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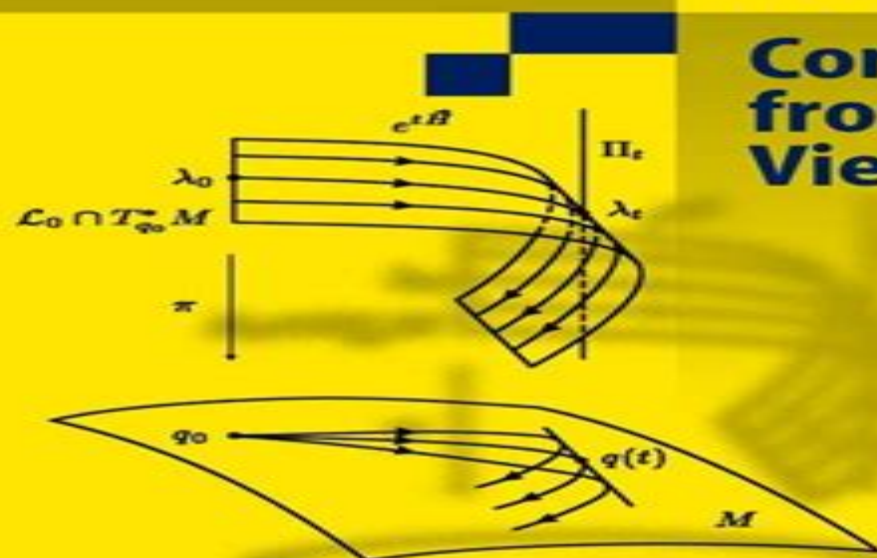
Control Theory From The Geometric Viewpoint

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Control Theory From The Geometric Viewpoint:

Control Theory from the Geometric Viewpoint Andrei A. Agrachev,Yuri Sachkov,2014-01-15 **Control Theory from the Geometric Viewpoint** Andrei A. Agrachev,Yuri Sachkov,2013-03-14 This book presents some facts and methods of the Mathematical Control Theory treated from the geometric point of view The book is mainly based on graduate courses given by the first coauthor in the years 2000 2001 at the International School for Advanced Studies Trieste Italy Mathematical prerequisites are reduced to standard courses of Analysis and Linear Algebra plus some basic Real and Functional Analysis No preliminary knowledge of Control Theory or Differential Geometry is required What this book is about The classical deterministic physical world is described by smooth dynamical systems the future in such a system is com pletely determined by the initial conditions Moreover the near future changes smoothly with the initial data If we leave room for free will in this fatalistic world then we come to control systems We do so by allowing certain param eters of the dynamical system to change freely at every instant of time That is what we routinely do in real life with our body car cooker as well as with aircraft technological processes etc We try to control all these dynamical systems Smooth dynamical systems are governed by differential equations In this book we deal only with finite dimensional systems they are governed by ordi nary differential equations on finite dimensional smooth manifolds A control system for us is thus a family of ordinary differential equations The family is parametrized by control parameters *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 Heisenberggroup the group of motions of the plane and the Engel group is described

Calculus of Variations and Optimal Control Theory Daniel Liberzon,2012 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 **Nonlinear and Optimal Control Theory** Andrei A. Agrachev,A. Stephen Morse,Eduardo D. Sontag,Hector J. Sussmann,Vadim I. Utkin,2008-06-24 The lectures gathered in this volume present some of the different aspects of Mathematical Control Theory Adopting the point of view of Geometric Control Theory and of Nonlinear Control Theory the lectures focus on some aspects of the Optimization and Control of nonlinear not necessarily smooth dynamical systems Specifically three of the five lectures discuss respectively logic based switching control sliding mode control and the input to the state stability paradigm for the control and stability of nonlinear systems The remaining two lectures are devoted to Optimal Control one investigates the connections between Optimal Control Theory Dynamical Systems and Differential Geometry while the second presents a very general version in a non smooth context of the Pontryagin Maximum Principle The arguments of the whole volume are self contained and are directed to everyone working in Control Theory They offer a sound presentation of the methods employed in the control and optimization of nonlinear dynamical systems Handbook of Variational Methods for Nonlinear Geometric Data Philipp Grohs,Martin Holler,Andreas Weinmann,2020-04-03 This book covers different current research directions in the context of variational methods for non linear geometric data Each chapter is authored by leading experts in the respective discipline

