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Heinz Schättler
Urszula Ledzewicz

Geometric Optimal Control

Theory, Methods and Examples

 Springer

Geometric Optimal Control

**Andreas Arvanitoyeorgos, George
Kaimakamis**



Geometric Optimal Control:

Geometric Optimal Control Heinz Schättler, Urszula Ledzewicz, 2012-06-26 This book gives a comprehensive treatment of the fundamental necessary and sufficient conditions for optimality for finite dimensional deterministic optimal control problems. The emphasis is on the geometric aspects of the theory and on illustrating how these methods can be used to solve optimal control problems. It provides tools and techniques that go well beyond standard procedures and can be used to obtain a full understanding of the global structure of solutions for the underlying problem. The text includes a large number and variety of fully worked out examples that range from the classical problem of minimum surfaces of revolution to cancer treatment for novel therapy approaches. All these examples in one way or the other illustrate the power of geometric techniques and methods. The versatile text contains material on different levels ranging from the introductory and elementary to the advanced. Parts of the text can be viewed as a comprehensive textbook for both advanced undergraduate and all level graduate courses on optimal control in both mathematics and engineering departments. The text moves smoothly from the more introductory topics to those parts that are in a monograph style where advanced topics are presented. While the presentation is mathematically rigorous it is carried out in a tutorial style that makes the text accessible to a wide audience of researchers and students from various fields including the mathematical sciences and engineering. Heinz Schättler is an Associate Professor at Washington University in St. Louis in the Department of Electrical and Systems Engineering. Urszula Ledzewicz is a Distinguished Research Professor at Southern Illinois University Edwardsville in the Department of Mathematics and Statistics.

Geometric Control Theory Velimir Jurdjevic, 1997 Geometric control theory is concerned with the evolution of systems subject to physical laws but having some degree of freedom through which motion is to be controlled. This book describes the mathematical theory inspired by the irreversible nature of time evolving events. The first part of the book deals with the issue of being able to steer the system from any point of departure to any desired destination. The second part deals with optimal control, the question of finding the best possible course. An overlap with mathematical physics is demonstrated by the Maximum principle, a fundamental principle of optimality arising from geometric control which is applied to time evolving systems governed by physics as well as to man made systems governed by controls. Applications are drawn from geometry, mechanics and control of dynamical systems. The geometric language in which the results are expressed allows clear visual interpretations and makes the book accessible to physicists and engineers as well as to mathematicians.

Symmetries and reduction in geometric optimal control theory Arturo Echeverría Enríquez, Miguel Carlos Muñoz Lecanda, Narciso Román Roy, Jesús Marín Solano, 2002

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 Schroedinger s 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

Geometric and Numerical Optimal Control Bernard Bonnard, Monique Chyba, Jérémy Rouot, 2018-07-27 This book introduces readers to techniques of geometric optimal control as well as the exposure and applicability of adapted numerical schemes It is based on two real world applications which have been the subject of two current academic research programs and motivated by industrial use the design of micro swimmers and the contrast problem in medical resonance imaging The recently developed numerical software has been applied to the cases studies presented here The book is intended for use at the graduate and Ph D level to introduce students from applied mathematics and control engineering to geometric and computational techniques in optimal control

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

Optimal Control for Mathematical Models of Cancer Therapies Heinz Schättler, Urszula Ledzewicz, 2015-09-15 This book presents applications of geometric optimal control to real life biomedical problems with an emphasis on cancer treatments A number of mathematical models for both classical and novel cancer treatments are presented as optimal control problems with the goal of constructing optimal protocols The power of geometric methods is illustrated with fully worked out complete global solutions to these mathematically challenging problems Elaborate constructions of optimal controls and corresponding system responses provide great examples of applications of the tools of geometric optimal control and the outcomes aid the design of simpler practically realizable suboptimal protocols The book blends mathematical rigor with practically important topics in an easily readable tutorial style Graduate students and researchers in science and engineering particularly biomathematics and more mathematical aspects of biomedical engineering would find this book particularly useful

Contemporary Trends in Nonlinear Geometric Control Theory and Its Applications A. Anzaldo-Meneses, 2002

