adaptive controllers in prior literature This book develops the Deadzone Adapted Disturbance Suppression DADS control a novel adaptive control method and constructs a novel robust identifier that can work in parallel with every direct adaptive controller not only DADS it presents a wing rock instability application of DADS and provides ideas for the extension of DADS to cases not studied in the book Robust Adaptive Control Deadzone Adapted Disturbance Suppression will be of interest to mathematicians working on feedback control and stability theory and to control engineers Physicists tackling control problems and biologists with an interest in controlling population dynamics will also find it of interest

Design of Delay-Based Controllers for Linear Time-Invariant Systems Adrián Ramírez, Rifat Sipahi, Sabine Mondié, Rubén Garrido, 2025-01-01 This book provides the mathematical foundations needed for designing practical controllers for linear time invariant systems The authors accomplish this by incorporating intentional time delays into measurements with the goal of achieving anticipation capabilities reduction in noise sensitivity and a fast response The benefits of these types of delay based controllers have long been recognized but designing them based on an analytical approach became possible only recently Design of Delay Based Controllers for Linear Time Invariant Systems provides a thorough survey of the field and the details of the analytical approaches needed to design delay based controllers In addition readers will find accessible mathematical tools and self contained proofs for rigorous analysis numerous examples and comprehensive computational algorithms to motivate the results and experiments on single input single output systems and multi agent systems using real world control applications to illustrate the benefits of intentionally inducing delays in control loops This book is intended for control engineers in various disciplines including electrical mechanical and mechatronics engineering It offers valuable insights for graduate students researchers and professionals working in industry

Mechanical Engineering, 1985 *Real-Time Optimization by Extremum-Seeking Control* Kartik B. Ariyur, Miroslav Krstic, 2003-10-03 An up close look at the theory behind and application of extremum seeking Originally developed as a method of adaptive control for hard to model systems extremum seeking solves some of the same problems as today s neural network techniques but in a more rigorous and practical way Following the resurgence in popularity of extremum seeking control in aerospace and automotive engineering Real Time Optimization by Extremum Seeking Control presents the theoretical foundations and selected applications of this method of real time optimization Written by authorities in the field and pioneers in adaptive nonlinear control systems this book presents both significant theoretic value and important practical potential Filled with in depth insight and expert advice Real

Time Optimization by Extremum Seeking Control Develops optimization theory from the points of dynamic feedback and adaptation Builds a solid bridge between the classical optimization theory and modern feedback and adaptation techniques Provides a collection of useful tools for problems in this complex area Presents numerous applications of this powerful methodology Demonstrates the immense potential of this methodology for future theory development and applications Real Time Optimization by Extremum Seeking Control is an important resource for both students and professionals in all areas of engineering electrical mechanical aerospace chemical biomedical and is also a valuable reference for practicing control engineers

Model-based Extremum Seeking Control for a Class of Nonlinear Systems Lina Fu,2010 Abstract The research on extremum seeking control problems where the operation of a dynamical system is to be regulated to maximize or minimize an unknown performance criterion is of both theoretical and practical values The application scope of extremum seeking include renewable energy automotive control and many other industrial optimization problems

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Optimization Yasser Bin Salamah,2019 As control techniques and optimization algorithms evolve the spectrum of potential applications also broadens Problems that previously were deemed intractable now become amenable to practical control and optimization methods Today stand alone wind turbines have been grouped with each other to form a wind farm Characterizing and optimizing the overall performance of a wind farm requires a new generation of control and optimization techniques This example and other newly emerged applications reveal the necessity to extend the classical control and optimization results to address the problems that arise in complex systems Here we are pursuing a new theoretical advancement in the field of sliding mode control Having its basis on previous research on the use of sliding mode control in optimization This dissertation proposes several sliding mode based extremum seeking control schemes for multivariable and distributed optimization problems In the first scheme a multivariable extremum seeking via sequential search is proposed This approach recasts the problem of multivariable extremum seeking control into a sequence of single variable problems The approach is suitable for non separable problems differentiating itself from existing work in this area We determine stability and convergence conditions from the unidimensional case and derive a sufficient condition for the multivariable scheme to converge to the vicinity of the optimal points Practical issues in implementation are discussed and several illustrative examples are presented to show the effectiveness of the scheme and highlight its potential use Next a simultaneous multivariable extremum seeking control scheme is proposed Different from the first scheme the presented

approach addresses the problem in a concurrent manner using a single sliding surface We determine a set of sufficient conditions under which the sliding mode will take place Then we demonstrate the convergence of the decision variables towards the optimal points Unlike classical sliding mode series of sliding modes will occur until the vicinity of the maximum is attained We investigate the applicability of the proposed scheme to the source seeking problem using a differential drive mobile robot A set of simulation experiments is conducted to illustrate the theoretical results evaluate the proposed scheme and demonstrate its applicability to real world application Although centralized control architectures have proven to be effective for some applications in the first two chapters decentralized control and distributed process improves the scalability of systems For this reason a distributed extremum seeking control is proposed The proposed scheme finds the solution cooperatively The main concept of this approach is to introduce a consensus algorithm to communicate the value of the cost function between the controllers And then we interface this algorithm suitably with sliding mode extremum seeking to find the optimal solution After analyzing the proposed scheme the applicability of the scheme to optimize energy production in wind farms is investigated Performance verification is conducted through a series of experiments and is compared versus several control architectures including centralized as well as non cooperative schemes under a variety of wind conditions