and provides an introduction an overview and a description of the current state of the art Non linear geometric data arises in various applications in science and engineering Examples of nonlinear data spaces are diverse and include for instance nonlinear spaces of matrices spaces of curves shapes as well as manifolds of probability measures Applications can be found in biology medicine product engineering geography and computer vision for instance Variational methods on the other hand have evolved to being amongst the most powerful tools for applied mathematics They involve techniques from various branches of mathematics such as statistics modeling optimization numerical mathematics and analysis The vast majority of research on variational methods however is focused on data in linear spaces Variational methods for non linear data is currently an emerging research topic As a result and since such methods involve various branches of mathematics there is a plethora of different recent approaches dealing with different aspects of variational methods for nonlinear geometric data Research results are rather scattered and appear in journals of different mathematical communities The main purpose of the book is to account for that by providing for the first time a comprehensive collection of different research directions and existing approaches in this context It is organized in a way that leading researchers from the different fields provide an introductory overview of recent research directions in their respective discipline As such the book is a unique reference work for both newcomers in the field of variational methods for non linear geometric data as well as for established experts that aim at to exploit new research directions or collaborations Chapter 9 of this book is available open access under a CC BY 4 0 license at link springer com **Nonlinear and Optimal Control Theory** ,2008 **Control Theory** J.R. Leigh,2004 For students or professionals in science math or industry with or without a background in control theory explains and illustrates the basic concepts underlying the theory with references to more detailed treatments Intended as a companion to more traditional approaches begins with simple concepts such as feedback and stability and advances to optimization distributed parameter systems and other complex ideas Annotation copyrighted by Book News Inc Portland OR *Time-Varying Vector Fields and Their Flows* Saber Jafarpour,Andrew D. Lewis,2014-10-10 This short book provides a comprehensive and unified treatment of time varying vector fields under a variety of regularity hypotheses namely finitely differentiable Lipschitz smooth holomorphic and real analytic The presentation of this material in the real analytic setting is new as is the manner in which the various hypotheses are unified using functional analysis Indeed a major contribution of the book is the coherent development of locally convex topologies for the space of real analytic sections of a vector bundle and the development of this in a manner that relates easily to classically known topologies in for example the finitely differentiable and smooth cases The tools used in this development will be of use to researchers in the area of geometric functional analysis **Lie Groups, Differential Equations, and Geometry** Giovanni Falcone,2017-09-19 This book collects a series of contributions addressing the various contexts in which the theory of Lie groups is applied A preliminary chapter serves the reader both as a basic reference source and as an ongoing thread that runs through the subsequent chapters From representation theory

and Gerstenhaber algebras to control theory from differential equations to Finsler geometry and Lepage manifolds the book introduces young researchers in Mathematics to a wealth of different topics encouraging a multidisciplinary approach to research As such it is suitable for students in doctoral courses and will also benefit researchers who want to expand their field of interest **Proceedings of MSR-RoManSy 2024** Pierre Larochelle,J. Michael McCarthy,Craig P. Lusk,2024-05-28 This book gathers the latest fundamental research contributions innovations and applications in the field of design and analysis of complex robotic mechanical systems machines and mechanisms as presented by leading researchers at the combined IFToMM Symposium of RoManSy and USCToMM Symposium on Mechanical Systems and Robotics MSR RoManSy held in St Petersburg FL USA on May 22 25 2024 It covers highly diverse topics including soft wearable and origami robotic systems applications to walking flying climbing underground swimming and space systems human rehabilitation and performance augmentation design and analysis of mechanisms and machines human robot collaborative systems service robotics mechanical systems and robotics education and the commercialization of mechanical systems and robotics The contributions which were selected by means of a rigorous international peer review process highlight numerous exciting and impactful research results that will inspire novel research directions and foster multidisciplinary research collaborations among researchers from around the globe **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 **New Directions and Applications in Control Theory** Wijesuriya P. Dayawansa,Anders Lindquist,Yishao Zhou,2005-08-31 This volume contains a collection of papers in control theory and applications presented at a conference in honor of Clyde Martin on the occasion of his 60th birthday held in Lubbock Texas November 14 15 2003 **A New Lotka-Volterra Model of Competition With Strategic Aggression** Elisa Affili,Serena Dipierro,Luca Rossi,Enrico Valdinoci,2024-08-30 This monograph introduces a new mathematical model in population dynamics that describes two species sharing the same environmental resources in a situation of open hostility Its main feature is the expansion of the family of Lotka Volterra systems by introducing a new term