Concerns contemporary trends in nonlinear geometric control theory and its applications **Introduction to Geometric Control** Yuri Sachkov, 2022-07-02 This text is an enhanced English version of the Russian edition published in early 2021 and is appropriate for an introductory course in geometric control theory The concise presentation provides an accessible treatment of the subject for advanced undergraduate and graduate students in theoretical and applied mathematics as well as to experts in classic control theory for whom geometric methods may be introduced Theory is accompanied by characteristic examples such as stopping a train motion of mobile robot Euler elasticae Dido's problem and rolling of the sphere on the plane Quick foundations to some recent topics of interest like control on Lie groups and sub Riemannian geometry are included Prerequisites include only a basic knowledge of calculus linear algebra and ODEs preliminary knowledge of control theory is not assumed The applications problems oriented approach discusses core subjects and encourages the reader to solve related challenges independently Highly motivated readers can acquire working knowledge of geometric control techniques and progress to studying control problems and more comprehensive books on their own Selected sections provide exercises to assist in deeper understanding of the material Controllability and optimal control problems are considered for nonlinear nonholonomic systems on smooth manifolds in particular on Lie groups For the controllability problem the following questions are considered controllability of linear systems local controllability of nonlinear systems Nagano Sussmann Orbit theorem Rashevskii Chow theorem Krener's theorem For the optimal control problem Filippov's theorem is stated invariant formulation of Pontryagin maximum principle on manifolds is given second order optimality conditions are discussed and the sub Riemannian problem is studied in detail Pontryagin maximum principle is proved for sub Riemannian problems solution to the sub Riemannian problems on the Heisenberg group the group of motions of the plane and the Engel group is described Nonsmooth Analysis and Geometric Methods in Deterministic Optimal Control Boris S. Mordukhovich, Hector J. Sussmann, 2012-12-06 This IMA Volume in Mathematics and its Applications NONSMOOTH ANALYSIS AND GEOMETRIC METHODS IN DETERMINISTIC OPTIMAL CONTROL is based on the proceedings of a workshop that was an integral part of the 1992-93 IMA program on Control Theory The purpose of this workshop was to concentrate on powerful mathematical techniques that have been developed in deterministic optimal control theory after the basic foundations of the theory existence theorems maximum principle dynamic programming sufficiency theorems for sufficiently smooth fields of extremals were laid out in the 1960s These advanced techniques make it possible to derive much more detailed information about the structure of solutions than could be obtained in the past and they support new algorithmic approaches to the calculation of such solutions We thank Boris S Mordukhovich and Hector J Sussmann for organizing the workshop and editing the proceedings We also take this opportunity to thank the National Science Foundation and the Army Research Office whose financial support made the workshop possible Avner Friedman

Willard Miller Jr v PREFACE This volume contains the proceedings of the workshop on Nonsmooth Analysis and Geometric Methods in Deterministic Optimal Control held at the Institute for Mathematics and its Applications on February 8 17 1993 during a special year devoted to Control Theory and its Applications The workshop whose organizing committee consisted of V J urdjevic B S Mordukhovich R T Rockafellar and H J **Geometric reduction in optimal control theory with**

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Geometry of Submanifolds and Homogeneous Spaces Andreas Arvanitoyeorgos, George Kaimakamis, 2020-01-03 The present Special Issue of Symmetry is devoted to two important areas of global Riemannian geometry namely submanifold theory and the geometry of Lie groups and homogeneous spaces Submanifold theory originated from the classical geometry of curves and surfaces Homogeneous spaces are manifolds that admit a transitive Lie group action historically related to F Klein s Erlangen Program and S Lie s idea to use continuous symmetries in studying differential equations In this Special Issue we provide a collection of papers that not only reflect some of the latest advancements in both areas but also highlight relations between them and the use of common techniques Applications to other areas of mathematics are also considered

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 Geometric Control And Nonsmooth Analysis: In Honor Of The 73rd Birthday Of H Hermes And Of The 71st

Birthday Of R T Rockafellar Fabio Ancona, Alberto Bressan, Piermarco Cannarsa, Francis H Clarke, Peter R Wolenski, 2008-07-08 The aim of this volume is to provide a synthetic account of past research to give an up to date guide to current intertwined developments of control theory and nonsmooth analysis and also to point to future research directions

Variational Analysis with Applications in Optimisation and Control Savin Treanță, 2019-08-01 This book focuses on the calculus of variations and related applications which combine tools and methods from partial differential equations with geometrical techniques More precisely it is devoted to nonlinear problems coming from different areas with particular reference to those introducing new techniques capable of solving a wide range of problems It provides the latest developments in multidimensional optimization and optimal control With various examples and applications to complement and substantiate mathematical developments the text is a valuable guide for researchers engineers and students in the field of mathematics and those working in operations research optimal control science artificial intelligence management science and economics Analysis and Geometry in Control Theory and its Applications Piernicola Bettiol, Piermarco

Cannarsa, Giovanni Colombo, Monica Motta, Franco Rampazzo, 2015-09-01 Since the 1950s control theory has established

itself as a major mathematical discipline particularly suitable for application in a number of research fields including advanced engineering design economics and the medical sciences However since its emergence there has been a need to rethink and extend fields such as calculus of variations differential geometry and nonsmooth analysis which are closely tied to research on applications Today control theory is a rich source of basic abstract problems arising from applications and provides an important frame of reference for investigating purely mathematical issues In many fields of mathematics the huge and growing scope of activity has been accompanied by fragmentation into a multitude of narrow specialties However outstanding advances are often the result of the quest for unifying themes and a synthesis of different approaches Control theory and its applications are no exception Here the interaction between analysis and geometry has played a crucial role in the evolution of the field This book collects some recent results highlighting geometrical and analytical aspects and the possible connections between them Applications provide the background in the classical spirit of mutual interplay between abstract theory and problem solving practice

Geometric Aspects of Optimal Control Problems with Discontinuities Russell Davis Shaver,1966

Optimization in Control Applications Guillermo Valencia-Palomo,Francisco Ronay López-Estrada,2019-01-10 This book is a printed edition of the Special Issue Optimization in Control Applications that was published in MCA

Toward the Geometric Unification of Optimal Control Theory, the Calculus of Variations, and Analytical Mechanics Robert Hermann,20??

Geometry of Feedback and Optimal Control B. Jakubczyk,Witold Respondek,1997-11-19 This work gathers important and promising information results in subfields of nonlinear control theory previously available in journals It presents the state of the art of geometric methods their applications optimal control and feedback transformations It aims to show how geometric control theory draws from other mathematical fields to create its own powerful tools

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