Control and Optimization with Differential-Algebraic Constraints Lorenz T. Biegler, Stephen L. Campbell, Volker Mehrmann, 2012-01-01 Differential algebraic equations are the most natural way to mathematically model many complex systems in science and engineering Once the model is derived it is important to optimize the design parameters and control it in the most robust and efficient way to maximize performance This book presents the latest theory and numerical methods for the optimal control of differential algebraic equations The following features are presented in a readable fashion so the results are accessible to the widest audience the most recent theory written by leading experts from a number of academic and nonacademic areas and departments several state of the art numerical methods and real world applications

Advanced Optimization for Motion Control Systems Jun Ma, Xiaocong Li, Kok Kiong Tan, 2020-01-24 Precision motion control is strongly required in many fields such as precision engineering micromanufacturing biotechnology and nanotechnology Although great achievements have been made in control engineering it is still challenging to fulfill the desired performance for precision motion control systems Substantial works have been presented to reveal an increasing trend to apply optimization approaches in precision engineering to obtain the control system parameters In this book we present a result of several years of work in the area of advanced optimization for motion control systems The book is organized into two parts Part I focuses on the model based approaches and Part II presents the data based approaches To illustrate the practical appeal of the proposed optimization techniques theoretical results are verified with practical examples in each chapter Industrial problems explored in the book are formulated systematically with necessary analysis of the control system synthesis By virtue of the design and implementation nature this book can be used as a reference for engineers

researchers and students who want to utilize control theories to solve the practical control problems As the methodologies have extensive applicability in many control engineering problems the research results in the field of optimization can be applied to full fledged industrial processes filling in the gap between research and application to achieve a technology frontier increment

Controller Tuning Optimization Methods for Multi-Constraints and Nonlinear Systems Maude Josée Blondin, 2021-01-06 This book covers controller tuning techniques from conventional to new optimization methods for diverse control engineering applications Classical controller tuning approaches are presented with real world challenges faced in control engineering Current developments in applying optimization techniques to controller tuning are explained Case studies of optimization algorithms applied to controller tuning dealing with nonlinearities and limitations like the inverted pendulum and the automatic voltage regulator are presented with performance comparisons Students and researchers in engineering and optimization interested in optimization methods for controller tuning will utilize this book to apply optimization algorithms to controller tuning to choose the most suitable optimization algorithm for a specific application and to develop new optimization techniques for controller tuning

Computational Optimal Control Roland Bulirsch, Dieter Kraft, 1994 There is public agreement that all resources should be used sparingly both from the point of view of economy and ecology Therefore optimization is the tool of choice in controlling industrial and economic processes This book collects the reviewed papers of the ninth IFAC Workshop on Control Applications of Optimization which took place in Munich in September 1992 Highlights from the ensuing discussions have been incorporated by the authors The volume reflects the state of the art in the application of finite and infinite dimensional optimization to open and closed loop control problems Its spectrum ranges from the theoretical foundations of the proposed methods and numerical implementations of algorithms to applications to real world problems Emphasis lies on the solution of practical industrial problems in aerospace mechanical and electrical engineering manufacturing technology and economic and management systems Among the theoretical papers are contributions from non linear programming interior point methods large structured problems nonsmooth problems and vector valued criteria and optimal control multipoint boundary value problems state and control constraints feedback solutions differential algebraic systems and differential games

Control and Optimization of Multiscale Process Systems Panagiotis D. Christofides, Antonios Armaou, Yiming Lou, Amit Varshney, 2008-10-28 This book the first of its kind presents general methods for feedback controller synthesis and optimization of multiscale systems illustrating their application to thin film growth sputtering processes and catalytic systems of industrial interest The authors demonstrate the advantages of the methods presented for control and optimization through extensive simulations Included in the work are new techniques for feedback controller design and optimization of multiscale process systems that are not included in other books The book also contains a rich collection of new research topics and references to significant recent work

Constrained Control and Estimation Graham Goodwin, María M. Seron, José A. de Doná, 2006-03-30 Recent developments in constrained control and

estimation have created a need for this comprehensive introduction to the underlying fundamental principles These advances have significantly broadened the realm of application of constrained control Using the principal tools of prediction and optimisation examples of how to deal with constraints are given placing emphasis on model predictive control New results combine a number of methods in a unique way enabling you to build on your background in estimation theory linear control stability theory and state space methods Companion web site continually updated by the authors Easy to read and at the same time containing a high level of technical detail this self contained new approach to methods for constrained control in design will give you a full understanding of the subject **Optimal Control** Daniela Tonon, Maria Soledad Aronna, Dante Kalise, 2017

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