that defines aggression Because the model is flexible it can be applied to various scenarios in the context of human populations such as strategy games competition in the marketplace and civil wars Drawing from a variety of methodologies within dynamical systems ODEs and mathematical biology the authors approach focuses on the dynamical properties of the system This is accomplished by detecting and describing all possible equilibria and analyzing the strategies that may lead to the victory of the aggressive population Techniques typical of two dimensional dynamical systems are used such as asymptotic behaviors regulated by the Poincar Bendixson Theorem A New Lotka Volterra Model of Competition With Strategic Aggression will appeal to researchers and students studying population dynamics and dynamical systems particularly those interested in the cross section between mathematics and ecology *Sub-Riemannian Geometry and Optimal Transport* Ludovic Rifford,2014-04-03 The book provides an introduction to sub Riemannian geometry and optimal transport and presents some of the recent progress in these two fields The text is completely self contained the linear discussion containing all the proofs of the stated results leads the reader step by step from the notion of distribution at the very beginning to the existence of optimal transport maps for Lipschitz sub Riemannian structure The combination of geometry presented from an analytic point of view and of optimal transport makes the book interesting for a very large community This set of notes grew from a series of lectures given by the author during a CIMPA school in Beirut Lebanon

Elements of Neurogeometry Jean Petitot,2017-11-08 This book describes several mathematical models of the primary visual cortex referring them to a vast ensemble of experimental data and putting forward an original geometrical model for its functional architecture that is the highly specific organization of its neural connections The book spells out the geometrical algorithms implemented by this functional architecture or put another way the neurogeometry immanent in visual perception Focusing on the neural origins of our spatial representations it demonstrates three things firstly the way the visual neurons filter the optical signal is closely related to a wavelet analysis secondly the contact structure of the 1 jets of the curves in the plane the retinal plane here is implemented by the cortical functional architecture and lastly the visual algorithms for integrating contours from what may be rather incomplete sensory data can be modelled by the sub Riemannian geometry associated with this contact structure As such it provides readers with the first systematic interpretation of a number of important neurophysiological observations in a well defined mathematical framework The book s neuromathematical exploration appeals to graduate students and researchers in integrative functional cognitive neuroscience with a good mathematical background as well as those in applied mathematics with an interest in neurophysiology   Linear Algebra for Control Theory Paul Van Dooren,Bostwick Wyman,2012-12-06 During the past decade the interaction between control theory and linear algebra has been ever increasing giving rise to new results in both areas As a natural outflow of this research this book presents information on this interdisciplinary area The cross fertilization between control and linear algebra can be found in subfields such as Numerical Linear Algebra Canonical Forms Ring

theoretic Methods Matrix Theory and Robust Control This book s editors were challenged to present the latest results in these areas and to find points of common interest This volume reflects very nicely the interaction the range of topics seems very wide indeed but the basic problems and techniques are always closely connected And the common denominator in all of this is of course linear algebra This book is suitable for both mathematicians and students **Neuromathematics of Vision** Giovanna Citti,Alessandro Sarti,2014-02-08 This book is devoted to the study of the functional architecture of the visual cortex Its geometrical structure is the differential geometry of the connectivity between neural cells This connectivity is building and shaping the hidden brain structures underlying visual perception The story of the problem runs over the last 30 years since the discovery of Hubel and Wiesel of the modular structure of the primary visual cortex and slowly cams towards a theoretical understanding of the experimental data on what we now know as functional architecture of the primary visual cortex Experimental data comes from several domains neurophysiology phenomenology of perception and neurocognitive imaging Imaging techniques like functional MRI and diffusion tensor MRI allow to deepen the study of cortical structures Due to this variety of experimental data neuromathematematics deals with modelling both cortical structures and perceptual spaces From the mathematical point of view neuromathematical call for new instruments of pure mathematics sub Riemannian geometry models horizontal connectivity harmonic analysis in non commutative groups allows to understand pinwheels structure as well as non linear dimensionality reduction is at the base of many neural morphologies and possibly of the emergence of perceptual units But at the center of the neurogeometry is the problem of harmonizing contemporary mathematical instruments with neurophysiological findings and phenomenological experiments in an unitary science of vision The contributions to this book come from the very founders of the discipline **Mathematics of Complexity and Dynamical Systems** Robert A. Meyers,2011-10-05 Mathematics of Complexity and Dynamical Systems is an authoritative reference to the basic tools and concepts of complexity systems theory and dynamical systems from the perspective of pure and applied mathematics Complex systems are systems that comprise many interacting parts with the ability to generate a new quality of collective behavior through self organization e g the spontaneous formation of temporal spatial or functional structures These systems are often characterized by extreme sensitivity to initial conditions as well as emergent behavior that are not readily predictable or even completely deterministic The more than 100 entries in this wide ranging single source work provide a comprehensive explication of the theory and applications of mathematical complexity covering ergodic theory fractals and multifractals dynamical systems perturbation theory solitons systems and control theory and related topics Mathematics of Complexity and Dynamical Systems is an essential reference for all those interested in mathematical complexity from undergraduate and graduate students up through professional researchers

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